

Proceedings  
*of the*  
**LONDON SWINE CONFERENCE**

**Today's Challenges...  
Tomorrow's Opportunities**

*Edited by*  
J.M. Murphy

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Proceedings of the London Swine Conference  
Today's Challenges... Tomorrow's Opportunities

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## CONTENTS

<b>Chair's Message .....</b>	<b>v</b>
<b>Steering Committee.....</b>	<b>vii</b>
<b>Sponsors .....</b>	<b>viii</b>
<b>Competitiveness in the Canadian Pork Segment: A Reassessment.....</b>	<b>1</b>
<i>Al Mussell and Kevin Grier</i>	
<b>New Tools to Manage Variability throughout the Pork Production Chain .....</b>	<b>19</b>
<i>Mike Tokach, Bob Goodband, Joel DeRouchey, Steve Dritz, and Jim Nelssen</i>	
<b>HANDLING DISEASE CHALLENGES .....</b>	<b>35</b>
<b>Principles of Health Management .....</b>	<b>37</b>
<i>François Cardinal</i>	
<b>Forgotten Diseases.....</b>	<b>45</b>
<i>Bob Friendship</i>	
<b>NEW DEVELOPMENTS DEALING WITH KEY PORK PRODUCTION ISSUES.....</b>	<b>51</b>
<b>New Tools to Make Genetic Progress.....</b>	<b>53</b>
<i>Jack Dekkers and Max Rothschild</i>	
<b>Feeding the Pigs' Immune System and Alternatives to Antibiotics .....</b>	<b>65</b>
<i>Hans Stein</i>	
<b>Nutritional Management of the Gilt for Lifetime Productivity - Feeding for Fitness or Fatness? .....</b>	<b>83</b>
<i>Pinder Gill</i>	
<b>BREAK-OUT SESSIONS.....</b>	<b>101</b>
<b>Alternative Feed Ingredients for Pigs .....</b>	<b>103</b>
<i>Hans Stein and Kees de Lange</i>	
<b>Alternative Energy Sources – Biogas Production .....</b>	<b>119</b>
<i>Harold House</i>	

<b>Alternative Energy Sources - A Hog Producer's Perspective of On-Farm Anaerobic Digesters.....</b>	<b>129</b>
<i>Gilbert Vanden Heuvel</i>	
<b>Alternative Energy Sources - What We Learned from European Technology and a Practical Look at Possible Ontario On-Farm Applications.....</b>	<b>137</b>
<i>Martin Van Raay</i>	
<b>On-Farm Health Management .....</b>	<b>141</b>
<i>François Cardinal</i>	
<b>Best Management Practices Used in the Control of PRRS .....</b>	<b>145</b>
<i>George Charbonneau</i>	
<b>Key Measures of Performance in the Growing-Finishing Barn for Informed Decision Making .....</b>	<b>151</b>
<i>Mike Tokach, Bob Goodband, Joel DeRouchey, Steve Dritz, and Jim Nelssen</i>	
<b>Managing and Monitoring the Finishing Barn - Six Things Not To Do .....</b>	<b>159</b>
<i>Mark Yungblut</i>	
<b>Benchmarking... Show Me the Money!.....</b>	<b>161</b>
<i>Ken McEwan</i>	
<b>Benchmarking... Show Me the Money!.....</b>	<b>167</b>
<i>Bev Hill</i>	
<b>Managing Reproduction - Critical Control Points in Exceeding 30 Pigs Per Sow Per Year .....</b>	<b>171</b>
<i>Pinder Gill</i>	
<b>Managing Reproduction - Fact and Folklore.....</b>	<b>185</b>
<i>Doug Wey</i>	
<b>Management Practices that Optimize Productivity in the Nursery - Case Studies on What Works! .....</b>	<b>195</b>
<i>Cameron Farrell and Catherine Templeton</i>	
<b>Recruiting and Training Employees .....</b>	<b>207</b>
<i>Carole Gumprich</i>	
<b>Recruiting and Training Employees .....</b>	<b>213</b>
<i>Aime Tamba</i>	
<b>On-Farm Feed Inspections.....</b>	<b>219</b>
<i>John Secord</i>	
<b>On-Farm Feed Medication Use – Challenges and Opportunities .....</b>	<b>223</b>
<i>John Rheume</i>	

## CHAIR'S MESSAGE

Welcome to the 7th London Swine Conference – **“Today’s Challenges... Tomorrow’s Opportunities”**.

Events in the past year and the future indicators are showing some significant changes could impact the Ontario and Canadian pork industry. Dealing with a stronger dollar, competing for corn with the ethanol boom, controlling disease challenges, uncertainty in the processing industry, and being competitive in pork production are a few of the major challenges that the industry is looking at for future opportunities. This conference challenges the pork production industry to be at the leading edge of technology and information to help create a globally competitive industry.

The plenary sessions provide perspectives to challenge our thinking on the new realities facing our industry, the new tools available to manage variability, the handling of disease challenges and the new developments with key pork production issues. Breakout sessions allow us to discuss the application of technology at the local level. Sessions deal with alternative feed and energy sources, workplace safety, on-farm health management, managing the weaner and finisher barn, benchmarking, reproduction, recruiting and training employees, and on-farm medication usage. Over the two day conference, participants will have the opportunity to exchange and discuss ideas with internationally renowned speakers and innovative industry leaders. The presentations, panel discussions, breakout sessions, and networking provide everyone the opportunity to learn.

It is through the hard work and dedicated effort of the steering committee, Janice Murphy the Technical Coordinator, Deb Campbell the Sponsorship Coordinator, Linda Dillon the Registration Coordinator, the support of industry partners, and industry wide participation, that the London Swine Conference successfully delivers its objectives. A special thanks to our generous sponsors, who through their financial commitment, support this initiative. Thank you to Ontario Pork, the University of Guelph, and the Ontario Ministry of Agriculture, Food and Rural Affairs for their support through the steering committee.

The commitment, cooperation, and professional presentations of the speakers are greatly appreciated. To our conference participants, thank you for attending. Your participation and implementation of the technology makes this conference a success.

Enjoy the Conference!

John Bancroft  
Chair, Steering Committee  
2007 London Swine Conference



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# **COMPETITIVENESS IN THE CANADIAN PORK SEGMENT: A REASSESSMENT**

**Al Mussell and Kevin Grier  
George Morris Centre  
225 - 150 Research Lane, Guelph, Ontario N1G 4T2  
E-mail: kevin@georgemorris.org**

## **ABSTRACT**

The Canadian pork industry has been one of the most successful parts of the Canadian agriculture and food industry for the past twenty years. It has been a world leader in exports and its growth in size and revenues has been extraordinary. During the last two years however, the industry has been faced with some of the biggest challenges of the past two decades. Those challenges relate to three main areas: feed grain competitiveness, packer competitiveness and labour availability. George Morris Centre analysis has shown that producer costs, particularly in the areas of feed grains, are significantly higher than in the hog producing regions of the United States. In addition Canadian packers face operating costs that are materially higher than their counterparts in the US. In addition to that, the growth prospects for the industry are severely constrained due to lack of labour availability. As a result of these challenges, the pork industry is undergoing a restructuring process at the packer level. In addition, the lack of competitiveness in feeding is likely causing increased attrition at the producer level. The decisions and steps that the industry takes in the next year will determine whether the industry continues to grow or whether the industry begins a prolonged period of decline.

## **INTRODUCTION**

The Canadian pork segment finds itself in a challenging position. While it has established itself as a leading international trader in pork and as something of a low-cost producer, it appears to be facing issues in these and other areas. In particular:

- The US recently surpassed Canada as the leading exporter of pork.
- Feed grain pricing patterns in Canada appear to have followed a different path relative to US feed grain prices than was anticipated in the mid-1990's, particularly for western Canada.
- Labour constraints are a significant factor facing the pork segment, particularly in western Canada.
- Significant rationalization is occurring in the Canadian pork packing segment.

Thus, a reassessment of the competitive stature of the segment, and the factors driving it, is warranted. The purpose of this paper is to discuss these developments, place them in context, and interpret them in the context of the future of the Canadian pork segment.

## NATURE AND STATUS OF COMPETITIVENESS IN HOG PRODUCTION

A combination of several factors is significant in determining regional competitiveness in hog production. The first is the set of natural factors and growing conditions that influence hog production. These relate to soil type and climate that influence the efficiency of pig growth; the principal factor that varies across regions is feed grains. The second critical factor relates to the availability of a quality workforce to work with livestock. The third factor is the proximity and ease of access to a population of consumers willing to pay for pork. A component of this factor is access to and the efficiency of the hog slaughter and pork processing function. The status of these factors in Western Canada and Eastern Canada relative to the Midwest US is explored below.

### Natural Factors

Figure 1 presents trends in Alberta barley yields relative to Iowa corn. The figure shows that Iowa corn yields significantly exceed Alberta barley yields and, more significantly, that yield growth in Iowa corn has proceeded at a much faster rate than Alberta barley. For example, when the 2004-06 average yields are compared with the 1985-87 average yields for Alberta barley and Iowa corn, the data show that Iowa corn yields increased by 30.7%, while Alberta barley yields increased by 22%. The situation is very similar for Manitoba yields versus Iowa corn. Comparing 1985-87 average yields with the 2004-2006 average, Manitoba yields increased only 3%.

**Figure 1.**

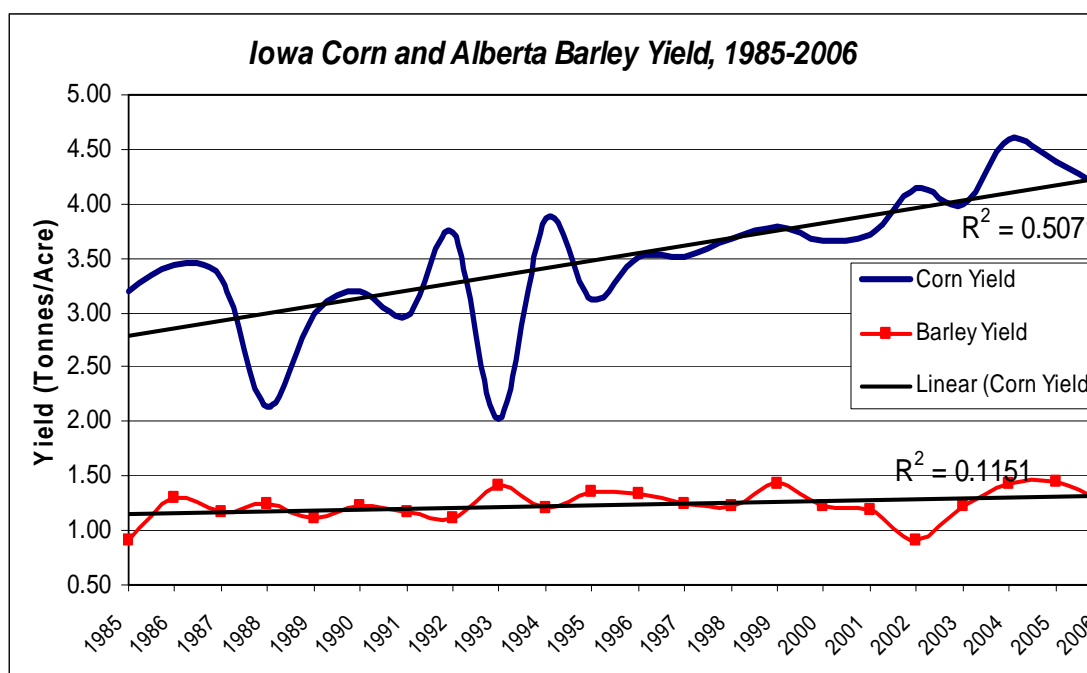
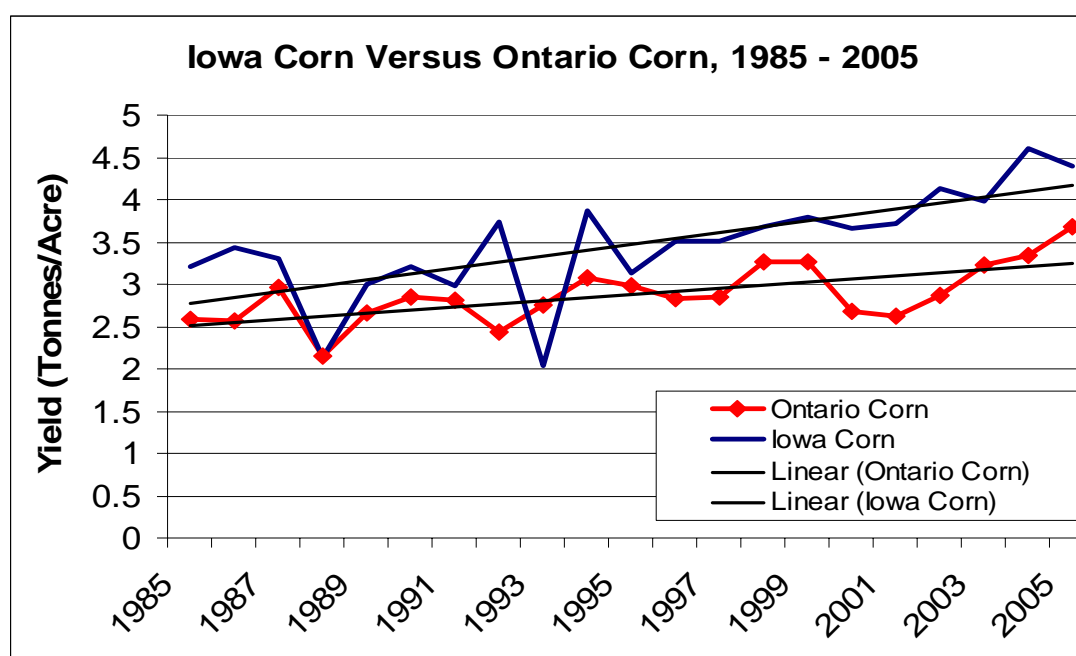


Figure 2 plots Ontario corn yields relative to Iowa for the period 1985 to 2005. The figure shows that Iowa corn yields have generally exceeded Ontario corn yields. The divergent trends also illustrate that Ontario corn yield growth has lagged behind Iowa. Using the same approach as above, Ontario yields grew by 26% comparing 2003-05 with 1985-87, compared with just over 30% in Iowa.

**Figure 2.**



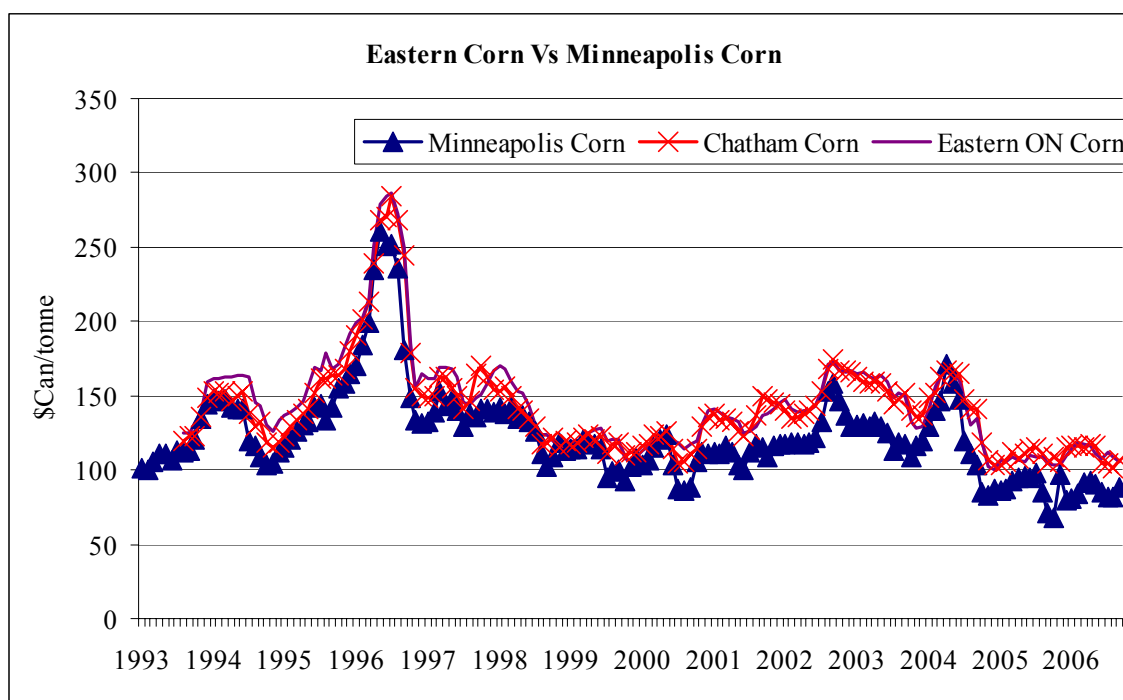
Consistent with mostly lagging productivity in Canadian feed grains relative to the US, Canadian feed grain prices have increased on a relative basis. This is most easily seen with respect to Ontario corn relative to US Midwest corn prices. Figure 3 and Table 1 illustrate the relationship. They show that Ontario and Minneapolis corn prices are very highly correlated, but that the spread between the two has widened over time, particularly since 2001.

Figure 4 plots relationships between barley at Calgary, barley at Winnipeg, and Minneapolis corn. The figure shows that, historically, Winnipeg barley has been at a discount to Calgary barley and to Minneapolis corn. In particular, the discount relationship between Winnipeg barley and Minneapolis corn is some reflection of the fact that barley has about 85% of the feeding value of corn in a livestock ration. During the 2002-03 droughts in western Canada, barley prices increased through Minneapolis corn prices. Barley prices have retreated since 2002-03 but remained priced at a premium to Minneapolis corn.

Soymeal pricing in Minneapolis and points in Eastern and Western Canada illustrate a classic freight cost relationship, in which Minneapolis is the low price point, followed by Winnipeg, Hamilton, and finally Calgary.

Broadly speaking, the above shows that Canadian feedgrain productivity has lagged that in the Midwest US. This is borne out in most comparisons of yield growth, but most clearly in direct price comparisons. Canada has become a high-cost feeding region compared with the US.

**Figure 3.** Source: AAFC, USDA ERS.



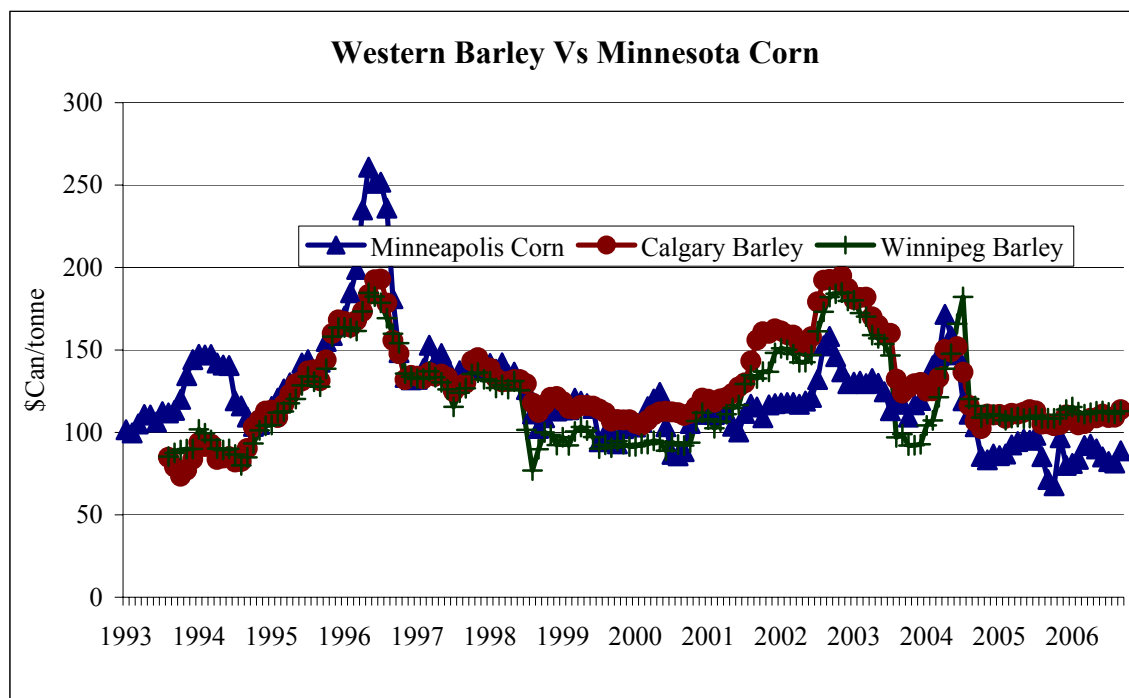
**Table 1.** Chatham-Minneapolis corn price spread.

Chatham-Minneapolis Price Spread, \$Can/tonne	
1995	12.33
1997	15.91
1999	9.20
2001	24.58
2003	27.91
2005	21.94

## Labour

A second critical determinant is the availability of a farm workforce. This has a couple of dimensions. The most tangible component is labour cost. However, some measure of labour productivity and interest in working with livestock in addition to cost is relevant.

**Figure 4.** Source: AAFC, USDA ERS.



Data on labour costs and wage rates is generally difficult to obtain, however data on wage rates for livestock workers is collected by Human Resources and Skills Development Canada according to National Occupation Classification (NOC) codes, including livestock workers (NOC 8253). The data is obtained from Employment Insurance claim data, and is fragmented by region, exclusive of benefits. In the US, data on wage rates is collected by the USDA National Agricultural Statistics Survey in the Farm Labour Survey for livestock workers. The wage rates collected are exclusive of benefits.

Table 2 below presents a comparison of Canadian regional and US Midwest wages rates, in \$Can/hour. The table shows that livestock worker wage rates are clearly the highest in Alberta. This is not surprising, given the competitive influence of the oil industry on Alberta labour markets. Manitoba and Ontario livestock worker wage rates are significantly lower than Alberta. Wage rates for livestock workers in the Midwest US are generally the lowest. Compared with the Midwest US livestock worker wage rates, Manitoba wage rates appear to range around \$2/hour higher, and Ontario wage rates range about \$3/hour higher. Alberta wage rates appear to range \$7/hour over the Midwest US.

### **Pig Productivity**

Another aspect of labour relates to pig productivity given management and labour productivity in Canada vs. the US. Since common swine genetics are in use throughout North American and pig housing is essentially the same in the US and Canada, labour productivity and management must be a significant determinant of differences in observed pig productivity.

**Table 2. Livestock worker wage rates.**

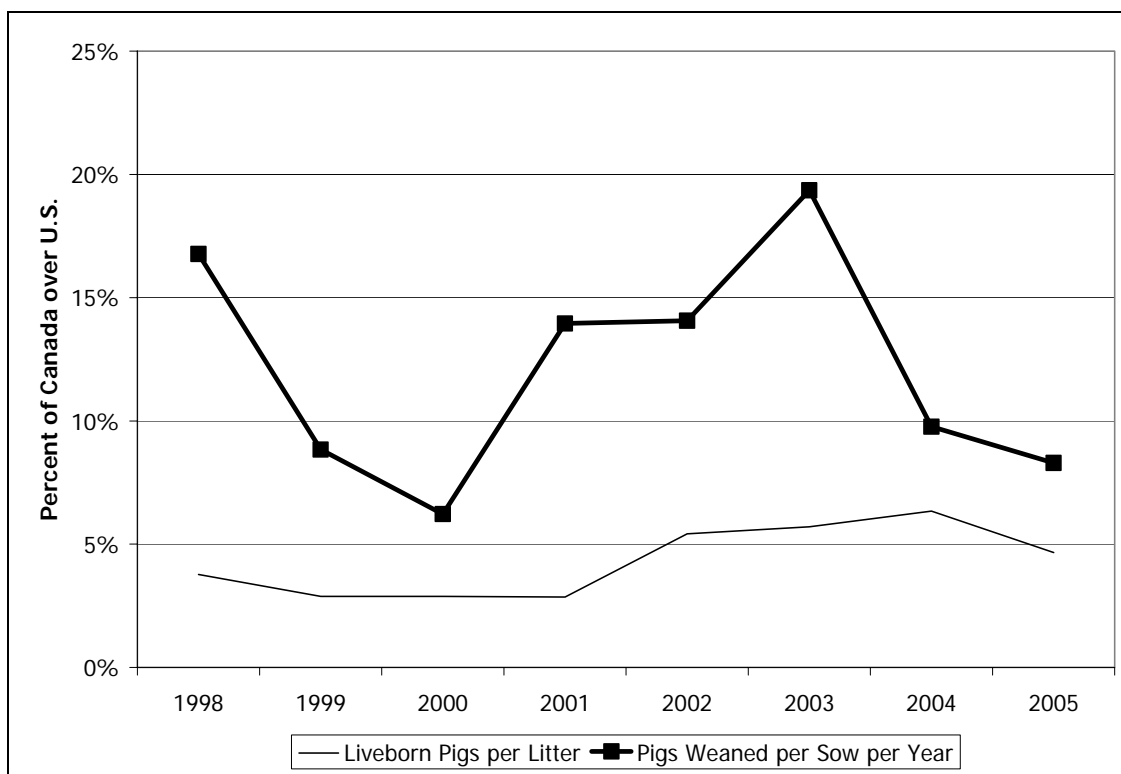
<b>Jurisdiction</b>	<b>Region</b>	<b>Reference</b>	<b>Time Period</b>	<b>Wage Rate (\$Can/hour)</b>
Alberta	Red Deer/ Camrose/Olds	NOC 8253	Sep. 2003-Sep 2005	\$17.54
Manitoba	Winnipeg	NOC 8253	May 2005	\$12.00
Ontario	Kitchener/Stratford	NOC 8253	2005 Average	\$13.10
Iowa/Missouri	Cornbelt II	Livestock Worker	July 2005 July 2006	\$10.15* \$11.28*

\*Converted to Canadian dollars assuming \$Can 1=\$US .90

Data on pig productivity in the U.S. and Canada suggest that Canada has had an advantage in farrowing exhibited by higher performance. Time series data obtained from PigCHAMP regarding breeding herd performance between Canada and the US provide some evidence. Figure 5 compares two key metrics of breeding herd efficiency: liveborn pigs per litter and pigs weaned per sow per year. Since 1998, aggregate data from Canadian producers show a 12 percent average advantage in pigs weaned per sow per year or approximately an advantage of 2.77 pigs weaned per sow per year.

### Historic Differences in Canadian and US Sow Productivity

**Figure 5. Source: PigCHAMP.**





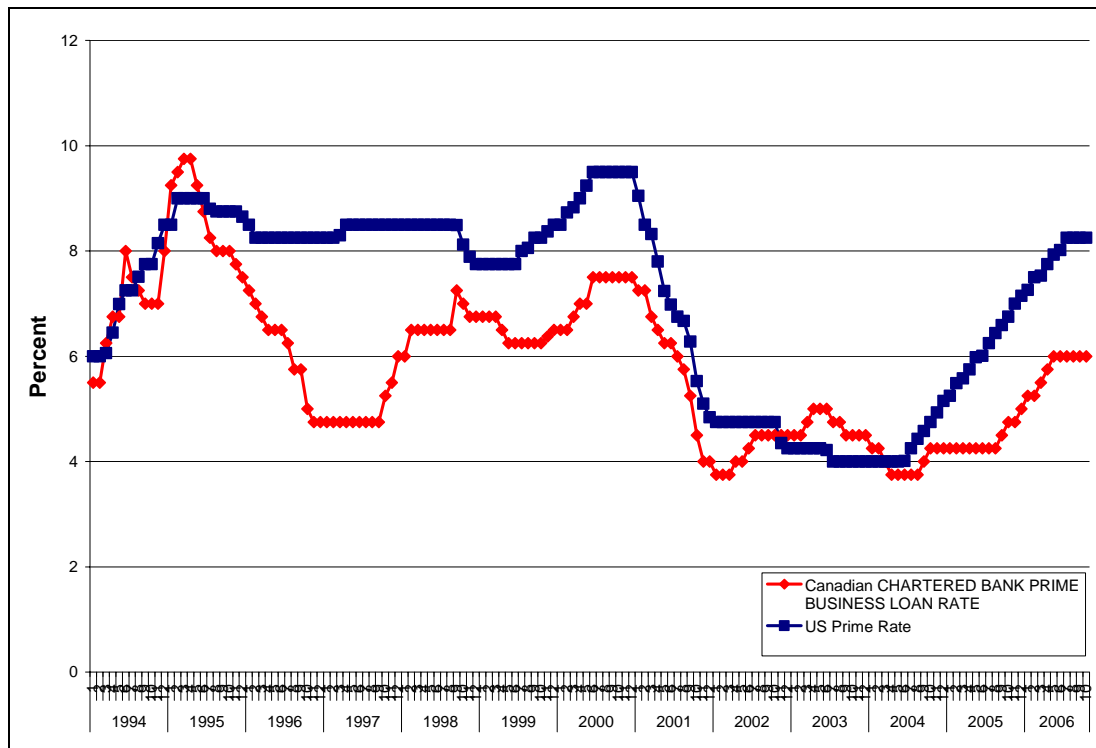
## Capital

One of the key factors influencing labour productivity is investment in capital, and thus the cost of capital. The key measurement of capital cost is the prime business interest rate. This is presented in Figure 6 below. The figure plots Canadian prime business interest rates and US business prime rates. The figure shows that Canadian interest rates have generally been below US rates through the period, with the exception of a brief period from late 2002 to early 2004.

Meanwhile data from the Dow Jones and TSX indices illustrate that the equity returns are highly correlated in the US and Canada (Table 3). Through the late 1990's, the Dow Jones index grew relative to the TSX; in recent years, the TSX has strengthened relative to the Dow Jones. Since 1990, the average rolling 12 month growth in the Dow Jones Index was about 11%, compared with 10% for the TSX. However, since 2000, the TSX has significantly outperformed the Dow Jones index, with an 11% growth rate compared with 2% for the Dow Jones. The TSX has experienced more volatile returns than the Dow Jones, regardless of which time period is used as a reference.

Thus, the underlying cost of debt capital is relatively low in Canada compared with the US, while the opposite appears true of equity capital. The historic spread between Canadian and US interest rates of 200-300 basis points has re-emerged, making Canadian debt inexpensive relative to the US. At the same time, based on recent performance, the expectation of return on stock equity investments has been higher in Canada compared with the US.

**Figure 6.**



## Canadian and US Prime Business Interest Rates

**Table 3. Annual average rates of return, mean and standard deviation.**

	Dow Jones	TSX
1990-2006 Average	11%	10%
2000-2006 Average	2%	11%
Std Deviation 1990-2006	0.133	0.167
Std Deviation 2000-2006	0.115	0.206

### Observations

The following observations emerge from the above. First, compared with the US, Canada currently appears to have little to offer in terms of competitiveness in hog feeding. This is surprising, particularly given that much of the development of the western Canadian hog industry was developed precisely on an anticipated advantage in hog feeding. However, the data show that US feedgrain productivity, measured simply as yield growth, has outstripped that in both western and eastern Canada. Consequently, feedgrain prices in western and eastern Canada have increased relative to that in the US. Points in western and eastern Canada are also at a freight cost disadvantage to the Midwest US.

Interestingly, Canada's comparative advantage in hog production appears to have developed in the area that has least to do with feedgains and feeding costs. The record of performance data obtained from PigChamp suggests that Canadian producers have been successful at obtaining larger litter sizes and in weaning more pigs from sows than their US counterparts. Thus, Canadian producers and hog farm workers have achieved greater sow productivity. However, based on the wage data, this relative performance may be occurring at a higher wage cost, particularly in Alberta. It is also consistent with new investment in the conversion of facilities originally intended for hog feeding to farrowing facilities, which was driven by the above feedgrain situation.

Thirdly, the structure of capital costs and returns in Canada relative to the US would appear to favour debt capital over public equity. As illustrated above, interest rates in Canada are currently at a discount to that in the US, similar to what occurred through the late 1990's when much of the investment in Canadian hog production facilities occurred. The equity situation is somewhat less clear, but the leading indicators suggest that rates of return are higher in Canada, and riskier, than in the US. Thus, projects in hog production or pork processing attempting to access external equity in Canada would need to offer higher returns than in the US in order to attract Canadian equity. This could be a significant factor, because debt is typically used to fund hog production investment projects, where processing plant projects would likely use a portfolio of debt and equity financing.

## **LABOUR CHALLENGES FACING CANADIAN PORK PACKERS**

Labour has become one of the most important issues facing the packing industry in Canada. This section will explain the current trends and impacts on the industry. The focus of the industry is primarily on labor availability and its impacts on packer operations and development. The section also addresses labor challenges at the producer level.

### **The Problem Overview**

Canadian livestock production and packing is facing a mounting labor shortage. This shortage has been brought on by many factors including an aging work force, a dramatic reduction in local youth enrolling in agriculture related programs/farm careers and an inability to compete in the labour market with other sectors. While the shortage is most noted in the west, particularly Alberta, the challenge faces the industry across the entire country. The following provides a perspective on the scope of the challenge in Alberta:

- In the 12 months ending in March 2006, 34 of 53 occupational groups had an unemployment rate below three per cent, compared to 22 occupational groups in 2003. (Statistics Canada says that an unemployment rate of below 4% indicates a labor shortage)
- The percentage of employers indicating a hiring difficulty in one or more occupational groups increased from 51.5 per cent in 2003 to 56.3 per cent in 2005.
- The percentage of employers reporting at least one position unfilled for over four months increased from 21.0 per cent to 28.2 per cent between 2003 and 2005.

Alberta's tight labour market is leading to increased competition among industries and employers for workers across a range of skill levels, including low-skilled entry-level positions. As competition for limited numbers of low- and semi-skilled workers increases, several industries are finding it difficult to offer the higher wages and benefits other industries are capable of offering to attract and retain the workers they need.

Again, it is important to note that while the situation is most acute in Alberta, the situation is the same, to varying degrees across Canada. This new labor environment is directly impacting hog production and packing from coast to coast.

### **Primary Agriculture Employers**

The growth of Alberta's and the prairies resource-based industries creates a downside that affects every aspect of the economy. It is driving up wages; consuming support industries such as construction, engineering, professional services; creating shortages in cement, steel, and other building materials; and has effectively consumed the available labour pool. The resulting supply/demand gap in labour raises fundamental questions about the sustainability of current growth levels, threatens the viability of every province's livestock industry, and

impacts the quality of life in rural communities.<sup>1</sup> In fact, in Alberta the situation is regarded as an “imminent labour crisis facing cattle feeders and pork producers in the province.”<sup>2</sup>

Dairy, pork and beef feedlot producers have been particularly impacted with labour shortages. Livestock require continuous management and labour shortages result in owners working longer hours. Numerous producers find some are struggling with 80-90 hour workweeks and are contemplating significant cutbacks in production, which threaten the viability of their farms. Extension staff in Alberta are increasingly hearing of decisions to keep teenage children home from school to help out with farm duties, and are concerned about risks to their personal and family health from overwork. Many are highly emotional and stressed regarding not being able to find workers and with the bureaucratic processes involved.

Over the past couple of years, hog production growth in Canada has been curtailed or in the case of the east, inventories have even declined. The lack of growth is due to a variety of reasons ranging from disease to poor financial returns. According to larger producers, however, another reason for the lack of growth is due to a lack of labor availability. There is no definitive measure on this factor, yet, but larger producers suggest that they are not able to run their operations at capacity due to a lack of labor. Suggesting a certain percentage lack of capacity would be misleading now, but there is no doubt that a lack of labor has now become a limiting factor in Canadian hog production.

### **Pork Packing**

Canadian pork packers across the country are suffering due to a lack of labor. The R.A. Chisholm company in Toronto, is one of several Canadian entities that is working on trying to address the labor availability issue in the agriculture and food industry. Chisholm notes that in Alberta, pork and beef packers currently require about 1,500 new workers. In Manitoba approximately 600 workers are required. Throughout Ontario and into Quebec and the Maritimes pork packers of varying sizes are in need of additional workers.

Maple Leaf Foods has repeatedly stated that the key reason it has not begun a double shift at its Brandon, Manitoba plant is due to insufficient labor. Olymel in Red Deer, Alberta was unable to continue its second shift during 2006 due to a lack of labor.

The impact of labor availability is both very obvious and subtle. From the obvious perspective, the lack of labor results in lower production volumes at the plant and in the industry as a whole.

Just using the Brandon and Red Deer examples, it is clear that the industry could be processing an additional 80,000 hogs per week. That translates into lost revenues for the

<sup>1</sup> Adopted from A Livestock Industry Perspective on BUILDING AND EDUCATING TOMORROW'S WORKFORCE: A framework to enhance Alberta's people capacity 10-YEAR STRATEGY, Alberta Pork and Alberta Cattle Feeders Association, March 2006.

<sup>2</sup> A Livestock Industry Perspective on BUILDING AND EDUCATING TOMORROW'S WORKFORCE: A framework to enhance Alberta's people capacity 10-YEAR STRATEGY Alta Pork and ACFA, March 2006

industry of approximately \$600 million per year.<sup>3</sup> That in turn translates to added transport costs on hogs shipped to the United States. This has obvious implications for Canada's pork market share in both domestic and export markets. It is of interest to note that in recent years, Canada has become one of the United States' fastest growing pork markets. At the same time, Canada has been losing share to the United States in world export markets.

There are more subtle losses associated with the labor challenge as well. One such loss is the fact that packers and processors are often not able to cut pork to more refined specifications due to a lack of labor. That contributes to a loss of value added production in Canada. Another subtle loss relates to the lack of asset utilization and the associated loss of return on investment. For example, Olymel has invested in a plant and equipment in Red Deer in order to facilitate a double shift. That investment is now significantly underutilized.

The Canadian pork packing industry faces many challenges but the lack of labor is arguably the most significant. Furthermore, when the packing industry suffers due to this or any other challenge, the ramifications are felt directly by producers as well.

## **INTERNATIONAL TRADE**

Previous research by the George Morris Centre conducted for the Canadian Pork Council illustrated the material benefits to the Canadian hog industry as a result of pork exports.<sup>4</sup> The following are some of the major points derived from that research:

- Pork exports have been the driver of the exceptional growth of pork production in Canada
- Canada is a world leader in pork exports (see graph below).
- Canada has diversified its export markets to over 100 countries and is increasingly less dependent upon the US market.
- Pork export demand has been rapidly growing while domestic demand has been stable.
- Pork exports of \$2.8 billion in 2005 are responsible for economic activity amounting to \$7.7 billion and 42,000 jobs.
- Pork exports support the incomes of about 6,000 farmers and about \$2 billion in farm cash receipts.
- Premiums derived from the export market due to value differences in those markets could result in enhanced producer income of up to \$9/hog.

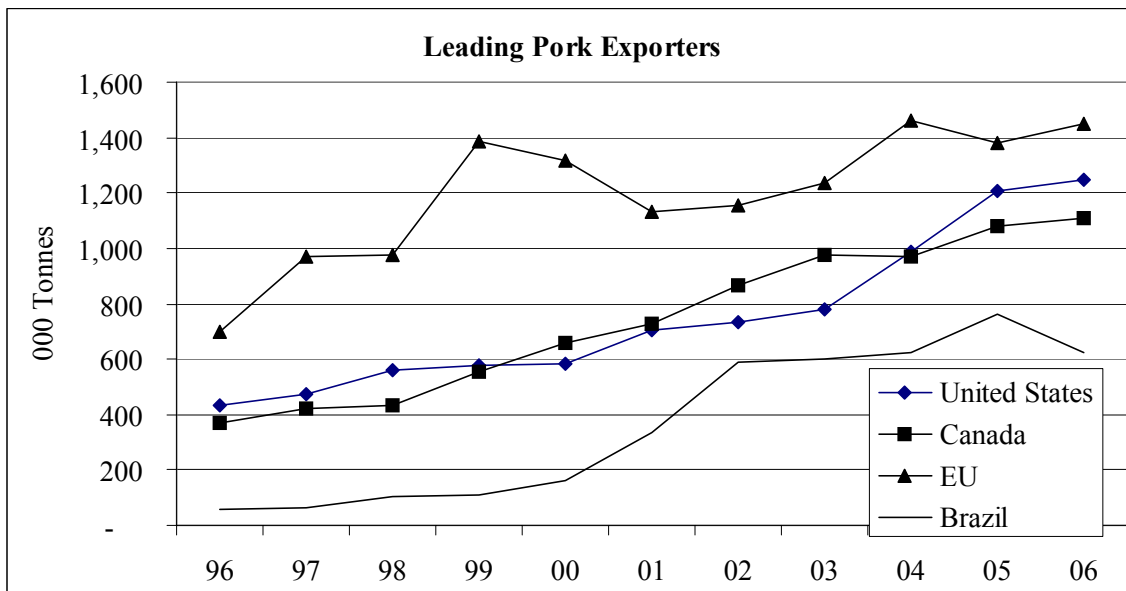
The key message of the report was the importance of exports to the Canadian hog production sector and to the Canadian economy in general. Further to that point it needs to be re-enforced here that pork exports are likely more important to Canada's pork industry than to other industries around the world. The following comparisons make that point clear:

<sup>3</sup> Utilizing an estimated 2006 cutout of about \$140/head.

<sup>4</sup> The Benefits for Canada from Pork Exports, October 16, 2006, George Morris Centre

World exports = 5% of total pork production  
 US exports = 10-13% of total production  
 Brazil exports = over 25% of total production  
 EU's exports = 7% of total production  
 Canada exports > 50% of total production

**Figure 7. Source: USDA.**



The importance of Canada's pork exports is well illustrated in the graph below. The graph clearly shows that pork exports have been the sole source of growth for the Canadian pork industry.

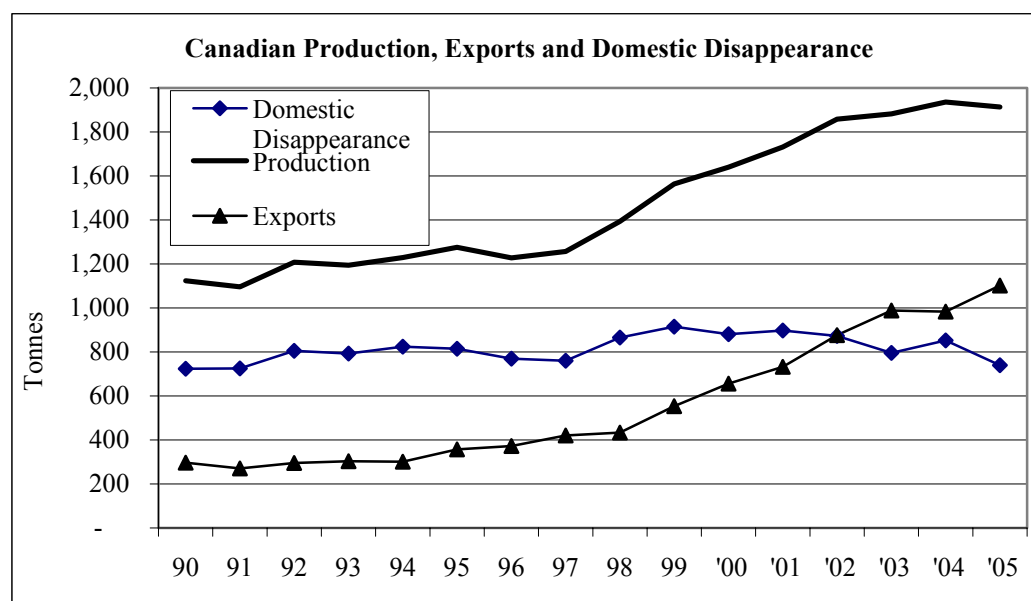
Obviously relative to other countries, Canada has a greater stake in exports and therefore in export market competitiveness. It is therefore important to assess longer-term issues and challenges in the export market. The Food and Agricultural Policy Research Institute (FAPRI)<sup>5</sup> specializes in longer term macro economic forecasting. In that regard, FAPRI sees pork trade increasing by 2.4% annually by 2015. Over that period of time, the market share of the enlarged EU drops by 3.3 points by 2015. Canada, the U.S., and Brazil gain 1.9, 2.7, and 4.2 points of market share, respectively.

FAPRI asserts that Brazil's long-term prospects are good; new investments are expected to improve infrastructure and raise productivity. Strong domestic and export demand fuels a 3.1% annual expansion in Brazil's pork sector. Net pork exports grow by 6.0%, to 1.2 mmt in 2015. Improvement in productivity (breeding and feeding programs), favorable domestic

<sup>5</sup> FAPRI is a dual-university research program. With research centers at the Center for Agricultural and Rural Development (CARD) at Iowa State University and the Center for National Food and Agricultural Policy (CNFAP) at the University of Missouri-Columbia.  
 The FAPRI paper referenced here is World Meat: FAPRI 2006 Agricultural Outlook

policies (credit, infrastructure, fiscal), and a weakening currency improve Brazil's competitiveness in the world pork market.

**Figure 8.** Source: Statistics Canada.



The EU's new member states are currently among the leading pork exporters in the world when grouped together. According to FAPRI, these countries will remain important exporters but their share of world markets will remain relatively stable or even decline by 2015.

In the EU, the decline in market share is driven by strict environmental regulations and animal welfare requirements. These limit the EU's (especially the EU-15's) long-term capacity, and production grows by only 0.7% annually.

China is often viewed as a potentially formidable competitor. FAPRI notes that pork is produced cheaply by backyard producers in China, but commercial producers' costs are comparable to those of other countries. The fact is, however that FAPRI sees China more as a market opportunity than as a major exporter. WTO accession for China will result in more open market opportunities in coastal population centers as tariffs are reduced from 20% to 12% and as foreign firms are allowed to engage in distribution. FAPRI sees net imports expanding significantly by 2015.

Other major importers are expected to remain as major importers. In Russia, FAPRI is forecasting that net imports decline by 1.4% as production grows faster than consumption. Russia, however, is expected to remain as one of the major pork importers in the world. With WTO accession, Taiwan's pork production increases only slightly, by 1.0%, and imports expand by 8.5% to meet the 1.3% annual increases in consumption. South Korea's consumption growth, at 2.7%, is faster than its production growth, at 2.6%, and is thus met by more net imports. Improved consumer purchasing power and population growth caused pork consumption in Mexico to increase by 3.0%. Despite some industry integration, a limited

supply of cheap feeds and credit problems keep growth in domestic production lagging behind.

The FAPRI analysis shows that the world's leading pork producers will continue to grow and compete for share in world markets. The main message garnered from FAPRI, however, is that the major import markets will remain very strong and growing markets for the world's pork producing countries.

## **PORK PACKER ISSUES AND CHALLENGES**

Exports are usually regarded as a sign of competitiveness. That is, the more an industry exports, the more competitive the industry is regarded. With that said, the Canadian pork packing industry offers a paradox. On one hand, the industry is a world leader in pork exports. That suggests that the Canadian packing industry is competitive on world markets. On the other hand, however, 2-3 million slaughter hogs and 6 million feeder hogs are annually shipped south to the US. That fact suggests that Canadian packers are not competitive with their US counterparts.

In some respects the issue of packer competitiveness is one of the most important factors facing the industry. The massive changes announced by Maple Leaf in the fall of 2006 as well as the expected structural changes to be announced by Olymel are major consequences of the competitiveness problem. Maple Leaf announced that it would close or sell five plants across the country. This is in addition to its earlier decision to exit its stake in plant operations in PEI and Quebec. The announcements in the fall of 2006 by Maple Leaf mean a potential loss of capacity of at least 4.5 million head. The company also said it would double shift its Brandon. The net potential loss of capacity could amount to over 2 million head, mostly in Ontario.

For its part, Olymel has already announced that one of its Quebec slaughter plants will close in March 2007. In addition, for a variety of reasons, the company elected not to go forward with its previously announced plans to construct a plant in Winnipeg. Further announcements are expected in light of its late 2006 external evaluation of its pork processing business. As noted earlier, the company was also forced to end its second shift at its Red Deer plant.

In addition to those massive developments, other developments are also occurring. For example there has been a protracted strike during late 2006 at a relatively small Quebec packing plant. This has likely been precipitated by poor financial results. The Quebec hog marketing system has been put in disarray due to the collapse in pricing of one of the three pillars of their system. In addition a packing plant in Moose Jaw has been opened and closed in 2006.

As a starting point in the discussion of the pork packing issues and what is driving these changes, it is worthwhile to review some of the key drivers to success in pork packing.



## Pork Packing Characteristics

The following points are key pork packing plant characteristics.

- Scale economies
- Plant location/utilization
- Labor costs
- Hog weights
- Credits

### Scale Economies

The following provides a good outline of relative plant sizes between Canada and the United States:

- Canada
  - average daily capacity: 3,200 head
  - 5 largest Cdn plants: 8,400 per day
  - 3 of top 29 are >40,000 per week
- United States
  - average daily capacity: 13,000 head
  - nearly 4 times greater than in Canada
  - 5 largest US plants: 21,000 head
  - 2.5 times greater than the top five in Canada
  - 20 of top 29 are > 40,000 per week

The main message is that Canadian plants or line speeds are much smaller or slower than in the United States. The following table provides another perspective on the same factor:

**Table 4.**

	US	Canada	Quebec
Avg Daily Capacity	13,000	3,200	2,700
Five Largest	21,000	8,400	5,500
# Plants >40,000 head/week	20	3	0

This is important because economic research as well as statistical analysis has consistently shown that larger plants have lower costs per head than smaller plants. In larger plants, direct and even indirect costs are spread over larger numbers. In addition labor is more productive and physical assets are more fully utilized. According to George Morris Centre, USDA and other academic research, costs can be C\$2-8/head lower costs for large (1,000/hour) versus small (300-400)/hour.

Double shifting is important for similar reasons. Indirect costs such as administration and depreciation are spread over a larger number of hogs and assets are generally more fully

utilized. All major US plants are double shifted whereas in Canada only two very small plants in Quebec are double shifted. According to George Morris Centre research, Canadian plant costs are at least C\$3 higher than US plants due to a lack of double shifting.

Essentially, Canadian plant costs are likely at least C\$5/hog higher than in the US due to the fact that they are smaller and not double shifted.

### **Other Drivers**

Generally the entire spectrum of factors that are important for success in pork packing tend to favor the United States.

- Canadian plant utilization rates have been declining in the last three years.
- Wage rates in Canada result in a cost disadvantage of at least \$1/hog.
- Lower hog weights in Canada result in a cost disadvantage of about \$1/hog.
- US packers receive up to C\$1/hog more on inedible by-products.

### **Canadian Dollar Appreciation**

The appreciation of the Canadian dollar has had an impact on Canadian packers in two ways. The first is that it has modestly resulted in reduced gross margins. That is due to the fact that appreciation has reduced pork cutout revenues at a slightly faster rate than it has reduced hog costs. As such, gross margins have been trimmed during the period from 2003 through 2006 as the appreciation occurred.

In addition to the impact on gross margins, operating cost competitiveness relative to the US competition has also been impacted. For example, if labor costs per hog in Canada amount to C\$10/hog, when the exchange rate is at 0.65, the US equivalent was just US\$6.50/hog. At a ninety cent dollar, that same US equivalent becomes US\$9/hog. As such, the appreciation results in a relatively higher cost structure.

### **Observations**

Canadian packers have significant challenges that have resulted in a material competitive disadvantage to their US counterparts. These challenges are being addressed by the packing sector but the adjustment is going to result in major uncertainty and disruption for producers across the country.

## **SUMMARY AND CONCLUSIONS**

The Canadian pork industry from producer through packer is at a critical point in its evolution. Pending decisions and stated intentions by the two leading pork-packing companies in Canada have placed the industry at this critical point. These leading packers have made decisions or have begun to make plans that have major ramifications for the entire industry. Moving forward, the industry faces at least two possible paths. One will result in

rationalization due to the packer actions while the other path involves taking advantage of opportunities created by the packer actions.

Regardless of the path that is eventually taken by the industry, it is important to realize how the Canadian pork industry and in particular, the packing sector evolved to this critical point in its development. The industry needs to have these factors enunciated and understood before it can move forward.



# **NEW TOOLS TO MANAGE VARIABILITY THROUGHOUT THE PORK PRODUCTION CHAIN**

**Mike Tokach, Bob Goodband, Joel DeRouchey, Steve Dritz, and Jim Nelssen**  
**Kansas State University**  
**246 Weber Hall, Manhattan, KS 66506 USA**  
**E-mail: [mtokach@ksu.edu](mailto:mtokach@ksu.edu)**

## **ABSTRACT**

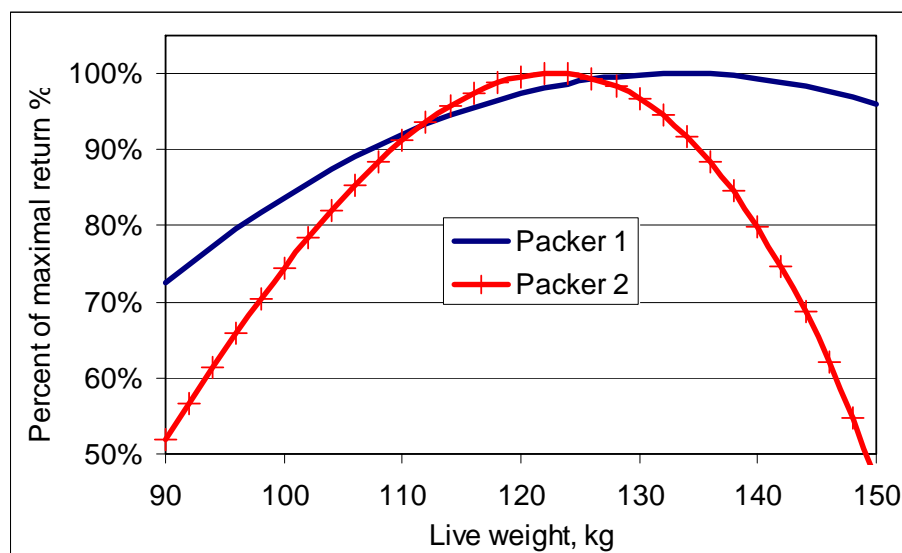
Reducing variation in the process of producing pigs has received considerable discussion over the last 10 to 15 years. Many people have argued that increased integration within the industry would lead to less seasonal variation in the number of pigs produced, decreased variation in production measures, and decreased variation in market weights. In reality, the real variation in the industry is as great as ever. More and more people are starting to understand that eliminating variation in a biological system is impossible. Most system design and productivity advances have led to a shift in averages, such that our industry is more productive and efficient, but without great reductions in variation measures. While we continue to work on system design and management changes that provide some reduction in variability, the most profitable pork chain systems have been designed to manage the variability in production. The alternative, of course, is forcing excess cost into the production segment in attempts to reduce variability.

End product variability can be reduced by sorting product in the plant and targeting segmented markets for each product or it can be reduced by attempting to control size of product entering the plant. Sorting pigs strictly by weight before sending to market also reduces variation in product size, but often adds production cost through increased labor and decreased facility utilization. Sort systems have been developed to reduce the labor cost, but they don't solve the decreased facility utilization issue. Some system design components, such as parity segregation, split-sex housing, use of opportunity barns, increased weaning age, and decreased fill time, do reduce variation in weights at market, but cannot be easily adopted within all production systems. The advantages of high health systems on improving productivity and reducing variation are clear, although maintaining a high health system is easier said than done. We are just in our infancy of understanding the impact of selection for litter size, and resultant high ovulation rate, on pig weight variation and whether we can moderate any negative impact by altering fetal development. Finally, there are some management strategies being used by producers, such as sorting pigs into the barn or excessive cross-fostering that decrease visual variation in the barn, but do not reduce weight variation in the barn. All aspects of the pork chain should be considered in managing variability. The greatest impact on product variability appears to be accomplished through system design changes and sorting and segmenting product in the plant.

## STARTING WITH THE END IN MIND

The market available for products exiting the processing plant helps dictate the variation in size of cuts for pigs entering the plant. For a processor that has a high proportion of value added cuts with relatively few market streams, controlling weight of market pigs is critical. An example of the discount for pigs that don't meet the weight goals of this type of processor is shown as Packer 2 in Figure 1. In contrast, Packer 1 has a wider range of products, higher proportion of product that is sold in the fresh market and can accept a wider range in product weights. For a producer marketing pigs to Packer 1, there is much less incentive to sort pigs at market. There is still value to not sell excessively heavy pigs or light pigs; however, the reduction in market weights that this grid allows greatly increases facility utilization and weight generated per unit space in the barn. The heavier weights allowed before discounts are received also allows the production system to spread fixed costs over more total weight to achieve a lower production cost. Similarly, the packer's fixed costs of processing a pig are spread over more weight to reduce the processing cost per pig. Thus, the producer and packer participating in this production chain can accept a lower price for their product and still be more profitable. Conversely, Packer 1, because of the lower variation in weight entering the plant has the opportunity to add more value to a more consistent product, and thus, has the potential to extract a higher value. Both of these production systems can be successful. As more and more vertical coordination occurs in the industry, communication is required to help explain to Packer 2 why a higher price must be paid because of the higher production cost incurred by the producer. Conversely, the producer supplying pigs to Packer 1 also must understand that they may have to accept a lower market price because of the increased variation in product stream being delivered to the processor.

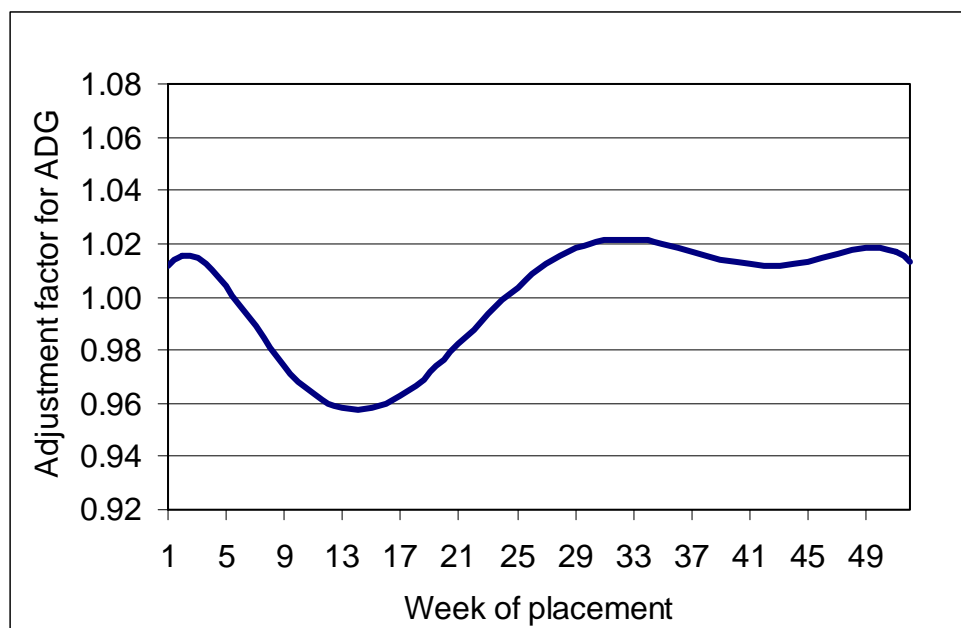
**Figure 1. Maximal return at two different processors as influenced by average market weight of a group of pigs delivered to the plant.**



## REDUCING SEASONAL VARIATION IN MARKET WEIGHTS

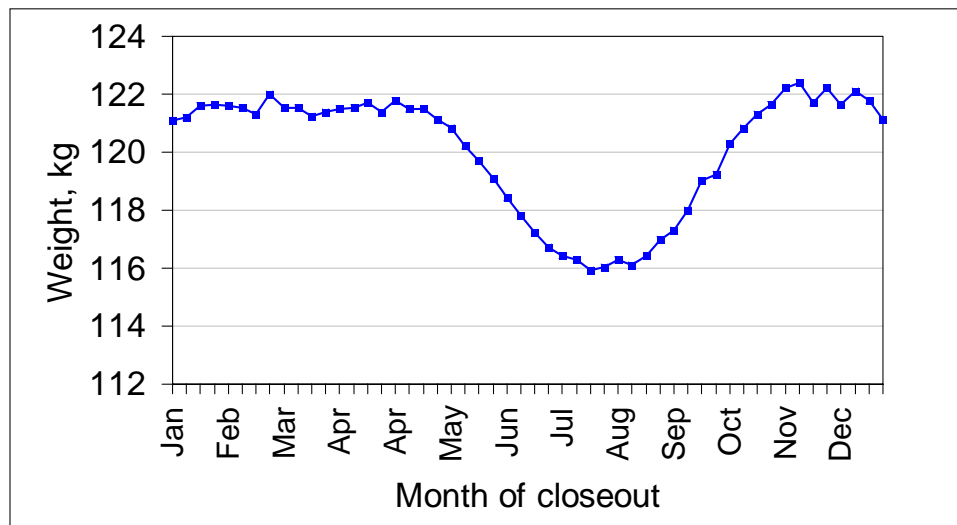
Although great strides have been made in managing the environment in barns, seasonal variation in growth rate remains a major obstacle within a production system. Pigs placed in the late summer through the early winter months grow faster than pigs placed in late winter months and spring (Figure 2). As a result, market weights are reduced by 4 to 6 kg for pigs marketed in June through mid September (Figure 3). Market price is normally highest during this same time period. For many production systems 75 to 80% of the net profit for the year is obtained during these summer months. The most profitable systems have determined methods to maintain market weights through the summer months.

**Figure 2.** Variation in ADG as influenced by week of placement (adapted from Bahnson and Dial, 1995).



The only way that weights can be maintained is by increasing growth rate for groups of pigs finished at this time or increasing days in the barn. Growth rate can be increased by increasing the energy density of the diet or by using Paylean seasonally during the summer months. If dietary energy is already at the economic maximum and Paylean is already being used, pigs must be given more days to grow to obtain the same market weight on the lower seasonal growth rate. Finding extra days is not easy, but the production system needs to be built with this flexibility. For example, wean to finish barns offer flexibility as they can be double or triple stocked in the summer months to allow pigs in other barns more time before the facility is needed. Similarly, heavier stocking density in nurseries in summer months reduces the finishing barn requirements. Heavier stocking density will reduce growth rate of these pigs; however, they will be marketed during the winter months when space is normally not a problem.

**Figure 3. Seasonal variation in market weight (adapted from Bahnson and Dial, 1995).**



## **MANAGING VARIATION ON THE FARM WITHOUT REDUCING VARIATION IN GROWTH**

Even within systems that manage the seasonal variation in group average ending weight, variation of within group final weights is still a challenge. Changing the system to reduce variation is difficult after the system is built. Thus, methods of managing the variation without reducing it must be used to control market weight. The two most effective ways of managing variation without reducing it are through sorting at market and by increasing the growth rate of the entire group of pigs.

### **Sorting at Market**

Sorting pigs visually without a weight has proven to not always be an effective means of removing the heaviest pigs from the barn. People often remove a normally distributed group of pigs from the barn rather than only the heaviest pigs. Manual weighing is an effective means of finding the heaviest pigs, but is also very time consuming. Auto-sort barns have increased in popularity and use in the industry. The barns greatly reduce the amount of labor required to sort and market pigs and can be effective to increase profit when marketing to a processor with a narrow optimal weight window (example: Packer 2 in Figure 1). The optimal design of auto-sort barns is still being debated. Many early versions didn't allow adequate feeder space and thus, weight gain was reduced in these barns. The longevity of the equipment is improving, but still a question. While limited research has been conducted with auto-sort technology, they appear to have a place within some systems. Their success largely appears to depend on the producer's technological ability and narrowness of the packer weight window.



The auto-sort barns have provided another opportunity to weigh pigs more easily at market. Some producers only use the auto-sort when pigs near market weight and move the pigs through the scale at a set time after placement or after a certain portion of the feed budget has been consumed to start pulling heavy pigs. By using the system only as a weighing system at market, it requires fewer scale heads, but is more labor intensive at marketing than if the pigs have been trained to use the auto-sorter throughout the growing period.

If an auto-sorter is not used, two options can be used to help determine when to market the pigs. First, test weighing or a weight tape can be used on a sample of pigs starting at a designated time post placement. Because of the seasonality in ADG and variation between groups, it is a mistake to use days after placement as the only method to determine when pigs should be marketed. A second option would be to use feed delivery and an estimate of the amount of feed that should have been consumed by a certain weight to determine the average weight of the pigs in the barn. Using previous variation data, the number of pigs that should have reached the optimal market weight can be determined. Some systems use the feed delivery and a standard growth curve with a seasonal adjustment to provide two estimates of when pigs should be nearing market weight. Then test weighing is used to more accurately estimate the actual weight in the barn. Number of pulls and number of pigs marketed at each pull is adjusted, mainly based on the amount of time remaining before the barn must be emptied.

### **Increase Growth Rate of the Entire Group**

Increasing the growth rate of the entire group will not reduce variation or the need to sort pigs at market, but it will increase the weight of the slow growing pigs, which is the main marketing issue. Producers should focus on areas where they can increase the growth rate of the entire group, such as:

- 1) Use of genetics capable of high growth rate in commercial conditions
- 2) Maintenance of high health status
- 3) Feeding of Paylean
- 4) Increased weaning age
- 5) Use of sows with high milk production
- 6) High feed intake in the farrowing house to increase weaning weight
- 7) Increase energy density of diet to increase growth rate
- 8) Feed correct amino acid levels (slightly higher levels than optimal for cost/lb may decrease downside risk, especially in the late finisher).

### **Increase the Weight Discount Window**

For the reasons discussed in the first section of this paper, narrow packer weight windows are one of the biggest limitations to profitability for producers marketing pigs in the Canadian packing system and with some U.S. packers. Wide weight windows encourage heavier market pigs and improved facility utilization. Some producers in the U.S. also have the opportunity to market to multiple packers to sell light pigs to a packer that desires light weights and heavy pigs to a packer that rewards for heavy weights. What are the options for increasing your sort

window? Similar to some of our producers, you are left with only a few options, such as owning your own processing plant, negotiating a wider sort window in a packer contract, or selling to multiple packers (i.e. sending heavy weight pigs to a U.S. packer with those specifications). The cost of a narrow sort window is too great for the industry to ignore.

In summary of this section, the most effective methods to manage variation in weight gain are to have a wide sort window and to increase weight gain of all the pigs in the barn (health, energy, lysine, increased weaning age).

## **DESIGNING A SYSTEM WITH REDUCING VARIATION IN MIND**

If the coefficient of variation (CV) for market weight is already below 10 to 12% in your system, you will be frustrated in your attempts to further reduce variation. Real reductions in variation can be achieved, especially if current CV is above 12%; however, in most situations they require major changes to the production system. Systems must be designed from the outset to be low variation systems in order to achieve the greatest and longest lasting improvement in this area. Many of the design factors require critical mass to implement. If you don't have large enough sow farms, it is difficult to implement technologies, such as segregated parity production or split sex housing; however, other technologies, such as increased weaning age can be effectively implemented with all size farms.

### **Segregated Parity Flow**

Having the offspring of gilts reared separately from the offspring of sows will reduce variation. The offspring from the gilts will grow faster when reared separately than when reared with offspring from multiple parity sows. The advantages are thought to be due to improvement in health status of pigs within both groups (Moore, 2003).

### **High-Health Systems**

Although "high-health systems" is a nebulous term, it is meant to encompass the many factors that improve the health status of pigs within a group. Schinckel et al. (2002) has demonstrated that pigs reared in an all-in, all-out manner have less variation in growth rate and market weight than pigs reared in a continuous flow manner. The CV for the all-in, all-out pigs was 7.5% compared to 8.8% for the continuous flow pigs. Other system design factors that can lead to sustained improvements in health status, such as reduction in sources of pigs, location of the source herd, and location of the growing barns themselves, would be expected to also reduce variation in weight gain.

Because health status has a profound impact on weight variation at market, prompt treatment of clinical bacterial disease with injectable antibiotics can reduce variation. Promptly treating clinical disease to enhance recovery and reduce spread of the bacteria within the group will reduce the number of light weight pigs at market and, thus, reduce variation.

## Split-Sex Housing

Simply put, raising the gilts separate from the barrows will reduce the variation in weight gain in the group, simply because the barrows grow faster than the gilts. Although simple in concept, the production system must be large enough to fill a barn or site with one sex within a reasonable amount of time. Filling a site or barn over multiple weeks or from multiple sources enters other large sources of variation (variation in weaning age and health status) that may overwhelm any advantage of single sex housing.

## Increase Weaning Age and Reducing Variation in Weaning Age

Main et al. (2004) demonstrated the impact of weaning age on pig weight and the variation in pig weight at the end of the nursery and finishing stages (Table 1). This data indicates that variation in weaning age is one of the biggest drivers of variation in final market weight in swine farms. From this dataset, the percentage of pigs in each weight category at the end of the experiment (d 156 after weaning) can be calculated (Figure 4).

**Table 1. Influence of weaning age on weight and variation in pig weight<sup>a</sup>**

Item	Weaning age, d			
	12	15	18	21
Wt at 42 d postweaning, kg	16.9	20.3	22.6	25.8
CV of wt at 42 d postweaning, %	20.0	15.6	14.4	12.9
Wt at 156 d postweaning, lb	103.9	109.1	112.0	117.3
CV of wt at 156 d postweaning, %	12.4	10.4	10.4	9.0

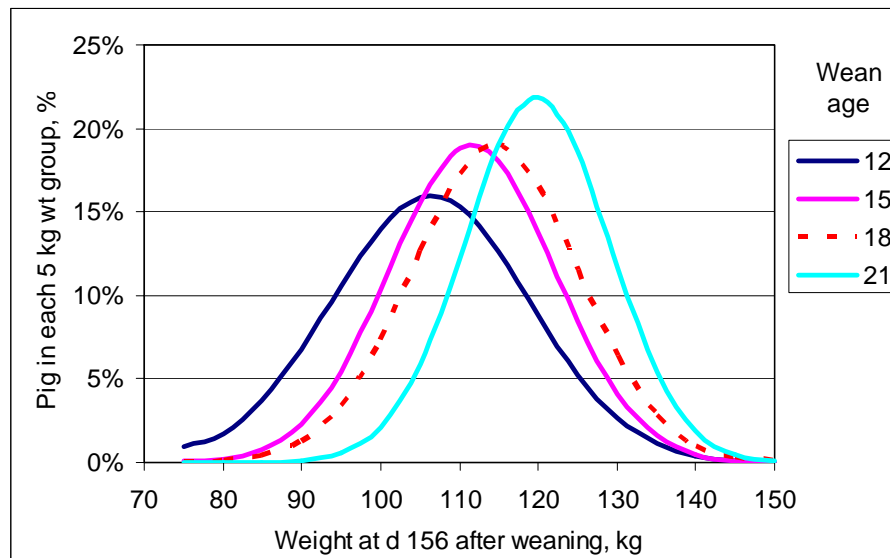
<sup>a</sup>Main et al., 2004

The data in Table 1 demonstrate the impact of weaning age when pigs are weaned within a day of age of each other. If age at weaning is highly variable, variation in market weight is further increased because the younger pigs grow slower than older pigs. Thus, if pigs are weaned over a seven day period, final market weight will encompass the variation caused by having younger pigs in the group and the variation in weight gain around each age group.

Reducing the variation in weaning age requires weaning multiple times per week. The number of weaning events per week is often limited by the system design, transport, or health protocols; however, it is often possible to increase weaning age by one to three days without any facility changes. Many of our production systems have increased farrowing capacity to increase average weaning age. The payback for adding marginal farrowing crates can be quite large. For example, adding the equivalent of one half of one weeks worth of farrowing capacity will allow you to increase the weaning age of all pigs on the farm by three days. Thus, the payback from the investment comes from all pigs weaned rather than just the pigs weaned from the added crates. Certainly, another way to increase weaning age is to increase the number of days farrowing crates contain lactating sows by increasing the date of gestation sows are moved into the farrowing room and reducing the time it takes to clean the room after weaning. Limiting bump weaning (weaning the largest pigs in the litter at a younger age) can

reduce weight variation at weaning, but has not been proven to effectively reduce variation at market. The weaning age of Main et al., (2004) indicates that early weaning of the biggest pigs may actually contribute to increased weight variation at market.

**Figure 4. Distribution in pig weight at 156 d after weaning (adapted from Main et al., 2004).**

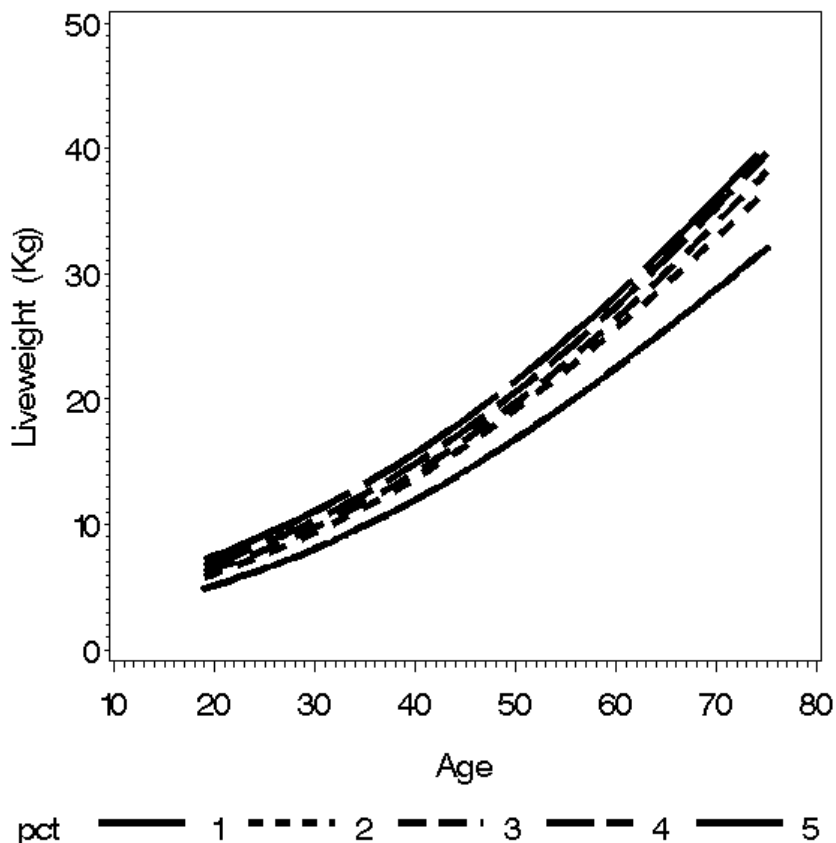


### Use of Opportunity Barns

Opportunity barns are used within some production systems to separate the smallest pigs (5 to 25% of pigs depending on the system) from the remaining pigs and rear them separately. In some systems, the pigs are reared on entirely different nursery sites and flow through different finishing sites. In other systems, pigs are simply separated into a different barn or room within the barn in the nursery stage and then moved to a separate finishing site. Management of the smallest pigs in these opportunity barns also varies across systems. Some systems provide supplemental milk replacer or special diets in an attempt to “normalize” growth rate. Other systems simply separate the pigs and treat them similarly to the other pigs, accepting that they will be slower growing and simply need additional days to reach market weight. The net result is variation in the original weaning group is not reduced, but variation within the production unit (barn or site) is reduced by removing the smallest pigs from the group.

Schinckel et al. (2004) demonstrated that the smallest 20% of the pigs at birth grow significantly slower after weaning and are responsible for a majority of the variation in pig weight at various ages after weaning (Figure 5). Thus, use of opportunity barns can effectively remove these slower growing pigs from the system. Again, the system must be large enough and designed with opportunity barns in mind to be able to take advantage of this method of reducing variation.

**Figure 5.** Relationship between body weight and age for five percentile groups of pigs based on birth weight (Schinckel et al., 2004). Note that the lowest 20% of birth weight pigs continue to deviate from the weight of the other pigs with increasing time after weaning.



### Increase Weight Gain of the Smallest Pigs in the Group

There are several procedures that can be used to increase the weight gain of the smaller pigs in the group in an attempt to reduce variation. These include: split suckling, use of complex nursery diets, use of supplemental milk, or shifting the smallest pigs to higher producing sows. These technologies all have been proven to slightly increase the weight gain of the small pigs and thus, they can reduce variation at market weight. However, the impacts are all relatively small and thus, the economic payback is small to nonexistent.

Donovan and Dritz (2000) demonstrated that split-nursing (allowing the smallest 50% of pigs access to the sow for 2 h within 24 h after farrowing) reduced variation in ADG and, thus, numerically reduced the variation in weaning weight. However, the impact is relatively small (about 2% lower CV). Wolter et al. (2002) found that offering milk replacer in the farrowing house can effectively increase weaning weight by approximately 0.9 kg/pig during hot weather. However, the difference did not increase during the nursery or finishing stage. Thus, the 0.9 kg advantage at weaning remains at market, but it must pay for the entire cost of the milk replacer. Similarly, trials with complex nursery diets have demonstrated increased

weight gain in the nursery. Although data has not been entirely consistent, the advantage often does not become larger during the finishing stage. In any event, these changes in pig weight are relatively small compared to the differences caused by weaning age, sex, or health status.

### **Selecting Sires with Similar Indexes**

Reducing variation by selecting sires with similar indexes or by using fewer sires also has been cited as a method to reduce variation in weight at market. Although this is outside my area of expertise, Dr. Allan Schinckel indicated that sires only account for about 1/4 of genetic variance. Selecting sires with similar ADG EBV's with accuracy of .5 will cause CV to be reduced to 96.875% of original. Thus, if market weight CV was 12% originally, it could be reduced to 11.625%. Thus, 95% of pigs with a mean weight of 260 lb would be in a market weight range of 199.6 to 320.5 instead of the original range of 197.6 to 322.4. Again, selecting boars with similar indexes is a means of reducing variation; however, the change will be relatively small. Creating all half sibs by using only using one sire would only reduce market weight CV to 96.25% of the original CV. Using full sibs (via embryo transfer or using cloned females and only one male) would reduce the CV to 92.5% of the original CV. Because of the high impact of environment on variation, even using clones will only reduce the CV to 83.5% of the original CV.

### **Feeding Multiple Diets within a Group**

Dividing a group of pigs based on sex in order to feed higher amino acid levels to the gilts has been practiced in the industry for some time. We hypothesized that dividing the group based on weight in order to feed the lighter pigs a higher energy diet may be more useful to reduce variation in market weight. Hastad et al. (2005) conducted two studies to test this concept. They divided the group of pigs into light, heavy or mixed weight groups at entry to the finishing barn and fed diets with either 0 or 6% added fat. Results from one of the experiments are shown in Table 2. For the overall trial, there were no fat  $\times$  initial sort category interactions. Pigs fed 6% added fat had greater ADG; however, there was no difference in CV for ADG during the overall study. For initial sort category, regardless of diet, heavy pigs grew faster than either the light or mixed pigs. Although no interactions existed for growth or carcass data, there was a fat  $\times$  weight category interaction for the financial response of margin over feed cost. Heavy pigs in both studies had greater margin over feed than either light or mixed pigs; however, when comparing 0 and 6% added fat within initial sort category, the increase in margin over feed was greater for light pigs fed added fat than heavy pigs fed added fat. These studies indicate that because adding fat to the diets of lighter weight pigs improves their growth rate, dietary fat can be used selectively in the barn to increase the weight of the lightest 50% of the pigs.

Feeding two diets to offer higher amino acid levels to the lighter pigs in the group is often cited as a possible means of increasing weight gain of the smaller pigs. In reality, the lightest pigs in the group may not actually have a higher amino acid requirement than the heavy pigs in the group. Weight doesn't accurately depict the pig's amino acid requirements within a population. Rate of protein accretion and feed intake are the major determinants of amino acid requirements. Therefore, the heavier, faster growing pigs may actually have a higher amino

acid requirement because they have higher protein deposition even though they consume more feed. With current knowledge, we formulate diets for the light and heavy groups to have similar amino acid:calorie ratios based on their average weight.

The importance of water intake also should be considered. Providing adequate water access has been shown to reduce variation as compared to insufficient water access (Dewey et al., 2001).

**Table 2. Effects of added fat and initial sort on weight variation, carcass traits, and economic value in grow-finish pigs (Hastad et al., 2005)<sup>a</sup>**

								Main effect <i>P</i> -value		
Added fat:		No fat			6% added fat			Fat	Heavy	Sorted <sup>b</sup>
Item	Wt group:	Heavy	Light	Mixed	Heavy	Light	Mixed		vs. light	vs. mixed
D 0 to 95										
ADG, kg		0.88	0.85	0.87	0.91	0.89	0.90	0.01	0.02	0.91
ADFI, kg		2.70	2.28	2.46	2.51	2.09	2.27	0.01	0.01	0.25
Feed/gain		2.78	2.63	2.70	2.44	2.33	2.38	0.01	0.01	0.68
Pig weight, kg										
D 0		37.7	32.5	35.3	37.6	32.6	35.1	0.83	0.01	0.87
D 95		121.2	113.6	117.5	123.0	117.0	119.9	0.01	0.01	0.97
Pig weight, CV										
D 0		9.33	12.56	15.85	9.99	12.08	15.88	0.91	0.01	0.01
D 95		7.23	9.78	9.78	7.47	8.67	9.65	0.41	0.01	0.01
Economic value										
Feed cost, \$/kg gain		0.36	0.34	0.35	0.37	0.35	0.36	0.03	0.01	0.82
Sort discount, \$/pig		-2.83	-2.13	-2.71	-3.87	-1.66	-3.72	0.26	0.03	0.23
Margin over feed, \$/pig <sup>c</sup>		96.69	88.53	92.56	95.88	91.72	92.29	0.25	0.01	0.23

<sup>a</sup> A total of 1,176 gilts (28 pigs per pen and seven pens per treatment) with an initial average weight of 35.1 kg.

<sup>b</sup> Sorted vs. mixed is the average of the light and heavy pigs compared with the mixed pigs.

<sup>c</sup> Margin Over Feed was calculated with corn at \$0.85/kg, soybean meal at \$0.205/kg, fat at \$0.294/kg, and carcass base price at \$1.00/kg.

Because the response to Paylean is consistent for different weight pigs, Paylean can also be used to increase the growth rate of the lightest pigs in the group to make them grow similar to the heaviest pigs. The difference between Paylean and increased diet energy density is that feeding Paylean is often economical regardless of whether the weight gain is needed or not. The economic value to Paylean is much greater in pigs that require the extra weight gain; however, the improvements in feed efficiency and carcass parameters (loin depth and yield) usually make it economical in heavy pigs also. Thus, if Paylean was only used in the light pigs in the group, the potential increase in profit on the heavy pigs would be lost.

## REDUCING VARIATION IN WEIGHTS AT BIRTH

Total and live born litter size has been increasing dramatically in the last six to seven years. The rate of progress since 2000 has been approximately 0.2 pigs/litter each year. This dramatic increase in litter size has been accomplished through the application of genetic improvement focusing on ovulation rate (Foxcroft & Town, 2004). Unfortunately, an increased number of stillborns and lower pig birth weights have been observed along with the increased litter size.

Many factors affect fetal growth and development including sow ovulation rate, uterine capacity, genotype, nutrition, and feeding regimens. Researchers are beginning to understand that uterine capacity, which determines the number of fetuses maintained during pregnancy (Vallet et al., 2003) is one of the greatest limitations to litter size (Ford, 1997; Foxcroft & Town, 2004). Litter weight is directly related to litter size. Pigs from large litters have lighter fetuses at term because of the decreased placental surface area (Père et al., 1997). Additionally, mobilization of energy substrates increases in sows with larger litters. Glucose is a major energy substrate for fetuses and has been shown to decrease in sows with large litters (Père, 1995) due to the high energy requirement for the uterus and fetuses.

Two ways to solve the problem of variability in piglet weight at birth would be to either solve it genetically (ex. moderate ovulation rate with high embryonic survival to reduce light weight fetuses) or by increasing nutrient availability to the lightest fetuses to increase their size. Research has shown secondary muscle fiber development, which is an important determinant of postnatal growth, can be improved by increasing maternal feed intake during d 25 to 50 of gestation (Dwyer et al., 1993 and 1994; Bee, 2004) or after d 70 of gestation (McPherson et al., 2004). But, high energy intake during gestation results in greater expense, decreased feed intake during lactation, and impairment of mammary gland development. Additionally, the high intake in gestation doesn't always increase birth weight, secondary muscle fiber number or carcass parameters (Musser et al., 2006).

The addition of L-carnitine, a water-soluble vitamin-like compound, to gestation diets has demonstrated increased litter weights at birth and weaning (Musser et al., 1999). During gestation, the addition of 50 ppm (100 mg/d; d 5 to 112) of L-carnitine increased sow body weight gain and last rib fat depth. In addition, sows fed supplemental L-carnitine had increased total litter (34.2 vs. 32.2 lb) and pig (3.4 vs. 3.2 lb) birth weight, increased litter weaning weight (99.2 lb vs. 91.1 lb; Musser et al., 1999), and increased fetal number (Waylan et al., 2005). Other researchers have observed similar results with increased sow weight gain and improved average fetal weight at d 70 of gestation in sows fed supplemental L-carnitine (Brown et al., 2005).

In addition to increased birth and weaning weights, researchers have observed an increase in the cross-sectional area and more total muscle fiber numbers in the semitendinosus muscle in pigs from sows fed supplemental L-carnitine (Musser et al., 2001). Specific growth factors, such as insulin-like growth factor I (IGF-I), insulin-like growth factor II (IGF-II), insulin-like growth factor binding protein-3 (IGFBP-3) and insulin-like growth factor binding protein-5 (IGFBP-5) have been shown to have promoting proliferative and differentiation effects on the



muscle cells of pigs (Hembree et al., 1996; Johnson et al., 1999). Researchers have shown the addition of L-carnitine lowers the expression of IGF-II and numerically increases the expression of IGF-I in porcine embryonic myoblasts or muscle cells (PEM; Waylan et al., 2005). Insulin-like growth factor-I has potent proliferative effects on PEM. This means the muscle cells keep multiplying when this growth factor is present. Insulin-like growth factor-II induces the expression of another gene, myogenin, which promotes the muscle cells to stop their proliferative capacity and differentiate into mature muscle fibers (Florini et al., 1991). Therefore, the increase in IGF-I and decrease in IGF-II due to supplementing the sow L-carnitine is allowing more muscle fiber cells to be developed, which increases birth weight. This research is supported by decreased levels of circulating IGF-II levels in fetuses at d 70 gestation (Brown et al., 2005). The significant changes in gene expression due to supplementing the sow L-carnitine is involved in the regulation of muscle fiber development of the fetus and improved pig and litter weight at birth.

Genetic improvement for selection of increased ovulation rate has increased sow litter size, but a decrease in pig weight at birth has been observed. Many factors may affect this including uterine capacity, genotype, nutrition, and feeding regimens. The addition of nutrient compounds, like L-carnitine, may be an option to improve pig and litter weights and to decrease the number of lightweight pigs at birth.

## **METHODS THAT REDUCE VISUAL VARIATION BUT COST PRODUCTIVITY**

Over time, producers have instituted various strategies to attempt to reduce variation in pigs within a group. The attempts have focused on reducing visual variation within the point of reference (i.e., litter or pen of pigs) without full knowledge of how these efforts impact variation of the overall group (i.e., weaning group or barn). The two most common strategies that fit this description are sorting by size in the nursery or finisher and aggressive cross-fostering in the farrowing house.

### **Sorting into the Nursery or Finisher**

Sorting pigs to create a pen of pigs with similar weights will reduce the variation within the pen at placement; however, several experiments have demonstrated that sorting reduces ADG without a reduction in variation (Gonyou et al., 1986; O'Quinn et al., 2001).

### **Continual Cross-Fostering in the Farrowing House**

Continual movement of pigs in the farrowing house is another practice used within the farm to reduce variation within the subgroup (litter). At least two experiments have demonstrated that the aggressive cross-fostering will reduce the variation within the litter. However, growth rate of the entire farrowing group is reduced (Milligan et al., 2001). Therefore, the reduction in variation appears to be because of reducing growth rate of the fastest growing pigs, rather than increasing growth rate of the smallest pigs in the litter. Thus, there is not a net benefit of improving facility utilization because the growth rate of the smallest pigs has not been improved.

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# **HANDLING DISEASE CHALLENGES**



# **PRINCIPLES OF HEALTH MANAGEMENT**

**François Cardinal, DVM, M.Sc.**  
**Les Consultants Avi-Porc**  
**1320 Boul. Jean de Brebeuf, Drummondville, Quebec J2B 4T6**  
**E-mail: francoiscardinal@sympatico.ca**

## **ABSTRACT**

The goal of this paper is to provide producers with a road map to limit the impact of diseases in swine herds. A good knowledge of key information on diseases and on how to accurately diagnose them at the farm level is the starting point for success. Table 1 summarizes some of the basic information on three major infectious agents: PRRS virus, *Mycoplasma hyopneumoniae* and porcine circovirus type 2 (PCV2). Also, to limit as much as possible the frustration and losses associated with re-breaks, regularly updated biosecurity measures should be established and observed. Air filtration will soon be part of a good biosecurity program even in commercial farms. Table 2 describes the basic elements of a sound biosecurity program for a commercial farrow-to-finish farm or a sow unit. The choice of the replacement stock health status (Table 3) and the proper acclimatization of animals to be introduced are also major concerns. Finally, management rules that can help to limit the transmission of diseases or improve the pig's natural defenses are good complementary tools to vaccination and strategic medication programs. Table 4 shows examples of such rules for PCVAD and PRRS.

## **INTRODUCTION**

In the past 30 years, the swine industry has seen many new diseases causing significant problems: porcine pleuropneumonia, swine influenza, PRRS and more recently PCVAD. It is more and more complex to raise healthy pigs. Also, health concerns are taking a growing share of the pig production cost which may affect our competitiveness on the export market.

The goal of this paper is to give pork producers a road map to limit the impact of diseases in a herd or system. Sometimes in this quickly changing world we have to stop, and reevaluate whether or not we are on the right path. So I will use a "back to the basics" approach to address this goal.

Four principles, or themes will be reviewed and commented on.

## **FIRST PRINCIPLE: KNOW YOUR OPPONENT**

Before trying to control diseases at the farm level, it is very important to get information about what we really have to fight. Understanding how a specific pathogen can spread, infect pigs, replicate and for how long are examples of the type of information needed. The more is

known about a disease, the better are the chances that this disease will be kept under control at a relatively low cost. Table 1 shows some basic information on three major infectious agents: PRRS virus, *Mycoplasma hyopneumoniae* and PCV2. The information in this table should not be used as definitive, carved in stone data. Indeed, many factors may interact with field situations that can result in potential timeline changes. Furthermore, what is found to be true today may not be exactly the same tomorrow. Veterinary medicine, just as human medicine, is not a static science. However, one needs to start somewhere and the data used in the table are quite representative of those that are reported in the scientific literature. These data can be useful in taking decisions on what health protocols to choose for a farm.

One should remember that we manage herds and not individuals, so the data presented here should be interpreted accordingly. For example, if a sow herd becomes affected by a new strain of PRRS virus and the idea is to get rid of it, the introduction of replacement gilts should theoretically be stopped for at least 100 days after the last sow was infected by the virus, and not 100 days after the beginning of clinical signs in the herd. I say theoretically because, as discussed later in the document, there is often a difference between the longest time that an animal can be carrier of an organism, and the longest time it can shed it.

Knowing the theory surrounding important infectious agents is not enough. One also has to know what's going on with them in the herd on a real-time basis. Specific and pointed diagnostic and serological monitoring programs are useful tools to follow these agents in a herd. It may allow the prediction of an outbreak long enough in advance to avoid it. Also, it can be used to record the efficacy of intervention strategies or the possible source of contamination if contamination was to occur. On the other hand, profiling herds without any specific goal may be a loss of money. I recommend an investment in diagnostic techniques only if they answer a specific question and if an action to be taken depends on the results. I don't carry out serological profiling "just to know".

## **SECOND PRINCIPLE: KEEP NEW BUGS AWAY**

Biosecurity measures will always remain a fundamental part of a pig farm health program. Indeed, it is a loss of time and money to try controlling or eradicating diseases from a herd if this herd is continuously exposed to exogenous infectious agents. It is like baling out water from a cracked boat.

There is virtually no limit to what could be done in biosecurity. It is easy to do too much in situations where there is a low probability risk, and the opposite is also true. Doing too much needlessly increases production costs and neglecting some aspects may result in an expensive outbreak.

I describe in Table 2 the basic elements of a biosecurity program that I recommend for a commercial farrow-to-finish farm or a sow unit.



**Table 1. Important information to know about PRRS virus, *Mycoplasma hyopneumoniae* and PCV2.**

	PRRS virus	<i>M. hyopneumoniae</i>	PCV2
Incubation time	3 days and over	2 weeks and over	2 weeks and over
Infection source	Direct contact, nasal secretions, saliva, urine, feces, milk, semen, blood, aerosol, transplacental, fomites	Direct contact, aerosol, nasal secretion, possibly fomites	Direct contact, nasal secretions, saliva, urine, feces, milk, blood, semen <sup>(1)</sup> , transplacental, fomites, possibly aerosol
Shedding period	99 days	200 days	42 days <sup>(2)</sup>
Survival outside the host	<ul style="list-style-type: none"> <li>○ Less than 24 hours at 25°C on solid material</li> <li>○ 9 to 11 days in water at 25°C</li> <li>○ 8 days in lagoon water at 4°C</li> <li>○ for months at minus 25°C</li> </ul>	<ul style="list-style-type: none"> <li>○ In liquid medium, 31 days at room temperature</li> <li>○ At refrigerator temperature, 100 days</li> <li>○ Survival increase with moisture and coldness</li> </ul>	Very resistant in environment and to disinfectants
Other particularities	<p>Partial and variable crossprotection between isolates</p> <p>Frequent genetic changes with this virus</p> <p>Fetuses are most susceptible to active infection after 60 days of conception and may become carriers until at least 150 days of age.</p>	Antibiotics may stop growth of the organism but will usually not kill it	<p>Genetic susceptibility / resistance of the host</p> <p>Triggering factors (other agent or factor) may play a role</p> <p>The virus is present everywhere but virulence may be different between strains</p> <p>Piglets may be born with the virus and become seeders of the virus</p>

<sup>(1)</sup> The virus can be found in semen, but the importance of semen in the diffusion of the organism is still debated.

<sup>(2)</sup> For PCV2, very few studies have looked at how long an infected animal can shed the virus. It is very likely longer than 42 days, and possibly much longer.

**Table 2. Basic elements of a biosecurity program for a commercial farrow-to-finish farm or a sow unit.**

Gilts source	TGE, <i>A.pleuropneumoniae</i> and mange negative. PRRS negative or at least non-shedding. <i>Mycoplasma</i> negative if the herd is negative only. Non-shedding flu and non-clinical PCVAD. Site of gilt production should be at least 3 km away from any other swine facilities.
Semen source	PRRS and TGE negative. Unit under air filtration or at least 3 km away from any other swine facilities.
Quarantine	For at least 4 weeks before entering the herd. Separate building than the main unit but not too far since we don't want to be closer to another pig farm or to have to truck the gilts again.
Transport	Transport pigs in cleaned trucks (washed, disinfected, dried). Never allow a truck containing pigs from another site to get close to the farm.
Air filtration	Mechanical air filtration will be a must in the very near future in high pig density regions
Carcass disposal	Compost or incineration
Visitors	Ask for washing hands; provide boots and clothes belonging to the farm. Do not allow entering tools or materials that have been in contact with pigs or pig manure.

A common mistake is to reduce the importance of biosecurity measures in PRRS positive farms because they are already contaminated. It is true that introducing a new PRRS strain or isolate may possibly not cause as severe an outbreak as it could in a naïve herd, but since the crossprotection between isolates is incomplete, a new PRRS isolate should be considered like a new bug. Therefore, there is no reason for positive farms to minimize biosecurity protocols.

### THIRD PRINCIPLE: MANAGEMENT OF REPLACEMENT ANIMALS

A lot of disease problems in our herds are the consequence of an infection pressure that is too high. This means that there is a large quantity of certain infectious agents in the environment. At some point the animals are not able to cope with this overload and they contract diseases.

One way to reduce the infectious pressure in a herd is to reduce the transmission of pathogens by the dams. This will be the case if the sows have overcome the disease and have a good immunity. Gilts are the most at risk of not having completely overcome the disease or of not having a good enough immunity. That is the reason why gilts should be properly acclimatized for the infectious agents of the receiving herd. This should be done as quickly as possible in order to maximize the chance that they will not be carriers of the infectious agents causing these diseases at farrowing. Even very clean herds may take advantage of entering gilts at a younger age. For example, *Streptococcus suis* and *Haemophilus parasuis* (Glasser's disease) are common bacteria even in these herds and there are multiple different strains. Therefore, exposing young gilts to the strains circulating in the herd may reduce the amount of bacteria and improve the immunity these gilts will transmit to their progeny.

Another possibility is to produce gilts at the farm and to close the herd. It is making sense for health concerns but has the disadvantage of making genetic improvement slower and more complex. At least, this option should be considered at some point for a limited period of time when diseases are not under control in a herd.

Also, the health status of the gilt producing herd may have an impact on the results that can be achieved (Table 3). For *Mycoplasma* positive herds, it may be profitable to purchase gilts from a positive herd. Gilts coming from this herd will not need acclimatization for *Mycoplasma* because they were already exposed, and thus immune. This way of thinking is unfortunately not as true for PRRS and swine influenza, since in their case the variations between strains can pose a problem. If gilts introduced in a given herd are infected with a PRRS strain that is very different than the one(s) present in the herd receiving these gilts, they may not be adequately protected. Besides the gilts may themselves be responsible for an outbreak in the receiving herd, because this herd is not totally immune to the strain that the gilts are shedding. Knowing if a gilt is infected or not with a PRRS strain at the time of introduction (in isolation) can be done much more easily if the gilt comes from a negative herd than if it comes from a positive herd. For this reason, even though previous PRRS virus exposure may facilitate acclimatization, I always favor a PRRS negative gilt source even for positive sow herds except in very specific situations.

**Table 3. Desired health status of the gilts entering a sow herd.**

	Positive destination herd	Negative destination herd
PRRS	Negative or non-shedding	Negative
Myco	Positive or Negative	Negative
Swine influenza	Non-shedding or Negative	Negative

The acclimatization protocols must be designed according to the diseases that we have to deal with in a given herd. It is not the facilities or any other part of the system that should dictate how gilts are acclimatized, but the opposite: we have to adapt our barns and our way of working to the needs of the acclimatization. For instance, we know that some animals may be carriers of *Mycoplasma* for at least 6 or 7 months, and possibly more. If we want gilts to farrow when they have cleared the infection and allow for some safety margin, we must expose them to *Mycoplasma* no later than at 1 month of age, and make sure that we are not covering them for long periods of time with therapeutic levels of antibiotics. This antibiotic coverage could delay the time that the organism would cause the disease and the immune system would get rid of the *Mycoplasma* organism. Another way of thinking would be to only introduce them in the herd at least 60 days after their second mating (parity 2 sows).

For PRRS virus, we have seen that, to date, the longest period of time where infected pigs were able to infect negative pigs placed in contact with them is 99 days. You thus have to allow more than 99 days after exposure before thinking that the gilts may not be contagious anymore. With some safety margin, most of the programs allow 120 days, which means only 3 gilts introductions per year. This can be achieved by purchasing gilts of different weights (5

to 75 kg) and ages (1 to 5 months) and operating the facility all-in all-out. Gilts are exposed in the first week using frozen or fresh serum/material from the farm. Other vaccinations or microbial exposure may take place later in this period. Gilts can be inseminated on site when they reach the desired weight and age. When the room is emptied, some gilts may be transferred directly into the farrowing crates.

A simpler protocol for PRRS virus may be to only enter 5 kg gilts and allow them to grow in the same pens as the commercial pigs. However, with this protocol the date of the PRRS virus exposure often remains unknown and sometimes exposure does not occur at all, or occurs too late. Consequently, some gilts may either be non immune to the resident virus, or actively shedding the organism at the time of introduction into the main herd. Non immune gilts that get exposed to the virus during gestation may infect their fetuses, and these pigs can be a source of virus once they are born. On the other side, gilts that are actively shedding the virus at the time of introduction into the main herd could destabilize the herd and create problems.

#### **FOURTH PRINCIPLE: GOOD HUSBANDRY**

Management will always have an impact on disease expression. It is true for all diseases but it was particularly striking for PCVAD, before vaccines became available, since it was one of the only tools to work on disease prevention.

Some management parameters like water, air and feed quality may compromise the animal resistance to diseases if they are not appropriate. Some husbandry rules can also favor virus and bacteria transmission between pigs or have a negative impact on natural defenses of the pigs against diseases. Again, a general knowledge of diseases should dictate how we manage our herds instead of relying on historical ways of raising pigs. In today's world, multiple diseases challenge many pig farms. The effect of these diseases can not only be cumulative, but synergic, which is increasing even more the pressure on the system. Pig farms may not afford for a long time to spend money solely on vaccines and medications for all these diseases. A good complementary or alternative tool can be found in what I call "dedicated management". Dedicated management is a management strategy that is designed to control, reduce or prevent a specific disease. This strategy has a cost or implies a reduction in some zootechnical parameters (ex: weaned/sow/year), but this cost is considered like an investment at the same level as a vaccine. Some of these strategies may give huge benefits because they improve the situation for many diseases at the same time.

Table 4 shows examples of dedicated management for PCVAD and PRRS.

Using these management rules, some herds have completely controlled PCVAD without any PCV2 vaccines. The age at slaughter was reduced by more than 7 days and feed conversion improved a lot. The associated costs are an increased usage of needles and milk replacer, and a deterioration of the pre-weaning mortality (2 to 3%). It should be kept in mind however that the impact of applying such management rules can vary from one farm to another.

**Table 4. Dedicated management strategies to control or reduce the impact of PCVAD and PRRS.**

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AIAO strictly applied in farrowing rooms, nursery and finisher

- Washing/disinfecting/drying between batches
- Consider batch farrowing to facilitate AIAO

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Hygiene

- Disinfectants: Virkon or Quat + Glutharaldehyde combination (PF-300, Aseptol-2000, Virocid, Vexkill-100)
- Wash boots at the end of the day with a brush and disinfect in a bath of disinfectant (new disinfectant solution made every day)
- Scrape sow's manure each day in farrowing room with a shovel: 1 shovel per room.

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0 to 3 day old piglets

- When possible, only handle piglets on the day of birth to ensure that they receive colostrum. Leave all other procedures until processing time (3 days of age).
- Identify piglets seen to receive colostrum. Use a stomach tube for those which are not seen to receive colostrum.
- Make sure the environmental temperature is within the piglets comfort zone (31-35 Celsius)
- Stop clipping teeth.
- Even out litter size the day of birth. Aim to have an average of 11.5/litter throughout the room. Euthanize the smallest pigs to arrive at 11.5 piglets/sow.

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Fostering

- Stop all fostering
- Only allow swapping on the day of birth, but do as little as possible. Objective: Less than 25 % piglets exchanged. Piglets sucking foster mothers should not come from more than 3 separate litters, ideally 2.
- The sows and litters must not change rooms under any circumstance. One exception: a weaned sow can be used as a nurse-on mother to replace a dead or completely dried up sow with less than 3 kg piglets.
- If there are very small piglets in the litter, or very large litters (13 piglets or more), place milk replacer in the crate.
- Inspect all litters at day 7, and euthanize piglets weighing less than 1.7 kg.

---

Early Weaning (weaning of piglets at a younger age than their brothers and sisters)

- Stop early weaning, if it is done, these pigs should then be moved to the nursery when cohorts are moved. Move all young pigs into the same nursery pen.
- 

... continued on next page

#### Aborted or Premature births (4 days or more)

- Do not try to save the piglets. Euthanize them as soon as they are born. Take care not to contaminate other piglets or the installation with their blood.
- These sows cannot be used to nurse litters. Pass the first heat before rebreeding or culling.

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#### Litter Integrity

- Whenever possible, wean intact litters into nursery pens (1 pen per litter or two litters). Keep these pigs together until slaughter.

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#### Needles

- Sows and Boars: discard after one injection. This includes oxytocin or prostaglandin injections, vaccinations and antibiotics.
- Piglets: discard after each litter or pen, or before drawing up more product with a conventional syringe.

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#### Castration Pliers

- Wash and heat (propane burner) between litters when castrating and docking tails.

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#### Piglet Carts

- Use as little as possible.
  - Wash and disinfect after using.
- 

## CONCLUSIONS

Controlling diseases in a swine herd may be a hard task. A good knowledge of key information on diseases and of how to accurately diagnose diseases at the farm level is the starting point for success. Also, to avoid the frustration and losses associated with disease breaks, adequate biosecurity measures have to be established, observed and regularly updated. Air filtration will soon be part of a good biosecurity program even in commercial farms. The choice of the replacement stock health status and the acclimatization of these new animals are also major concerns. Finally, management rules dedicated to limit disease transmission or to improve the natural defenses of the pigs are good complementary tools to vaccination and strategic medication programs.

## ACKNOWLEDGEMENTS

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# **FORGOTTEN DISEASES**

**Bob Friendship**  
**Department of Population Medicine**  
**University of Guelph**  
**Guelph, Ontario N1G 2W1**  
**Email: rfriends@uoguelph.ca**

## **ABSTRACT**

There are other diseases besides PRRS and PCVAD that need to be given some attention. The common but less dramatic diseases that result in reduced growth and poor feed efficiency are still with us and can have a significant impact on profitability. Examples of these diseases that tend to fly under the radar screen include coccidiosis, porcine proliferative enteropathy, and swine influenza. There are other diseases that may not have a direct impact on pig performance but are important to the swine industry because they potentially have public health implications and therefore it is important for producers to be aware of these pathogens. Among the many organisms that have zoonotic potential, *Salmonella* are probably the bacteria that pose the greatest problem for the Canadian swine industry, but there are others that we need to study and monitor.

## **INTRODUCTION**

In the past two years the Ontario swine industry has struggled with two major health challenges: Porcine Respiratory and Respiratory Syndrome (PRRS) and Porcine Circovirus Associated Disease (PCVAD). Understandably, producer and veterinary meetings have had little room on the agenda for other disease issues, and so one could be excused for believing that all the other diseases somehow disappeared. The purpose of this presentation is to remind everyone that there are other health problems in addition to PRRS and PCVAD. I will outline these diseases under the categories of: production diseases, and public health concerns. In addition I will try to discuss some of the research work being conducted at the University of Guelph with regard to these health problems.

## **PRODUCTION DISEASES**

### **Reducing Stillbirths and Ensuring Adequate Colostrum**

Stillbirth levels on most farms range from half to one pig per litter representing a significant economic loss. In addition, lack of neonatal supervision can result in some of the piglets not receiving adequate colostrum. This has a major impact on piglet survival and can result in the spread of disease into the nursery from the farrowing room because of sick or carrier piglets. In an effort to improve colostrum management we have studied methods of inducing farrowing and monitored the impact of neonatal intervention. In one study we examined the

use of a half dose of prostaglandin injected into the vulval mucosa of sows and then repeated 6 hours later to consistently induce farrowing at a time when births could be supervised and piglets assisted to suckle, ensuring colostrum intake. In our research trials supervised farrowing resulted in reduced stillbirths (0.38 vs. 0.99 pigs per litter) and guaranteed all piglets in a litter were protected by receiving antibodies from their mother. We used a syringe to orally feed weak piglets with colostrum and supervised nursing. This level of care is likely needed to prevent one or two small piglets from missing out on protective colostrum and then becoming susceptible to disease at an early stage and posing a risk to all the other pigs.

## **Coccidiosis**

*Isospora suis* (coccidia) is a protozoan parasite that reproduces in cells lining the villi of the small intestine of pigs. The disease is characterized by a pasty diarrhea occurring in pigs between 1 and 3 weeks of age and is generally thought to result in reduced growth rate but low mortality. Current information on the prevalence and impact of coccidiosis in Canadian pigs is not available – the last prevalence study was carried out in the late 1970s. In most countries the only drug that has been licensed for prevention of coccidiosis in piglets is toltrazuril (Baycox) – administration of a single dose in the first week of life has been shown to be effective and may have significant economic benefits. Although toltrazuril was never licensed for use in Canada, it was commonly used under veterinary supervision with an emergency import permit. Unfortunately, in 2005, the use of the drug in pigs in Canada was banned.

As a first step in trying to convince the drug companies and the regulatory bodies that a coccidiostat for pigs is needed we conducted a study to determine the prevalence of the disease in Ontario. We visited 50 farms and gathered fecal samples from suckling piglets. We found evidence of coccidia on 75% of farms and an association between the presence of diarrhea and coccidia. Currently we are looking at potential treatment or control techniques. The impact of this disease is subtle but it likely is responsible for causing lighter weaning weights and uneven growth in the early nursery on many farms.

## **Post Weaning *E. coli* Diarrhea**

Post-weaning diarrhoea in pigs is a complex disease with multiple contributing factors. In the late 1990's an outbreak of disease occurred in Ontario characterized by sudden death and severe watery diarrhoea in newly weaned pigs. An investigation was undertaken to determine whether the disease was caused by a change in management and/or nutrition or whether *E. coli* had become more virulent. In addition a series of trials, both clinical field studies and controlled challenge studies were undertaken to determine the efficacy of various control measures. In a case-control study of 50 farms it was determined that management factors did not appear to be associated with an increased risk of disease. The most common *E. coli* isolated from cases of diarrhoea O149 F4 (STa, STb, LT) was shown to be different from the predominant strains isolated from cases a decade earlier, suggesting that the disease was in part due to a more virulent pathogen. Novel approaches to control of the disease including vaccination, egg-yolk antibody products, probiotics, essential oils and bacteriophages were



investigated. Certain of these intervention strategies showed promise in the laboratory and in controlled studies but their effectiveness under the field conditions remains in doubt.

### **“Sui-cide” Diseases (Glasser’s, Strep meningitis, APP and *Actinobacillus suis* infection)**

One aspect of PCVAD is the weakening of the immune system and consequently the emergence of disease caused by bacteria that are generally not very pathogenic. The so-called “sui-cide” diseases have become more important in herds battling PCVAD and PRRS. We have been monitoring these weaker pathogens, including *Streptococcus suis*, *Actinobacillus pleuropneumoniae*, *Actinobacillus suis*, and *Haemophilus parasuis*.

Tonsillar and nasal swabs were collected from weanling pigs in 50 representative Ontario swine herds and tested for the presence of five important bacterial upper respiratory tract pathogens. All but one herd (2%) tested positive for *Streptococcus suis*; 48% of herds were *S. suis* serovar 2, 1/2 positive. In all but 2 herds there was evidence of *Haemophilus parasuis* infection, the causative agent of Glasser’s Disease. In contrast, toxigenic strains of *Pasteurella multocida*, the cause of atrophic rhinitis, were detected in only one herd. Eighty percent of the herds were diagnosed positive for *Actinobacillus pleuropneumoniae*. Sera from finishing pigs on the same farms were also collected and tested by ELISA for the presence of *A. pleuropneumoniae* antibodies. Seventy percent of the herds tested had evidence of antibodies to *A. pleuropneumoniae* including serovars 1-9-11 (2%), 2 (4%), 3-6-8-15 (15%), 5 (6%), 4-7 (26%), and 12 (17%). This likely represents a shift from previous years when infection with *A. pleuropneumoniae* serovars 1, 5, and 7 predominated. Possibly as many as 92% of the herds tested were *Actinobacillus suis* positive; only 3 of the 50 herds were both *A. pleuropneumoniae* and *A. suis* negative. Taken together, these data suggest that over the past 10 years, there has been a shift in the presence of pathogenic bacteria carried by healthy Ontario swine with the virtual elimination of toxigenic strains of *P. multocida*, the cause of atrophic rhinitis, and a move to less virulent *A. pleuropneumoniae* serovars. As well, there appears to be an increase in prevalence of *S. suis* serovar 2, 1/2, but this may be a reflection of the use of a more sensitive detection method.

Drs. Brooks and Hayes in the Pathobiology Department and Dr. Squires from Animal and Poultry Science at Guelph are also investigating the possibility that the emergence of more serious problems with diseases such as Streptococcal meningitis or polyserositis caused by *H. parasuis* is due to genetic defects in the pig’s innate immune system. These researchers have identified specific gene defects that appear to be associated with higher morbidity and mortality. This work will hopefully progress to the point where tests will be available to identify breeding animals carrying these defects and we will be able to select for more disease resistant animals.

### **Swine Influenza**

Swine influenza viruses are common on many pig farms and contribute to respiratory disease problems and slow growth rates but are frequently ignored or under-diagnosed. Most of the interest and funding for our influenza research work in the past few years has come from the

Ontario Ministry of Health and Long Term Care because of the public health concerns associated with swine flu and avian flu. New strains of swine flu have entered Ontario.

The epidemiology of influenza in the North American swine population has changed since the emergence of a triple-reassortant H3N2 influenza virus. Although seen previously in North America, the Ontario swine population was likely free of viruses of the reassortant H3N2 lineage until 2005. We have examined the outbreak of clinical disease associated with influenza over the past few years. In total, 919 and 978 sera collected in cross-sectional studies from 46 and 49 finisher herds in 2004 and 2005 were tested by a H1N1 subtype-specific and a H3N2 subtype-specific commercial ELISA. For the H1N1 subtype, the point prevalence of positive herds (>2 reactors) was 26.1% and 36.7% in 2004 and 2005, respectively. For the H3N2 subtype the point prevalence of positive herds (>2 reactors) was 6.5% and 42.9% in 2004 and 2005, respectively. This work documented the sudden appearance and then rapid spread of the new strain of flu. Current biosecurity procedures were inadequate to prevent the movement of this virus from herd to herd in regions of dense pig production. This work also demonstrated that on some Ontario farms there are at least two separate strains of influenza virus circulating in the pig population.

## **DISEASES OF PUBLIC HEALTH CONCERN**

### **Salmonellosis**

*Salmonella* can cause diarrhea and reduced growth rate but historically salmonellosis has not been a major problem in the Ontario industry, but the prevalence of clinical disease may be increasing. More importantly, *Salmonella* is a concern from a food safety standpoint, and control and monitoring programs are being put into place in some pork exporting countries. We have tested a sample of 113 farms in Ontario over a 5-year period from 2001 to 2006, with 54 farms visited all 5 years. *Salmonella* were recovered from 60% of the herds at least once, but there were 13 farms that were tested for 5 straight years and considered negative each year. This may still be a low estimate of the prevalence of *Salmonella* positive herds because in our sampling we concentrated on examining the pigs close to market weight. In a separate study we looked at pigs of varying ages and found that the highest prevalence was generally the weanling and young growing pigs. As the pigs get older they are less likely to shed the organism. So it is possible if we repeated our survey of Ontario herds but sampled younger animals the prevalence could be higher. The most common serovar of *Salmonella* was *S. Typhimurium* and the most common phage type was DT104. This particular *Salmonella* is a major concern because it is associated with multiple antimicrobial resistance.

We have done some work at controlling *Salmonella* at the farm level. Antibiotics tend to be ineffective. All-in/all-out flow and thorough cleaning and disinfection are generally advocated but there is little evidence that they are useful. Feed does have an impact, with the use of finely ground pelleted feed being associated with more *Salmonella* and coarse feed and fermented liquid feed associated with lower levels of *Salmonella*. We have been studying a variety of alternative control measures such as acidifiers, probiotics, bacteriophages and essential oils.

## Other Diseases of Public Health Concern

We have examined fecal samples from pig farms for the presence of agents that could pose a health risk to humans. We have sporadically isolated *E. coli* O157:H7, (the bacteria associated with Walkerton) on a small number of farms and in low numbers demonstrating that it can occur but cattle remain a far greater concern. We have isolated *Yersinia enterocolitica* from about 20 % of farms during cold months, and the serotypes and biotypes of these bacteria found in pigs match closely the bacteria isolated from human cases of food poisoning. This is a relatively uncommon cause of human disease but when it occurs, pig meat is a likely source. In contrast *Campylobacter* is the most common cause of human illness associated with food contamination, and although our work shows all pigs carry *Campylobacter* the serotypes and antimicrobial resistance patterns suggest that the pig *Campylobacter* is different than the common bacteria infecting humans. Poultry is likely the primary source.

Very recently there has been a lot of press coverage regarding “superbugs”, mainly referring to bacteria in hospitals that have become resistant to almost everything because of the heavy antibiotic use and sanitation pressure. In particular Methicillin-Resistant *Staphylococcus aureus* (MRSA) has become a major concern because it is moving out of the hospitals and into the community. In the Netherlands, researchers discovered that pig farmers were 700 times more likely to carry MRSA than the general population suggesting that pigs were a source. Preliminary results of a small study we are conducting indicate that MRSA is widespread in the Ontario pig population. We will need to do further studies to determine if this finding has any significant health implications for pig farm workers.

## CONCLUSIONS

The disease picture on Ontario farms is constantly changing. As one disease disappears a new one, or possibly an old one in a new form, emerges. It is important that we not only monitor the most obvious and costly disease(s) but also study less significant pathogens as well.



# **NEW DEVELOPMENTS DEALING WITH KEY PORK PRODUCTION ISSUES**



# NEW TOOLS TO MAKE GENETIC PROGRESS

**Jack Dekkers and Max Rothschild**

**Department of Animal Science, Center of Integrated Animal Genomics**

**Iowa State University**

**239 Kildee Hall, Ames, Iowa 50011**

**E-mail: [jdekkers@iastate.edu](mailto:jdekkers@iastate.edu) or [mfrothsc@iastate.edu](mailto:mfrothsc@iastate.edu)**

## ABSTRACT

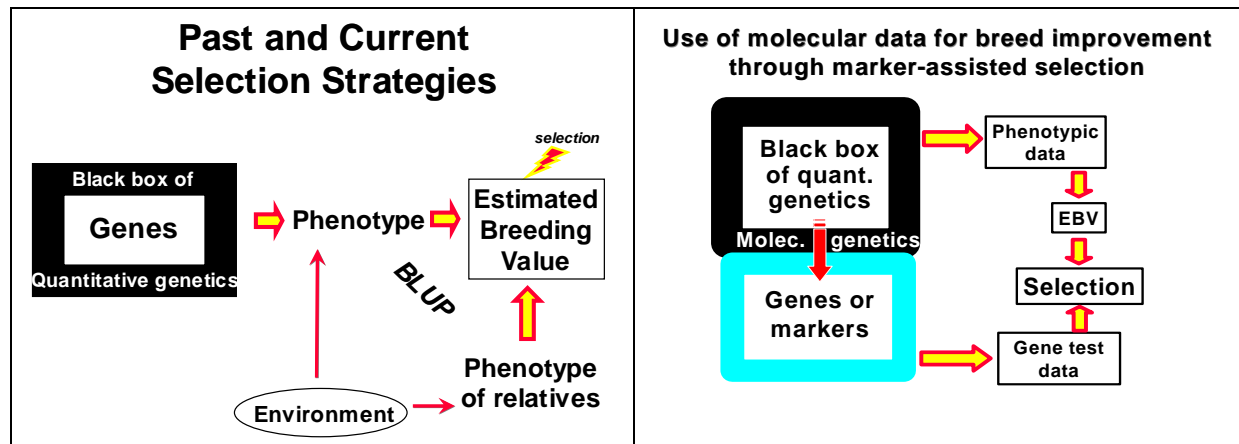
Advances in molecular genetics have opened opportunities to enhance strategies for genetic improvement of pigs by directly selecting on genes or chromosomal regions that harbor genes that affect traits of interest. In this paper, we review molecular technologies that have become available, the current state of the use of gene- or marker tests in pig breeding programs, and future prospects. The main conclusion is that, while current applications of molecular technology in selection are limited, recent developments in molecular genotyping technology will greatly accelerate the rate of implementation of molecular methods for pig breeding in the fore-seeable future. These developments include ongoing efforts to sequence the pig genome, availability of high-density genetic marker maps, and cost-effective high-throughput genotyping of large number of markers across the genome. These opportunities open great opportunities for more effective selection to enhance performance under commercial conditions.

## INTRODUCTION

To date, most genetic progress for quantitative traits in pigs has been made by selection on phenotype or on estimates of breeding values (EBV) derived from phenotype, without knowledge of the number of genes that affect the trait or the effects of each gene. In this quantitative genetic approach to genetic improvement, the underlying genetic basis of traits has essentially been treated as a 'black box' (Figure 1a). Despite this, the substantial rates of genetic improvement that have been and continue to be achieved are clear evidence of the power of quantitative genetic approaches to selection. This success does, however, not mean that genetic progress could not be enhanced if we *could* gain insight into the black box of quantitative traits, in particular for traits that are currently difficult to improve. The latter include traits with low heritability (litter size, disease resistance), traits that are difficult to measure (disease resistance), traits that can only be measured on one sex (litter size), traits that are measured late in life (longevity), or traits that require the animal to be slaughtered (meat quality). By being able to study and assess the genetic make-up of individuals at the DNA level through genetic tests, molecular genetics has given us the tools to make those opportunities a reality (Figure 1b). Molecular data is of interest for use in genetic selection because gene tests have heritability equal to 1 (assuming no genotyping errors), can be done on both sexes and on all animals, can be done early in life, and may require the recording of less phenotypic data. The purpose of this paper is to review the current status and future prospects for the use of molecular genetic tools for genetic improvement. Although molecular

genetic data is useful for other purposes, including parentage verification and traceability, the focus of this paper will be on the use of molecular genetics to enhance within-breed improvement.

**Figure 1a. Quantitative genetic selection. Figure 1b. Use of molecular data in selection.**



## CURRENT STATUS

Through the use of molecular genetic technology, a large number of genes have been mapped over the past 10 years in the main livestock species (Figure 2). Although some of these genes have a functional role in the animal's physiology (i.e. they contain the genetic code for a protein), most are non-functional or 'neutral' genes (Figure 3). The latter are referred to as 'genetic markers'. The fact that genetic markers are non-functional does, however, not mean that they are not useful. In particular, genetic markers can be used to identify genes that affect the quantitative traits we are interested in (so-called quantitative trait loci or QTL). The important difference between genetic markers and their linked QTL is that we can determine what genotype an animal has for a genetic marker but not directly for the QTL. However, if the observable genetic marker is linked to the QTL, we can use a genetic marker to indirectly select for the QTL, which is the concept behind marker-assisted selection (MAS).

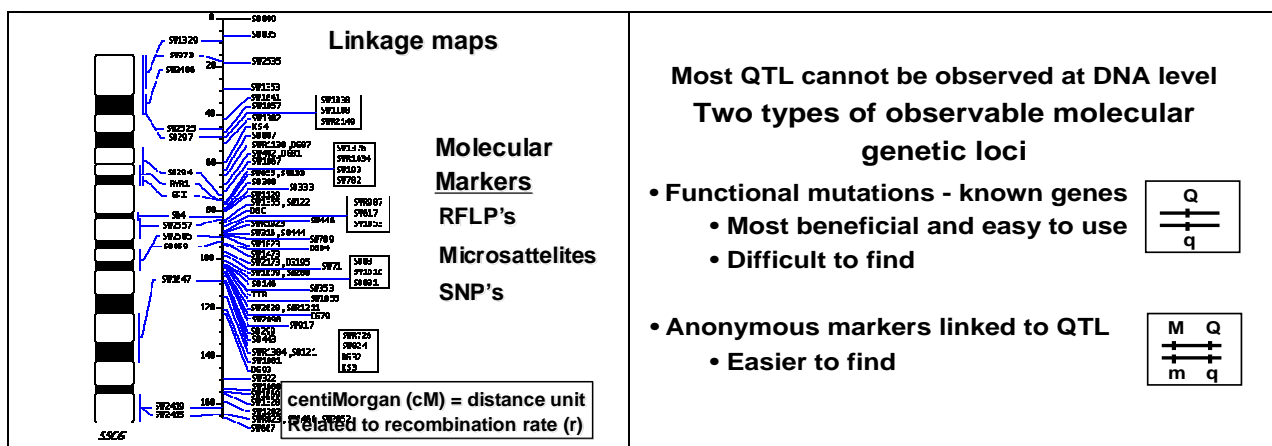
A marker that is linked to the QTL and, therefore, associated with phenotype, can be detected by comparing the mean phenotypes of individuals that have alternate marker genotypes (Figure 4). A difference in mean phenotype indicates that the marker is linked to a QTL.

Over the past decades, tremendous advances have been made in the use of molecular genetics to find genes or markers linked to genes that affect traits of economic importance in livestock. The main strategies that have been used to find such genes include genome-scans in breed crosses and candidate gene association studies. The breed-cross genome scan approach to QTL detection uses genetic markers spread over the genome to identify genomic regions that harbor QTL. In pigs, the main populations used in these studies have been F2 crosses between breeds or lines. An example of such a cross is the three-generation F2 population that was developed at Iowa State University (Malek et al. 2001a,b) (Figure 5). These studies have



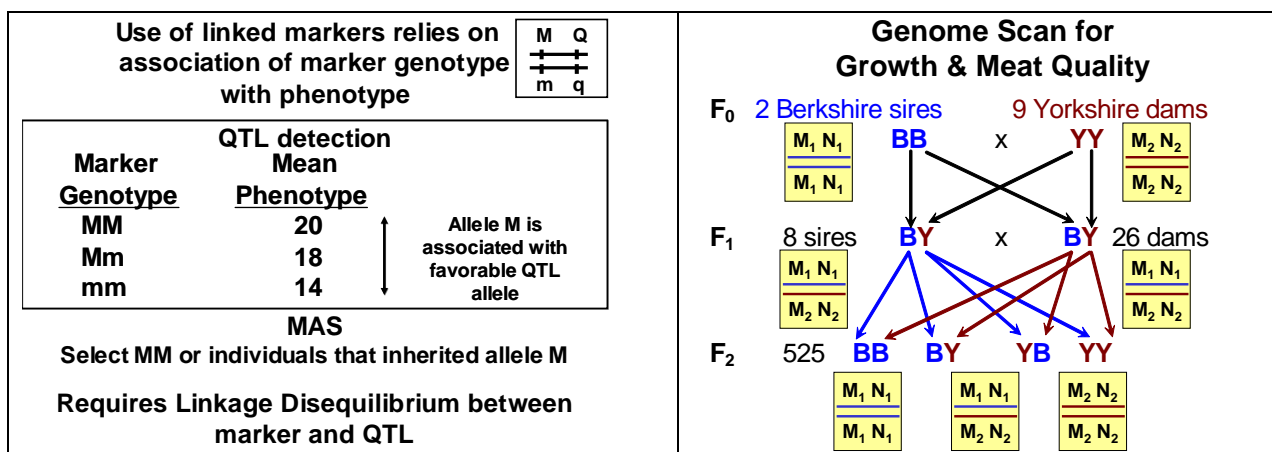
identified many regions of the genome that are associated with economic traits. A database that summarizes the results from most studies is available on the web at: <http://www.animalgenome.org/OTLdb/pig.html>.

Figure 2. Example linkage map (Rohrer et al.). Figure 3. Types of molecular genetic loci.



<http://www.genome.iastate.edu/maps/marcmmap.html>

Figure 4. Principle of marker-QTL associations. Figure 5. Breed-cross genome scan design.



Although breed crosses are very powerful to detect QTL, a problem with the breed-cross genome scan approach is that the markers that are found to be associated with the trait in these crosses may actually be quite some distance from the gene that causes the effect. In addition, these approaches detect genes that differ between the breeds that are used in the cross and these genes may not show variation within a breed, which is what is required for within-breed selection. Both these factors limit the direct utility of results from breed-cross studies for within-breed selection.

The candidate gene approach utilizes knowledge from species that are rich in genome information (e.g., human, mouse), effects of mutations in other species, previously identified QTL regions, and/or knowledge of the physiological basis of traits to identify genes that are

thought to play a role in the physiology of the trait. Following mapping and identification of polymorphisms within the gene, the association of genotype at the candidate gene with phenotype can be estimated in a closed pig breeding population. In contrast to the breed-cross genome scan approach, the candidate gene approach identifies markers that are at or close to the causative gene and that segregate within the breeds. These markers can, therefore, be more directly used for within-breed selection.

To date, these techniques for finding genes and QTL, in particular the candidate gene approach, have resulted in the discovery of several genes or markers that are used in the industry. Prime examples are the ryanodine receptor gene (halothane gene) for meat quality, the estrogen receptor gene for litter size, and genetic markers for QTL for growth, backfat, litter size and disease on several chromosomes. These and others are summarized in Table 1.

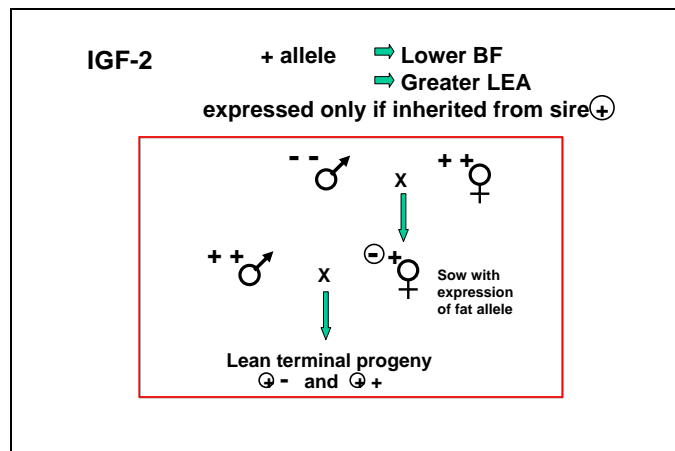
**Table 1. Candidate genes and gene tests identified and used in the industry.**

<b>Candidate genes</b>	<b>Traits</b>	<b>Industry use</b>
HAL	meat quality/stress	yes
KIT	white color	yes
MC1R	red/black color	yes
MC4R	growth and fatness	yes
RN, PRKAG3	meat quality	yes
AFABP, HFABP	intramuscular fat	??
CAST	tenderness	yes
IGF2	carcass composition	yes
ESR, PRLR, RBP4	litter size	yes
FSHB	reproduction	unknown
NRAMP, SLA	disease susceptibility	unknown
FUT1	disease susceptibility	yes
Trade secret tests	several traits	yes

Recent gene and QTL mapping studies have also revealed that the effect of some genes or QTL depends on whether it was inherited through the sow or the boar. For example the IGF2 gene, which affects carcass composition, has been found to be ‘paternally expressed’, which means that only the copy that is inherited from the boar is expressed in the offspring (Van Laere et al. 2003). This opens opportunities for the strategic use of genes in crossbreeding programs, as illustrated in Figure 6.

By producing sows from a cross between a boar that is homozygous for the fat (-) allele for IGF2, and mating this sow to a terminal sire that is homozygous for the lean (+) allele, all market pigs will be lean because their sire allele is the lean allele. But, by having inherited the fat allele from their sire, the sows will have the reserves that may help them through gestation and lactation (Buys et al. 2006), but will not pass this on to their progeny.

**Figure 6. Tactical use of imprinted genes in cross breeding (Buys et al. 2006).**



## CURRENT AND FUTURE EFFORTS

At present, we have the ability to select pigs on the basis of individual gene tests for improved reproductive performance, growth rate, leanness and meat quality. Already this has meant benefited genetic improvement of several of these traits. Despite these advances, it is clear that the genes and QTL that have been identified to date only represent the tip of the iceberg and that the majority of genes for the traits of interest have not (yet?) been detected. These genes, therefore, continue to reside in the ‘black box’ domain (Figure 1b). But imagine for the moment, using not just 5 or 10 genes to select for a trait but 100s or 1000s of genes to improve pig production and create specialized pork products. This has already begun in the US where the two largest swine breeding companies, PIC USA and Monsanto Choice Genetics, are using in some cases 100 to 400 markers in selection in some of their lines. Several additional efforts are currently underway that could further increase these numbers, as described in the following.

## Genome Sequencing

The completion of the human genome sequence in the beginning of 2001 has catapulted our understanding of our genetic complexity as human beings. Furthermore, mining this wealth of information allows biologists to understand human diversity including traits like height and weight or eye and hair color, and even more complex traits like susceptibility to various diseases. This means that in the next 10-20 years a whole new form of medicine, called genomic medicine, may make it possible to develop individualized diagnoses, treatments and cures for each person based on their individual and unique genotype. This will revolutionize medicine. Around the world, scientists are spending billions of dollars to learn more about the human genome and these results may also be used to better understand pig health, reproduction, growth, and behavior by comparing the pig genome sequence to the human genome sequence. However, given that our competitors in the chicken and beef industries already have the chicken and cattle genomes sequenced, it is crucial that we also move forward with sequencing the pig if we are to remain competitive.

**What is sequencing?** Sequencing is the unraveling of the DNA to understand the genetic code (Figure 7). It is equivalent to breaking down books into individual sentences and even specific letters in these sentences and words. The letters in the genetic code (A, T, G, C) are combined into “words” and these words are the genes that control traits or contribute to phenotypes of the animal like rate of growth, level of fat, reproductive performance and disease susceptibility.

**Figure 7. Unraveling of chromosomal information to the individual genes.**

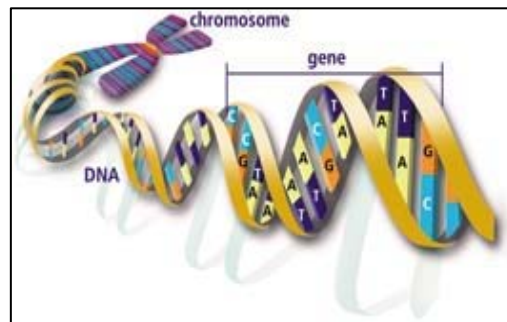


Figure adapted from DOE human genome figure.

Knowing the genetic code requires that we apply modern molecular biology or laboratory methods to break up the code into smaller pieces and then “read” the code.

**Progress of the sequencing efforts.** Pig genome sequencing began in part when a Danish-Chinese project was initiated several years ago. This project produced a 0.6 X sequence coverage but to have excellent sequence, a 6X copy of sequence is needed. The new effort initiated recently by the US, UK and other country partners has as its goal a 3X -4X coverage, with additional sequencing coverage being obtained from foreign lab contributions, including Canada. Funding to sequence the pig genome is an international effort provided by the USDA, National Pork Board, Iowa Pork Producers Association, University of Illinois, Iowa State University, North Carolina Pork Council, North Carolina State University, the Wellcome Trust Sanger Institute, UK and a number of research institutions from around the world including those from China, Denmark, France, Japan, Korea, Scotland and the U.K. Already this new effort is progressing nicely. Updates can be seen daily at <http://www.animalgenome.org/pigs/genomesequence/>. These updates are provided as part of the USDA Bioinformatic Coordinator's team effort. Other information about the sequencing can be seen at that page and web pages at the Sanger Institute and the University of Illinois (see <http://piggenome.org/index.php>). Additional details about the sequencing efforts can be read from the Pig Genome Update also at <http://www.animalgenome.org/pigs/newsletter/index.html> or at the International Genome Consortium Sequencing Newsletter (<http://piggenome.org/newsletter.php>).

**How does sequencing help?** At present we have good but not complete maps of the pig genome. Sequencing will provide not only the “ultimate genetic map” but will allow us to have the tools to hunt down mutations of interest in our own specialized herds and families. This genome sequence of the pig serves as a template to look into the sequence differences in pigs of interest for traits that are economically important (see next section). Sequencing the

swine genome is an investment in basic research with both long- and short-term goals. The potential usefulness of genes in selection for improved pig performance will be determined more quickly if the pig genome sequence is available. Discovery and elimination of undesirable forms or alleles of these genes will be accelerated. Past examples include removal of mutant or negative alleles of the stress gene (HAL) and the Rendement Napole (RN) gene. In the last 10 years, several genes have been identified which improve performance and leanness (IGF2, MC4R), meat quality (CAST, PRKAG3) and reproduction (ESR, PRLR). Sequencing of the pig genome offers the ability to multiply these discoveries into the 1000s and speed the rate of these discoveries. Greater federal funding for pig genomic research can be leveraged to provide more rapid application in these areas. The pig genome sequence can also be used to provide insights into how genes work together. This will allow better genetic planning to allow pig breeders and producers to select animals possessing certain sets of genes that interact in a favorable manner for a particular production system or niche market. Sequencing the pig genome will dramatically accelerate identification of determining the genetic basis of economic traits and their interaction with the environment, which could revolutionize pork production.

For the average pork producer, the many benefits include improved growth and litter size performance due to identification of genes affecting these traits. The genome sequence is a powerful tool, which will enable discoveries for improving traits of interest for producers regardless of their operational size. However, producers and companies associated with more advanced research groups or breeding companies may have the opportunity to leap frog with new genomic strategies. For these better positioned producers and early adopters, more advanced opportunities are likely to include in the next 5-20 years the ability to produce pigs with improved immune response abilities (vaccine ready pigs), growth primed sire lines and development of increased niche and branded products representing unique or special attributes that one producer or one company wishes to use to increase market share and profits. It is likely that producers will have the ability to select certain genetic lines in the future that will require specialized feeds but that could outperform existing lines.

### **High-Density SNP Genotyping**

Genome sequencing typically uses the DNA from a single individual. Genetic selection, however, requires us to identify locations in genome where individuals differ in sequence. These so-called single nucleotide polymorphisms (SNPs) can be identified by comparing the detailed sequence of the single individual to the sequence of other individuals, e.g. from other breeds. For example, in the chicken, over 2.8 million SNPs were identified by comparing the sequence of the Red Jungle Fowl to that of three domesticated breeds (International Chicken Polymorphism Map Consortium, 2004). Efforts to identify large numbers of SNPs have also been initiated through the Danish-Chinese project and in-house by some pig breeding companies. This large number of SNPs enables sufficient numbers of markers to be placed along the genome (e.g. 6 to 50 thousand) such that most QTL will have one or more SNPs located close enough that they can be detected by within-breed association studies. Note that this is similar to candidate gene studies, except that every region of the genome is evaluated, rather than only the candidate gene regions. Studying this many markers is now also possible because of the development of less expensive high-throughput genotyping technology, which

allows large numbers of individuals to be genotyped for a large number of markers at a reasonable costs (estimates as low of \$300 for genotyping an individual for 40,000 SNPs have been quoted). This will greatly accelerate the discovery of genes associated with traits and will allow analysis to be conducted directly within a breed and even on commercial pigs.

### **Genomic Selection**

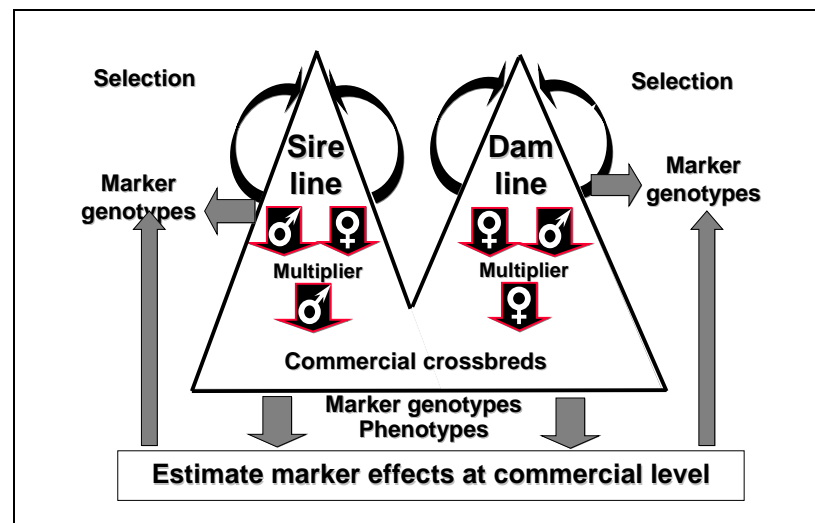
When only a limited number of markers or genes are available, a large proportion of genes that affect the trait will remain in the 'black box' of quantitative genetics (Figure 1b). In this case, selection on marker data alone will not result in great advances in genetic improvement but marker data must be used in combination with regular EBV estimated from phenotypic data on the individual itself and/or its relatives, to ensure that balanced genetic progress is achieved for all genes that affect the trait. This, however, changes if animals can be genotyped for a large number (5,000 or more) of markers across the genome, as is now possible at much reduced costs using high density SNP genotyping. With such technology, Meuwissen et al. (2001) showed that an individual's EBV could be estimated with accuracies as high as can be achieved by progeny testing based only on the individual's genotypes for the markers across the genome. In this strategy, which Meuwissen et al. (2001) called genomic selection, estimates of marker effects are obtained using phenotypes and marker genotypes from a previous generation, which are then used to estimate the breeding value in new generations without the need for additional phenotypes. Although the practical feasibility of genomic selection has yet to be demonstrated, applications of genomic selection are near or underway in several livestock breeding programs.

Genomic selection does not require the actual location of genes that affect the trait to be known. Instead, statistical methods similar to animal model BLUP EBV are used to estimate breeding values of each of many regions across the genome based on associations of phenotype with alternate marker genotypes that exist in the population in each region. Then, the breeding value of an individual can be estimated by simply summing the EBV of the marker genotypes that the individual has for each region.

### **Marker-Assisted Selection for Commercial Crossbred Performance**

A major limitation of today's pig breeding programs is that most selection is in purebred herds, where pigs are raised under high biosecurity. Several studies have, however, shown that purebred performance under nucleus conditions can be a poor predictor of performance of crossbreds raised under commercial circumstances, with genetic correlations as low as 0.4 to 0.7. These limitations can be overcome by collecting phenotypic data on crossbred progeny raised under commercial conditions and using this data to estimate breeding values of purebred pigs, but this is difficult and expensive to implement. These limitations can, however, be overcome by selecting on effects of markers estimated on commercial crossbreds, as illustrated in Figure 8. Results in Table 2 suggest that this cannot only improve response to selection for commercial crossbred performance, but also reduce rates of inbreeding.

**Figure 8.** Diagram of a pyramid breeding program, with selection among purebreds in a purebred environment and illustrating the sources of phenotypic and marker data that can be used for selection among purebreds.



**Table 2.** Potential benefit of using marker data to improve commercial crossbred performance.<sup>1</sup>

Data used for selection	% of genetic variance explained by markers							
	9		25		49		64	
	Resp.	Inbr.	Resp.	Inbr.	Resp.	Inbr.	Resp.	Inbr.
Purebred phenotype	100	2.09	100	2.09	100	2.09	100	2.09
Purebred phenotype + Crossbred phenotype	137	3.02	137	3.02	137	3.02	137	3.02
Purebred phenotype + X-bred marker data	108	1.90	124	1.56	145	1.25	158	1.12

<sup>1</sup> Selection was for commercial crossbred performance for a trait with heritability 0.4 and a genetic correlation of 0.7 between purebred nucleus and commercial crossbred performance, mimicking selection for growth in pigs. Resp = response relative to selection on purebred phenotype (=100%); inbr = rate of inbreeding per generation

## CONCLUSIONS

In the past decade, several genes and many genomic regions affecting economic traits have been identified and several of these have been incorporated in selection programs. The impact of molecular genetics on pig breeding programs and pig production is, however, expected to dramatically accelerate in the future through complete sequencing of the pig genome and

availability of large numbers of markers. Sequencing efforts have started and are moving along nicely. Results of these efforts are already being used to help select markers for improved growth and meat quality. Given the funding available, about \$15 million presently, it is likely we will have a draft sequence of the pig genome by late 2007 or early 2008. Will companies and seedstock breeders be ready to take advantage of these discoveries? Producers must ask the difficult questions. Are they ready to use the new genetics and genomics information? Are they positioned to 1) understand the information and 2) to use it effectively? Are there genetic systems in which this information can be used more effectively to improve pig production? Are there niche markets for new products that can be produced using these technologies? Team work and partnerships with the right seedstock breeders or breeding companies and university or government research faculty are likely to be keys in transforming this public information from a useful resource to a real payoff. Only then will producers, companies and geneticists help members of the pig industry really bring home the bacon.

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# **FEEDING THE PIGS' IMMUNE SYSTEM AND ALTERNATIVES TO ANTIBIOTICS**

**Hans Stein**  
**Department of Animal Sciences, University of Illinois**  
**Urbana IL 61801**  
**Email: [hstein@uiuc.edu](mailto:hstein@uiuc.edu)**

## **ABSTRACT**

Diet formulation and feeding strategies may be used to boost the pigs' immune system and reduce the negative impact of weaning. Post-weaning diarrhea can be reduced or prevented by feeding diets that have low concentrations of crude protein. Such diets may supply fewer amino acids than recommended and pig growth rate may be reduced, but if pigs are provided a diet with a normal or elevated concentration of protein after the immediate post-weaning period, then the overall post-weaning performance will not be compromised. Diets that are based on barley, oats, or naked oats have been shown to improve pig performance compared with diets based on wheat or corn, and there is evidence that the fiber fraction in barley and oats help improve intestinal health of pigs. However, it has also been shown that diets based on cooked white rice may improve performance and the immune status of the pig.

Diets fed in a liquid or in a fermented liquid form improve pig performance compared with diets fed in a dry form, and the liquid diets help maintain intestinal integrity during the post-weaning period. It is, therefore, recommended that weanling pigs should be fed liquid diets to maximize performance. Many feed additives are available for inclusion in diets fed to pigs. Positive responses on pig performance have been reported in some, but not all, studies in which the inclusion of acidifiers, probiotics, or pre-biotics was studied. However, there are many unknowns regarding the usage of these additives, and the responses to the inclusion of them are not always predictable.

## **INTRODUCTION**

Producing pigs without using antibiotic growth promoters represents a challenge. Disease problems often are elevated and general performance is compromised on farms practicing non-medicated swine production. That is true in particular during the immediate post-weaning period whereas antibiotics can often be removed from diets fed to growing-finishing swine without introducing major disease problems (Wierup, 2001). Because of the difficulties associated with producing pigs without antibiotics, many producers are looking for alternative growth promoters or management strategies, but at this point, no "magic bullets" are available. Producing swine without in-feed antibiotics requires a combination of different strategies. These strategies can be divided into three categories: Management strategies, nutritional strategies, and alternative dietary supplements. Many different approaches have been proposed within each strategy, but the one thing these approaches have in common is that they all aim at improving the pigs' ability to prevent pathogenic bacteria from colonizing in the intestinal system. This can be accomplished via an improved immunological response

to pathogens or via mechanisms that prevent the pathogens from adhering to intestinal tissue, and thus, reduce the damaging effects of the pathogens. In this summary, some of the approaches that are available to improve the pigs' ability to reduce the impact of intestinal pathogens will be discussed. However, this is not a complete list of strategies or supplements that may be used and other strategies or products that are equally or more effective than the ones discussed here, may be available.

## **NUTRITIONAL STRATEGIES**

### **Low-Protein Diets**

The single most important nutritional factor for reducing scouring in pigs fed diets without antibiotic growth promoters is to reduce the dietary crude protein concentration because undigested crude protein entering the large intestine will increase microbial fermentation in the hind gut and provide substrates for pathogens. It is also likely that the increased metabolic demand for deaminating excess amino acids and excreting the extra nitrogen compromises the pigs' immune system. In addition, undigested feed protein may accelerate the production of toxic nitrogenous compounds including ammonia which is harmful to intestinal health (Bolduan et al, 1988; Pluske et al., 2002; Nyachoti et al., 2006). Therefore, formulating low-protein diets supplemented with crystalline amino acids results in less diarrhea and fewer intestinal problems than using diets with greater protein concentrations (Ball and Aherne, 1987; Bolduan et al., 1988; Goranson et al., 1995). For most groups of pigs, it is possible to reduce the dietary concentration of crude protein by 3-4% without compromising the pig's requirement for amino acids (Cinq-Mars et al., 1988; Hansen et al., 1993; Han et al, 1995). In a recent experiment, it was demonstrated that by reducing the dietary crude protein concentration from 21.2 to 18.4, a linear reduction in diarrhea was observed, but growth performance was not affected (Reynoso et al., 2004). The low protein diets that were used in this experiment were fortified with crystalline amino acids, which is likely the reason performance could be maintained. Likewise, le Bellego and Noblet (2002) reduced dietary crude protein concentration from 22.4% to 16.9% with the addition of crystalline amino acids without reducing pig performance.

It is usually possible to reduce the dietary concentration of crude protein in diets fed to weanling pigs to approximately 18% by including crystalline amino acids in the diets without under-supplying any indispensable amino acids. However, sometimes it may be necessary to formulate diets containing less than 18% crude protein during the immediate post-weaning period to avoid scouring and intestinal malfunctions. In such diets, it may not be possible to include the indispensable amino acids at recommended concentrations. Therefore, growth performance will be compromised. However, if the pigs suffer from diarrhea, they will also have reduced performance (Goranson, 1997). Because the period of time that amino acid concentrations are sub-optimal is usually relatively short (i.e., 2-4 weeks), it is of little or no practical consequence that growth performance is slightly reduced during this period. Recent data indicate that pigs fed diets containing approximately 20% less amino acids than recommended (NRC, 1998) will have a reduced daily gain of 40 – 60 g per day (Table 1). If such diets are fed during the initial two weeks post weaning, then a total of 560 - 840 g of

gain is sacrificed. However, if the protein concentration in the diet is returned to normal levels from day 15 post-weaning, then the pigs on the low-protein diets will compensate and by day 35 post-weaning, there is no difference in the body weight of pigs regardless of the protein concentration they received during the initial 2 weeks post weaning (Stein and Kil, 2006; Table 1). These observations are consistent with data demonstrating that pigs will compensate for protein restriction during one period of growth by utilizing proteins more efficiently when dietary protein levels are restored to normal values (Kyriazakis et al., 1991; Reynolds and O'Doherty, 2006).

It is, therefore, concluded that the incidence of diarrhea during the post-weaning period may be reduced by feeding low-protein diets without compromising overall nursery pig performance.

**Table 1. Effects of feeding low protein diets followed by either normal or high protein diets to weanling pigs <sup>a,b</sup>**

Item	Treatment:	High/low	High/high	Low/low	Low/high	SEM
Crude protein/lysine, day 0 - 14		20.8/1.35	20.8/1.35	15.7/1.15	15.7/1.15	-
Crude protein/lysine, day 14 - 35		17.5/1.15	19.3/1.34	17.5/1.15	19.3/1.34	-
Average daily gain, g, day 0 - 14		171 <sup>xy</sup>	180 <sup>x</sup>	148 <sup>xy</sup>	129 <sup>y</sup>	16
Average daily gain, g, day 14 - 35		516	529	499	535	13
Average daily gain, g, day 0 - 35		377	389	359	373	11
Average daily feed intake, g, day 0 - 14		249	257	228	237	18
Average daily feed intake, g, day 14 - 35		790 <sup>x</sup>	756 <sup>xy</sup>	778 <sup>xy</sup>	735 <sup>y</sup>	17
Average daily feed intake, g, day 0 - 35		574	556	558	535	15
Average gain:feed ratio, g/g, day 0 - 14		0.68	0.70	0.65	0.55	0.029
Average gain:feed ratio, g/g, day 14 - 35		0.65 <sup>x</sup>	0.70 <sup>y</sup>	0.64 <sup>x</sup>	0.73 <sup>z</sup>	0.007
Average gain:feed ratio, g/g, day 0 - 35		0.66 <sup>x</sup>	0.70 <sup>y</sup>	0.65 <sup>x</sup>	0.70 <sup>y</sup>	0.007

<sup>a</sup> Data from Stein and Kil, 2006.

<sup>b</sup> Values are means of six pens per treatment with 5 pigs per pen.

<sup>xyz</sup> Values lacking a common superscript letter are different ( $P < 0.05$ ).

### Selected Cereal Grains

In most parts of the world, the major cereal grains used in diets fed to weanling pigs are corn, wheat, sorghum, or barley. These grains contain varying quantities of starch and non starch polysaccharides, which results in differences in the effects these grains have on intestinal physiology and on the concentration of the microorganisms in the intestinal tract (Bach Knudsen, 2001). Work in Australia has indicated that pigs fed diets based on cooked white rice and animal proteins are less susceptible to infections than are pigs fed diets based on other cereal grains with higher fiber contents (Pluske et al., 1996; 1998). Therefore, weanling pigs fed such diets have fewer incidences of diarrhea than pigs fed diets based on corn starch (Pluske et al., 2003), which often results in improved pig performance (Vicente et al., 2004, Mateos et al., 2006). The majority of the carbohydrates in diets based on cooked rice are digested in the small intestine with a subsequent absorption of monosaccharides. Therefore, only small quantities of non-starch polysaccharides will enter the large intestine, which in turn prevents pathogenic bacteria from getting nourishment in the GI-tract. Therefore, a change in

the microbial population is observed, fewer pathogens are able to colonize in the intestinal tract, and fewer short chain fatty acids are produced (Siba et al., 1996; McDonald et al., 1999).

In contrast with the above results it also has been reported that the inclusion of barley and oats in diets fed to weanling pigs may reduce the incidence of diarrhea (Medel et al., 1999; Paulicks et al., 2000). Barley and oats contain both fermentable and non-fermentable fibers and they will, therefore, stimulate fermentation in the hind gut in contrast to diets based on cooked white rice. However, barley and oats may also contain unidentified nutrients that improve overall digestion of pigs and performance of newly weaned pigs fed diets based on barley or oats is elevated compared to pigs fed diets based on corn or wheat (Medel et al., 1999). Data from our laboratory indicate that this is also the case if diets are based on naked oats rather than corn, milo, or wheat (Stein and Kil, 2006; Table 2). The reason for these observations may be that the increased production of short chain fatty acids that results from the fermentation of the fibers in barley and oats may stimulate the expression of certain cytokines in the intestinal tract of the pigs (Pie et al., 2007). This in turn would improve the immune status of these pigs, which may explain the positive performance results from pigs fed diets based on barley or oats. Barley and oats also contain relatively high quantities of beta-glucans that may have prebiotic effects because they stimulate lactic acid production (Bach Knudsen and Canibe, 2000; O'Connell et al., 2005). The improved production of short chain fatty acids may also stimulate water and electrolytes absorption, improve gut morphology, and reduce colonic pH to levels that are unfavorable for pathogens, which in turn may reduce the incidence of diarrhea (Montagne et al., 2003).

These results indicate that two options for improving performance, health, and the immune status of weanling pigs are available. One option is to reduce the concentration of dietary fiber to reduce the nourishment for microbes in the hind gut, and therefore, reduce colonization by pathogens in the intestinal tract of the pigs. The other option is to use cereal grains containing specific fibers that have prebiotic effects in the hind gut of pigs. Barley, oats, and naked oats seem to contain such fibers and the inclusion of these grains in diets fed to weanling pigs may, therefore, improve performance and intestinal health of the pigs.

**Table 2. Effects of grain source in starter diets fed to weanling pigs from day 0 – 7 post-weaning<sup>a,b</sup>**

Item	Grain source:	Corn	Sorghum	oats	Naked oats
Average daily gain, g		95 <sup>x</sup>	74 <sup>x</sup>	81 <sup>x</sup>	129 <sup>y</sup>
Average daily feed intake, g		160 <sup>x</sup>	146 <sup>x</sup>	145 <sup>x</sup>	195 <sup>y</sup>
Average gain:feed ratio, g/g		0.60 <sup>xy</sup>	0.51 <sup>x</sup>	0.55 <sup>x</sup>	0.66 <sup>y</sup>

<sup>a</sup> Data from Stein and Kil, 2006.

<sup>b</sup> Values are means of six pens per treatment with 5 pigs per pen.

<sup>xy</sup> Values lacking a common superscript letter are different ( $P < 0.05$ ).

## **Restricted Feeding**

Feeding weanling pigs a restricted amount of feed will reduce intestinal problems and incidences of diarrhea compared with pigs that are allowed to consume their diets on an ad libitum basis (Goranson et al., 1995). The reasons for this observation have not been elucidated, but it is possible that reduced feed intake results in less undigested feed entering the large intestine, and, therefore, less fermentable substrate for the pathogens in the intestines. Restricted feeding also results in a reduced pH in the intestinal tract, which may prevent pathogens from colonizing in the upper gut. Feeding as often as 4 to 6 times per day may be required during the initial two weeks post-weaning to prevent pigs from developing diarrhea. Usually, this can be accomplished by feeding the pigs on a floor-mat during this period. For older pigs, restricted feeding is usually not practical because most feeding systems are based on ad libitum intake of feed.

## **Functional Proteins**

Protein is added to diets for pigs to provide amino acids that can be used for tissue protein synthesis. However, it is recognized that certain proteins may have functions other than strictly providing amino acids and several proteins are believed to improve the immune status of weanling pigs. For example, it has been shown that the dietary inclusion of spray dried plasma may improve the immune status of weanling pigs (Touchette et al., 2002; Bosi et al., 2004), which reduces the pigs' susceptibility to E.coli infections (Bosi et al., 2001; van Dijk et al., 2002, Owusu-Asiedu et al., 2003). The immunoglobulins that are present in spray dried plasma are the functional units that provide the improved immunity (Pierce et al., 2005). Spray dried plasma also has been shown to down-regulate the inflammatory process in healthy pigs (Touchette et al., 2002; Bosi et al., 2004), which in turn may contribute to increased feed intake and direction of nutrients towards gain of body weight. It is, therefore, not surprising that reviews of a large number of studies in which spray dried plasma was included in diets fed to weanling pigs has shown that plasma increases average daily growth rate by approximately 25% (Coffey and Cromwell, 2001; van Dijk et al., 2001). Spray dried plasma is, therefore, commonly included in diets fed to weanling pigs.

If it is correct that it is the immunoglobulins in spray dried plasma that provide the improvement in pig immunity then it would be expected that other sources of immunoglobulins also can improve the immune status of pigs. The most abundant source of immunoglobulins is immunoglobulins from dairy cows that are present in the whey protein fraction of cows' milk. It has been demonstrated that the inclusion of whey proteins in diets fed to weanling pigs may improve performance (Nessmith et al., 1997; Grinstead et al., 2000). However, in a recent analysis of data from 11 experiments in which whey proteins had been used, it was shown that the average improvement in growth rate obtained by the addition of whey proteins to diets fed to weanling pigs is only 4% (Pettigrew, 2006).

Egg proteins also contain immunoglobulins and the inclusion of dried whole eggs to diets fed to weanling pigs may also improve pig performance (Schmidt et al., 2003; Hong et al., 2004). If hens are immunized against certain pathogens, they will produce antibodies against these pathogens and the antibodies will be present in the eggs from these hens. It is therefore

possible to increase the concentrations of antibodies in eggs against certain pathogens and if these eggs are fed to weanling pigs, the pigs will gain an improvement in their immune status. It has been demonstrated that if eggs containing high concentrations of antibodies against *E.coli* are fed to weanling pigs, these pigs will experience fewer cases of *E.coli* associated diarrhea (Yokoyama et al., 1997; Marquardt et al., 1999). There are, however, relatively large costs involved in the production of these eggs, and this practice is, therefore, not widely used in the industry.

Because of the positive effects of adding immunoglobulin containing proteins to diets fed to weanling pigs, it is a common practice to use at least one of the above proteins in starter diets, which improves the pigs' immune status. The greatest improvements in immune status and average daily gain are obtained when spray dried plasma is used, but other proteins may also provide benefits.

### **Liquid Feeding/Fermented Liquid Feeding**

Liquid feeding generally results in fewer intestinal upsets than dry feeding because liquid diets reduce gastric pH, which results in reduced or inhibited growth of pathogens in the intestinal tract (Geary et al., 1996; van Winsen et al., 2000). Liquid feeding also prevents the atrophy of intestinal villi that often is observed during the post-weaning period in pigs provided a dry diet (Deprez et al., 1987; Gu et al., 2002; Scholten et al., 2002). With a healthier and more intact villi-structure in the small intestine, it is likely that pigs are less susceptible to *E.coli* infections, which in turn can explain why liquid feeding has a positive influence on overall pig health and pig performance.

In ten experiments, daily gain was improved by 12.3% on average in pigs fed liquid diets compared with pigs fed dry feed (Jensen and Mikkelsen, 1998). However, other experiments have reported a greater improvement in pig performance for pigs fed liquid diets rather than dry diets (Zijlstra et al., 1996; Kim et al., 2001). Increased concentrations of short-chain fatty acids, reduced microbial activity, and improved immune status in pigs fed liquid or fermented liquid diets rather than a dry diet may also contribute to improved performance (Scholten et al., 1999).

Fermentation of the liquid feed prior to feeding has been reported to further decrease the risk of developing intestinal problems in pigs (Geary et al., 1996; Scholten et al., 1999; Brooks et al., 2003). Other benefits of fermented liquid feeding include improved protein digestion due to lower stomach pH and probiotic effects resulting from the supply of lactic acid bacteria via the fermented feed (Brooks et al., 2003). Thus, fermented liquid feeding could have characteristics similar to probiotics and organic acidifiers. On average, fermented liquid feeding resulted in an increase in growth rate of 13.4% compared with non-fermented liquid feeding and by 22.3% compared with dry feed (Jensen and Mikkelsen, 1998).

Fermentation of the entire diet may reduce the gain to feed ratio (Jensen and Mikkelsen, 1998) because of fermentation of sugars and free amino acids in the diet. However, it has been demonstrated that fermentation of only the carbohydrate source in the diet (i.e., the cereal grains) improves average daily gain and the gain to feed ratio (Scholten et al., 2002),



and it is, therefore, recommended that only the cereal grains are fermented. Alternatively, the fermentation of free amino acids during fermentation may be prevented if small concentrations of lactobacillus are included in the fermentation (Niven et al., 2006). Therefore, there seems to be several options for creating fermentation conditions that are not detrimental to pig performance.

It is concluded that liquid and fermented liquid feeding of weanling pigs improves intestinal health, immunity, and pig performance. Producers who have the ability to feed such diets, may, therefore, want to consider this option. The dietary inclusion of solubles from the industrial fermentation industry such as from beer breweries, ethanol plants, or enzyme fermentation plants are also believed to have a positive effect on intestinal and overall health of the pig but a scientific evaluation of these products still needs to be conducted.

## **DIETARY SUPPLEMENTS**

### **Acidifiers**

The inclusion of organic acids in diets fed to weanling and growing pigs has been reported in numerous papers. Of all alternative dietary supplements, the products belonging to the group of organic acids are probably the best researched. Positive responses to the inclusion of Fumaric acid (Falkowski and Aherne, 1984; Giesting and Easter, 1985; Giesting et al., 1991; Radecki et al., 1988), formic acid, citric acid and Propionic acid have been reported (Falkowski and Aherne, 1984; Henry et al., 1985). Usually, between 1 and 2% of the products are included in diets fed to weanling or growing pigs. Despite many years of research, the mode of action of acidifiers has not yet been elucidated. Improved nutrient digestibility has been reported in several experiments (i.e., Broz and Schulze, 1987; Blank et al., 1999), but not in other experiments (Gabert et al., 1995).

The addition of inorganic acids to diets fed to weanling pigs has also been researched. Positive responses to the inclusion of phosphoric and hydrochloric acid (Mahan et al., 1996) were reported, whereas the addition of sulfuric acid had a negative effect on pig performance. As was the case for organic acids, the mode of action of inorganic acids has not been elucidated.

Another group of diet acidifiers include salts of acids. These products have also been researched extensively. Positive responses were reported from experiments in which weanling pig diets were supplemented with Potassium diformate (Overland et al., 2000; Canibe et al., 2001), calcium formate (Kirchgessner and Roth, 1990; Pallauf and Huter, 1993), and sodium formate (Kirchgessner and Roth, 1987).

Therefore, there is strong evidence that pig performance may be enhanced if starter diets are supplemented with an acidifier. Of the various acidifiers on the market, fumaric acid and potassium formate have shown the most promising results, but many other acids may work equally well. Many commercial acidifiers contain combinations of organic and inorganic acids and are often included in diets at relatively low inclusion levels. Because the combination

of acids included in these products are often proprietary, the effects of these products cannot always be verified.

## **Probiotics**

Probiotics are live cultures of bacillus, lactic acid producing bacteria, or yeast that are added to diets for piglets. For a culture to have a positive effect on pig performance, the following needs to be verified:

- The culture needs to be able to establish itself in the GI-tract of the animal
- The culture needs to have a high growth rate
- The culture needs to excrete metabolites that have a suppressing effect on pathogens
- It should be possible to grow the culture under commercial conditions
- The culture need to be stabilized and have the ability to survive in feed

Probiotics are supposed to colonize in the intestinal tract of the animal and increase in concentrations to dominate the intestinal microflora, which in turn will prevent intestinal pathogens from colonizing. They may also suppress pathogens by competitive exclusion.

Many of the commercial probiotic products on the market are lactic acid producing bacteria that are used to circumvent the drop in the enteric lactic acid producing bacteria that is often observed during the immediate post-weaning period (Doyle, 2001). Recently, it was reported that in 30 out of 31 trials in which a combination of *Bacillus licheniformis* and *Bacillus subtilis* had been included in diets fed to weanling pigs, a positive growth response had been obtained (Kremer, 2006). In experiments where other lactic acid producing bacteria were fed to weanling pigs, positive responses were also reported (Apgar et al., 1993; Zani et al., 1998; Kyriakis et al., 1999).

Yeast cultures may be added to pig diets as live yeast or dried yeast and there is no evidence that one form is better than the other. Positive performance responses to the inclusion of yeast in diets fed to weanling pigs have been reported (Matthew et al., 1998; van Heugten et al., 2003). The positive responses of yeast in diets fed to swine may be a result of the ability of yeast to suppress the concentration of coliform bacteria in the intestinal tract of weanling pigs (White et al., 2002).

## **Non-Digestible Oligosaccharides/Prebiotics**

Certain dietary fibers have been shown to improve intestinal secretions and growth of the digestive mucosa (Mateos et al., 2000), and a number of different fiber fractions have been tested for their ability to enhance pig growth and suppress pathogenic bacteria colonization. The mode of action of the dietary fibers is believed to depend on the specific fraction in question. Readily fermentable non-digestible oligosaccharides (i.e., fructo-oligosaccharides, galacto-oligosaccharides, and trans-galactooligosaccharides) are believed to improve pig performance by stimulating the proliferation of *Bifidobacteria* in the large intestine, which in turn reduces colonic pH and increases the concentration of lactic acid (Houdijk et al., 2002). It is also believed that galacto-oligosaccharides stimulate beneficial bacterial growth in the large intestine and improves intestinal health (Smiricky-Tjardes et al., 2003). *Bifidobacteria* also

suppress the growth of pathogenic bacteria (i.e., *E. coli*) by stimulating the production of acetate, which further decreases the pH and reduces the incidence of diarrhea (Mosenthin et al., 1999). Because of the ability of these oligosaccharides to improve the growth of the probiotic bacteria in the GI-tract, they are often called nutra-ceuticals or pre-biotics.

Other fiber fractions (i.e., mannan-oligosaccharides) are believed to improve pig health and performance by binding to specific lectin ligands on the surface of epithelial cells, thus preventing pathogenic bacteria from binding to these ligands resulting in a “flushing” effect on pathogenic bacteria (LeMieux et al., 2003; Rozeboom et al., 2005). Mannan oligosaccharides may also enhance the immune system by directly evoking an antibody response (Davis et al., 2004). Results from several experiments in which mannan-oligosaccharides were used showed an increase in pig performance (LeMieux et al., 2003; Rozeboom et al., 2005).

### **Essential Oils**

Antimicrobial properties of various extracts of herbs and spice preparations have been reported for many centuries. The essential oil of the plant is often the biologically active component of herbs and spices (Zaika et al., 1983) although this is not always the case (Deans and Ritchie, 1987). The activity of plant extracts is related to the composition of the oils and may be influenced by factors such as the genotype of the plant and the growing conditions (Deans and Ritchie, 1987; Piccaglia et al., 1993). The antimicrobial effects of essential oils may be related to changes in lipid solubility at the surface of the bacteria (Dabbah et al., 1970), but disintegration of the outer membrane of certain pathogens has also been demonstrated.

Garlic, oregano, thymol, and carvacrol are among the essential oils that are most commonly used in diets fed to swine. All of these compounds have strong anti-microbial properties in vitro, but there are no reports in the peer-reviewed literature that demonstrate that they also have a positive effect on pig performance. In contrast, reduced pig performance has been reported from the inclusion of a combination of oregano, thyme, and cinnamon in diets fed to weanling pigs (Namkung et al., 2004) and no effects on pig performance were reported from studies using other combinations of essential oils (Manzanilla et al., 2004; 2006; Insley et al., 2005).

There are already a number of commercial products containing proprietary blends of essential oils on the market. These products are claimed to improve pig performance, reduce scouring, and sometimes also improve the immunity of the animals. However, at this point, there is a lack of carefully controlled in vivo studies reported in the peer-reviewed literature that can support the argument that essential oils have beneficial effects on pig performance or health if included in diets fed to weanling pigs.

### **Minerals**

Several minerals are included in the regulation of the pig's immune system. The role of selenium in protecting biological membranes from oxidative degeneration was established many years ago (Lessard et al., 1991; Oldfield, 2003). A number of functional selenoproteins

are synthesized in the body and the glutathione peroxidase enzymes (GSHPx) have been shown to be part of the body's antioxidant defense system (Reilly, 1998). Dietary selenium is, therefore, necessary to obtain maximal immunity in pigs, but to avoid toxicity due to over supplementation the inclusion of selenium in diets fed to livestock is regulated by FDA and cannot exceed 0.3 ppm. However, recent research indicates that organic sources of selenium are better utilized by pigs than inorganic sources (Mahan and Parrett, 1996; Mahan et al., 1999). As a consequence, to obtain maximum improvements in the immune system, it may be advisable to use organic selenium, rather than inorganic sources of selenium.

Copper sulfate is usually added to nursery diets at concentrations between 150 and 250 ppm, although the nutritional requirement for copper is much lower. Likewise, zinc oxide is often added to starter diets at levels of 2,000 – 4,000 ppm, which is much higher than the nutritional requirement for zinc. However, the inclusion of these minerals at high concentrations in diets fed to nursery pigs has been shown to reduce scouring and to control post-weaning diarrhea without causing any toxicity symptoms (Poulsen, 1995; Goransson, 1997). These effects may be caused by the ability of zinc and copper to reduce concentrations of coliform bacteria in the intestinal tract of weanling pigs (Namkung et al., 2006). Both minerals have also been shown to have growth promoting effects of the same magnitude as what is usually expected from antibiotic growth promoters (Hahn and Baker, 1993; Smith et al., 1997; Hill et al., 2000).

The role of chromium as the glucose tolerance factor, and thus, the importance of chromium in insulin activity has been demonstrated (Steele et al., 1977; Houseknecht and Kahn, 1997). It also has been shown that supplemental chromium may improve the immune response in stressed feeder calves (Chang and Mowat, 1992; Kegley and Spears, 1995), and it has been demonstrated that chromium may modify carcass composition in finishing pigs (Kornegay et al., 1997; Mooney and Cromwell, 1997). Because of the crucial role of chromium in glucose and insulin metabolism and because of the demonstrated roles of chromium in improving the immune system in calves, it is likely that chromium may also contribute to an improvement of immunity in pigs, but at this point, this has not been experimentally verified (van Heugten and Spears, 1997).

Because of the high buffering capacity of limestone and inorganic phosphate sources, decreasing or omitting the dietary inclusion of these ingredients in diets fed to weanling pigs can reduce scouring. Exogenous phytase can be added to improve the digestibility of phytate-bound phosphorus and the requirement for calcium can be met by using calcium salts rather than limestone. Therefore, pigs can be fed diets without any calcium phosphates or limestone during the initial 2 to 3 weeks post weaning. Such diets have much lower buffering capacity than diets containing calcium phosphates and limestone, which will help the pig get through this period without developing diarrhea. However, after the initial post-weaning period, diets with normal levels of Ca and P need to be provided.

## CONCLUSIONS

A variety of strategies are needed to successfully wean pigs. The most effective way to reduce diarrhea in pigs is to reduce the crude protein content of the diets and to change the use of ingredients towards more barley and oats and less wheat and corn. Liquid or fermented liquid feeding may also be used to improve the intestinal health and the immune status of the pigs. Feed additives such as probiotics, acidifiers, and oligosaccharides also be used and all of these additives have well-documented effects on weanling pig performance.

Future developments likely will focus on identifying other means to improve the immune status of weanling pigs. The positive responses and dramatic improvements in growth rates obtained with functional proteins demonstrate that it is possible to influence the immune status of pigs in ways that enable pigs to resist pathogens and become less susceptible to diseases. As the pigs' genome becomes mapped and knowledge about the genomics involved in enhancing the immune system of pigs becomes available, more opportunities for feeding the pigs' immune system may become available. The genomics of beneficial enteric microbes as well as pathogens also will be elucidated, which may further improve the chance of creating diets that will improve the pigs' immune system.

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# **NUTRITIONAL MANAGEMENT OF THE GILT FOR LIFETIME PRODUCTIVITY - FEEDING FOR FITNESS OR FATNESS?**

**Pinder Gill**

**Meat and Livestock Commission**

**P.O. Box 44, Winterhill House, Snowdon Drive, Milton Keynes, UK, MK6 1AX**

**E-mail: [pinder\\_gill@mlc.org.uk](mailto:pinder_gill@mlc.org.uk)**

## **ABSTRACT**

Premature culling of sows, primarily due to reproductive failure and lameness, remains a major constraint to capturing the potential lifetime productivity of replacement gilts. On many farms, a lifetime productivity of between 30 and 40 piglets per sow is the norm and only a few sows will achieve the potential of 60 or more. Current feeding and management recommendations for improving longevity continue to focus on the importance of fatness in gilts at first service. This rationale is explored by reviewing the literature, including studies with modern genotypes on the long-term benefits of nutritionally enhancing fatness in gilts and young sows. It is proposed that emphasis should shift from fatness to more holistic thinking towards the concept of fitness, which includes feeding and management of gilts and young sows for body condition, and soundness of legs and feet. In modern lean genotypes changes in body condition will primarily arise from gains and losses in lean mass and to a lesser extent body fatness. Longevity will be improved by avoiding rapid weight gain before first service, provision of flooring and bedding which promotes the development of healthy legs and feet, and a nutritional and feeding programme which aims to achieve a body condition score (BCS) of 3 at first service and farrowing, limits weight loss during lactation and re-conditions young sows during subsequent pregnancies to farrow with a BCS of 3.

## **INTRODUCTION**

Sow lifetime productivity is important to herd profitability. However premature disposal of gilts and young sows result in most sows producing only 30 to 40 piglets per lifetime against the potential for 60 or more. In this paper, the reasons for premature disposal are reviewed. Current feeding and management recommendations for enhancing lifetime productivity are considered. The rationale behind the focus on fatness is explored by reviewing the literature, including studies with lean modern genotypes on the long-term benefits of nutritionally enhancing fatness in gilts and young sows. The concept of fitness is introduced as an alternative to fatness, which takes a holistic approach in managing body condition through feeding and nutritional programmes which are aligned to the lean gain potential of modern genotypes and the increasing evidence supporting the role of body lean in reproductive function. Fitness also includes the provision of flooring systems which promote the development of healthy feet and legs as around 16 to 17% of first and second litter sows are culled for lameness.

## PREMATURE CULLING

In many commercial units sow output falls considerably short of the potential to produce 60 to 70 piglets weaned per lifetime, with 40 to 50% of sows culled before reaching their third or fourth parity (Dijkhuizen et al., 1989; Rodriguez-Zas et al., 2003) and weaning only 30 to 40 piglets per lifetime (Lucia et al., 2000). Maiden gilts and first and second parity sows together can account for around 45% of total culls (D'Allaire et al., 1987; Lucia et al., 2000) resulting in a herd inventory dominated by a high proportion of young females, which have yet to fulfil their lifetime reproductive potential. Herds with high replacement rates also need larger gilt pools, with higher overhead and operating costs and adding further inefficiencies to the system as non-productive days. Purchased replacement gilts are also a potential vector of disease as identified in a recent retrospective cohort study of post weaning multisystemic wasting syndrome (PMWS) on pig farms in Great Britain (Green, 2005)

Sow longevity has a major impact on herd profitability, with premature disposals estimated to represent around 16% of farm income (Dijkhuizen et al., 1989). To improve financial return, the productive lifespan of each sow in the herd must be increased, since net present value per gilt purchased improves with parity number (Lacy et al., 2007). In general a reduction in premature culling and the loss of sows in early parities give producers the scope for increasing their profitability. The financial incentive to extend sow productive lifespan increases as replacement gilt costs rise, net income per litter and cull sow value fall, and sow productivity deteriorates (Rodriguez-Zas et al., 2006; Lacy et al., 2007).

In Denmark, the probability of a first litter sow remaining in the herd until insemination for the second is included as a trait for longevity in the national breeding programme. The current rate of genetic progress for longevity is reported as 0.82% per year averaged over 4 years and the economic benefit of this is given as 0.85 DKK (0.17 CAD) per finished pig for every 1% improvement in longevity (Danske Slagterier, 2006).

Recent and historic farm records and survey data show consistency in the reasons for overall sow disposal across pig producing countries (Table 1), with reproductive failure being the predominant reason followed by low productivity, poor health and locomotion.

Analyses of within parity culling patterns show that reproductive failure and lameness are the major reasons for the disposal of young sows, accounting for about 42% and 17% of first and 35% and 16% of second litter culls respectively (Dagorn and Aumaitre, 1979; D'Allaire et al., 1987; Dijkhuizen et al., 1989; Stein et al., 1990; Lucia et al., 2000). As commercial breeding inventories are represented by a high proportion of young sows, which are prone to reproductive failure and the accumulation of non-productive days, an improvement in lifetime productivity can only be achieved by a reduction in the wastage of maiden gilts and first and second litter sows.

**Table 1. Reasons (%) for culling sows from commercial herds (all parities).**

	Britain <sup>4</sup>	USA <sup>3</sup>	France <sup>1</sup>	Netherlands <sup>2</sup>
Reproductive failure				
Failure to conceive	17.84	24.6	31.0	25.2
No oestrus	7.77	9.1	5.4	9.0
Total	25.61	33.6	36.4	34.2
Low productivity				
Old age	28.51	8.7	27.2	11.0
Small litters	2.08	14.1	4.0	6.2
Health/physical damage	7.66	3.1	-	16.0
Mothering ability	3.84	4.9	8.4	13.9
Lameness/leg weakness	7.34	13.2	8.8	10.5
Death	5.47	7.4	6.5	-
Aborted	1.89	-	2.8	-
Miscellaneous	17.60	15.0	5.9	8.2

(Source: <sup>1</sup>Dagorn and Aumaitre, 1979; <sup>2</sup>Dijkhuizen et al., 1989; <sup>3</sup>Lucia et al., 2000; <sup>4</sup>MLC, 2005b)

## CURRENT RECOMMENDATIONS

The rationale behind current nutritional standards and targets for age, weight and fatness at first mating is to ensure that gilts have reached sufficient maturity and have adequate reserves of body lean and fat which can support reproductive performance over several parities. For example, Close (2003) recommends that gilts should be first mated at the 2<sup>nd</sup> or 3<sup>rd</sup> oestrus, when they are between 220 and 230 days of age, weighing between 130 and 140 kg with 16 to 20 mm backfat thickness at P2. Whittemore (1998) has placed importance on the need to achieve adequate stores of fat at the start of the breeding life and has recommended a backfat depth in excess of 18 mm (>17% body lipid) at this stage. A target weight of around 130 kg and an age of 220 days at first mating are suggested for optimum subsequent fertility and longevity. An outline of the nutritional strategy to achieve these targets is based on a combination of reduced protein levels in the diet to limit lean gain and encourage fat deposition and feed restriction to restrict growth and allow attainment of maturity.

Whilst these age, weight and fatness targets appear to be universally known to pig producers, vets and nutritionists, it would be interesting to establish the extent to which they are followed and how many gilts are weighed and measured for fatness to ensure that they fall within the recommended limits. As Foxcroft et al. (2005) conclude, “age is not a good measure of weight or fatness, and the only way to be certain that gilts are at target weight for breeding is to weigh them.” By inference this would also apply to fatness.

## **FATNESS**

It would be reasonable to conclude that current recommendations and thinking over gilt rearing continue to be dominated by the importance of fatness at first mating to lifetime productivity. This raises the following questions:

What is the intrinsic relationship between fatness at first mating and lifetime productivity?

What is the effect of manipulating fatness at first mating on lifetime productivity?

### **Fatness and Lifetime Productivity**

There are few published studies on the intrinsic relationship between fatness at first mating and lifetime productivity of the gilt, because such studies require a large number of animals and the time taken to complete the work may extend over several years. Additionally the interpretation of any findings, such as a positive correlation between fatness and lifetime productivity, requires caution: correlations do not prove causation and may be confounded by other factors such as age and weight at mating.

In a large scale study, Gaughan et al. (1995) found that gilts with backfat depths of between 9 to 13 mm at selection farrowed fewer litters and produced fewer lifetime total born alive (2.81; 24.03) than gilts with depths of 14 to 16 mm (3.47; 30.86) and  $\geq 17$  mm (3.75; 32.76) respectively. These results would indicate a lifetime difference of an extra 9 piglets born alive associated with an extra 6 mm of backfat in gilts before exposure to the boar at 165 days of age. Similarly Challinor et al. (1996) reported an increase in the number of lifetime born alive from 51.2 to 59.8 as mean P2 backfat depth increased from 14.6 to 21.7 mm at first mating. However in this study gilt body weight at first mating had statistically a more significant correlation with lifetime born alive than P2.

In contrast, a retrospective analysis of the data from a study conducted by the Meat and Livestock Commission (MLC; see below) showed no relationship between gilt backfat depth at first mating and lifetime productivity for all animals and for those able to successfully complete their sixth parity (Figures 1 and 2). There was also no evidence supporting a positive relationship between mean fatness at first mating and the number of parities completed at disposal as a measure of longevity (Figure 3). It is also worth mentioning that as with fatness, we found no clear relationship between gilt body weight at first service and lifetime productivity and longevity. Similarly Rozeboom et al. (1996) and Williams et al. (2005) found no differences in lifetime reproductive performance recorded over three parities that could be related to body composition of gilts at first service, with Foxcroft et al. (2005) concluding that it is hard to suggest that there are any inherent differences in lifetime reproductive performance that can be ascribed to the relative leanness of the sows *per se*.

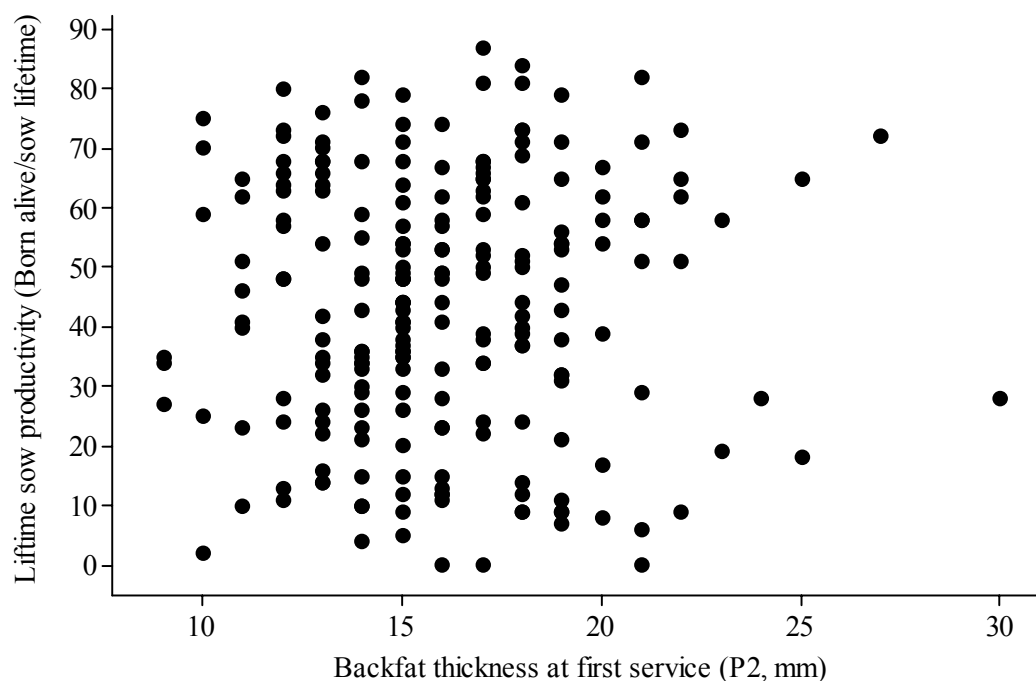
### **Manipulating Fatness and Effects on Lifetime Productivity**

An alternative approach to understanding the role of fatness in lifetime productivity is from the manipulation of backfat at first mating for the study of any long-term effects on sow reproductive performance. Such an approach may hold greater scope and value in females

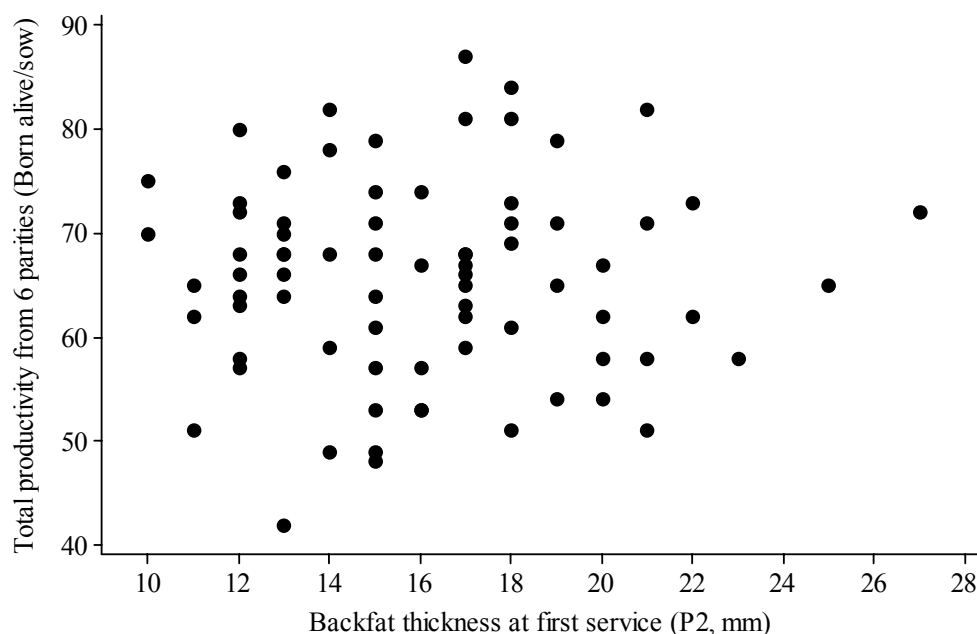


from genetic lines selected for increased lean content, as a reduction in fatness in these genotypes has been associated with a fall in reproductive performance (Nelson et al., 1990; Kerr and Cameron, 1995).

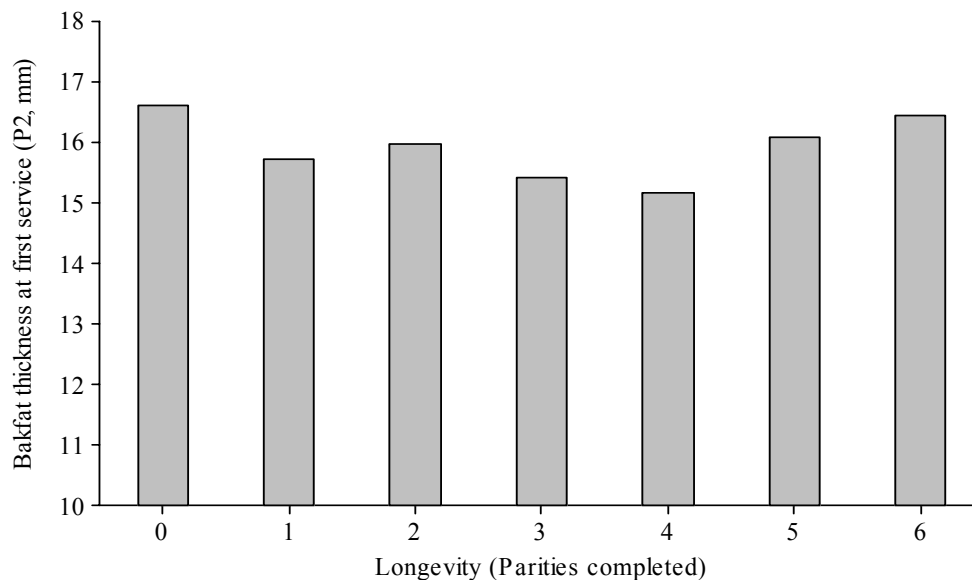
**Figure 1. Lifetime productivity and backfat at first service.**



**Figure 2. Productivity from sows completing 6 parities and backfat at first service.**



**Figure 3. Longevity and backfat at first service.**



Fat manipulation studies in gilts genetically determined to achieve high P2 values have mainly employed intake restriction or dietary energy diluent treatments to reduce fatness. In lean gilts, where an adjustment in feed allowance may simply shift body weight and not composition, manipulation strategies have aimed to increase fat deposition by reducing dietary protein content, thus partitioning net energy in favour of lipid deposition.

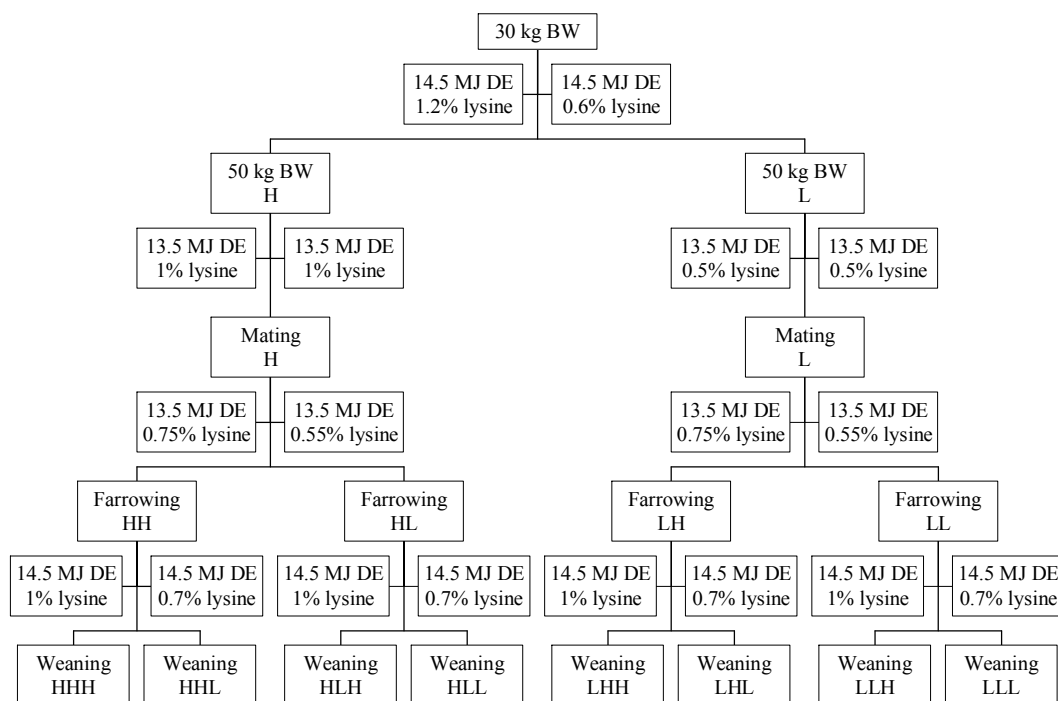
Studies using feed allowance treatments to investigate the effects of fatness on lifetime litter productivity have generally proved inconclusive (Simmins et al., 1992; Sorensen et al., 1993; Rozeboom et al., 1996). Longevity can be reduced due to culling for lameness and reproductive failure, where feeding allowance results in animals with body condition extremes (Danielsen et al., 1993). This is likely to interact with housing, where the provision of an optimal physical and thermal environment diminishes the risk of premature culling associated with feeding allowance effects on body condition (Simmins et al., 1993; Dourmad et al., 1994).

In Britain, the development of ultra lean genotypes has been driven by consumer pressure and producer payments based on tight processor carcass P2 and weight specifications. There has been concern over the negative effects that this may have on longevity and lifetime productivity of replacement gilts for the production of slaughter pigs with P2 values currently averaging 11.0 mm with a carcass weight of 74.4 kg (MLC, 2006). This led to research at Aberdeen on the long-term benefits of nutritionally enhancing and conserving fatness in gilts by feeding a low protein diet (11.3% CP; 0.45% lysine; 13.0 MJ DE/kg) before and during pregnancy to restrict lean gain and increase fat deposition and the provision of a high-nutrient density diet (18% CP; 0.95% lysine; 14.8 MJ DE/kg) during lactation to limit fat loss (O'Dowd et al., 1997). The implementation of this strategy over three consecutive parities did not influence litter size and performance but significantly reduced the first weaning to

conception interval and number of sows culled for reproductive failure, especially before the second pregnancy. These sows had reduced P2 and weight losses in lactation and maintained a P2 advantage of around 3 mm over 3 parities resulting in 18 mm following weaning of the third litter compared with 15 mm for sows fed a single diet in pregnancy and lactation containing 16% CP, 0.75% lysine and 13.0 MJ DE/kg.

The MLC further investigated the scope for increasing fat levels in commercial replacement gilts before first service by introducing them to a low-protein diet at around 30 kg, much earlier than the 105 kg live weight used in the Aberdeen study. Using a low (L) versus high (H) dietary lysine treatment comparison during rearing (30 kg to first mating), pregnancy and lactation, the MLC study subjected gilts to 1 of 8 different nutritional pathways from 30 kg to weaning of the first litter (Figure 4). Thereafter all sows were fed and managed according to standard commercial procedure. Longevity, sow and reproductive performance and reasons for culling were monitored over 6 parities. A total of 361 Large White x Landrace gilts from 4 major breeding companies were placed on trial and 75 were serially slaughtered for determination of dietary effects on body composition at 30, 50 and 90 kg body weight and at mating, farrowing and weaning of the first litter (Gill, 2006). Further details have been described by Edge et al. (2003).

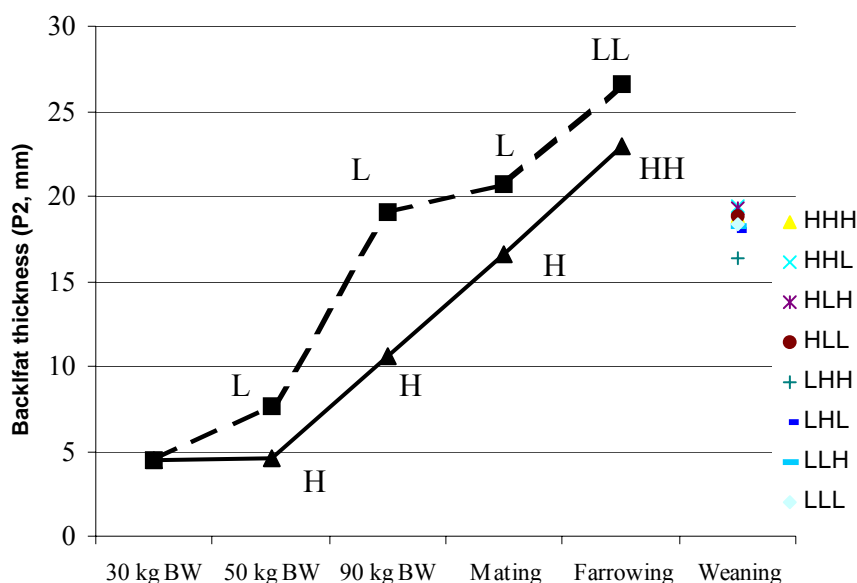
**Figure 4.** Diagram illustrating the dietary treatments fed to gilts from 30 kg BW to weaning of the first litter. The high (H) or low (L) designation indicates a high or low lysine diet from 30 to 50 kg BW, from 50 kg BW to mating, during pregnancy and lactation.



The key findings of the study are as follows:

- From 30 kg BW to mating at either 3<sup>rd</sup> or 4<sup>th</sup> oestrus, L fed gilts had reduced daily gain (632 vs. 749 g/day), reached first oestrus 10 days older and were lighter at service (123.8 vs. 136.7 kg BW).
- Gilts fed L diets during rearing and pregnancy remained around 4 to 6 kg BW lighter at weaning the first litter and the effect of the L rearing diet on sow BW remained through to weaning of the 6<sup>th</sup> litter (234.6 vs. 243.8 kg BW).
- Serial slaughter showed that L fed gilts were fatter at mating (20.73 vs. 16.53 mm P2), but P2 differences across treatments were reduced at farrowing, with no evidence of residual rearing, gestation and lactation dietary treatment effects on P2 at weaning the first litter (Figure 5).
- Gilts fed diet H during pregnancy produced increased number born alive at their first litter (10.26 vs. 9.47) but there were no other significant treatment effects on litter productivity within parity, lifetime productivity (averaging 39 born alive) or total productivity (averaging 65 born alive) of sows that successfully completed 6 parities.
- Feeding the H diet during rearing, tended to reduce sow longevity, with lameness being the major reason for culling sows on this dietary treatment (Figs 6 and 7).

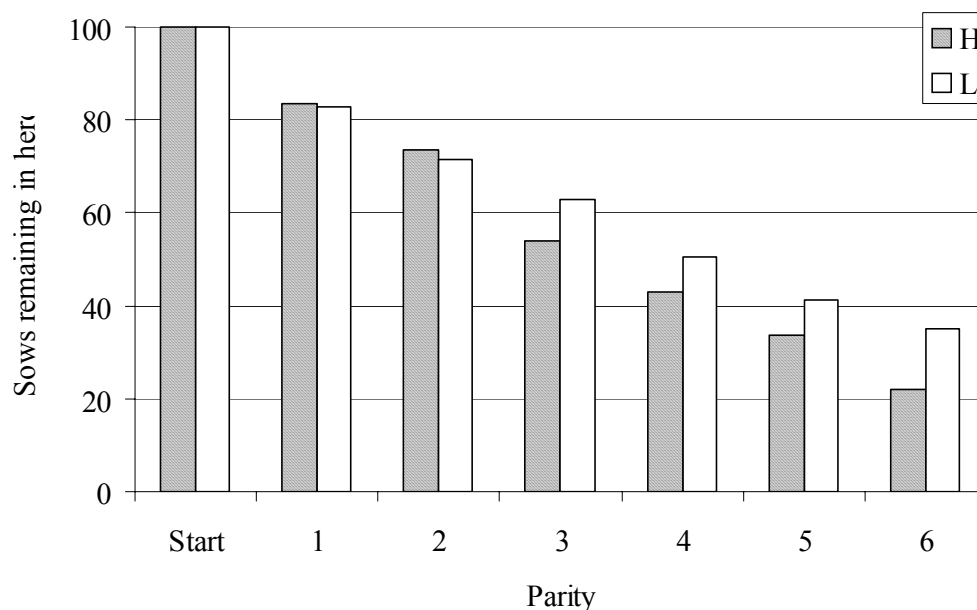
**Figure 5. Changes in body fatness (P2) during rearing, at mating, farrowing and weaning according to high (H) and low (L) lysine dietary treatments.**



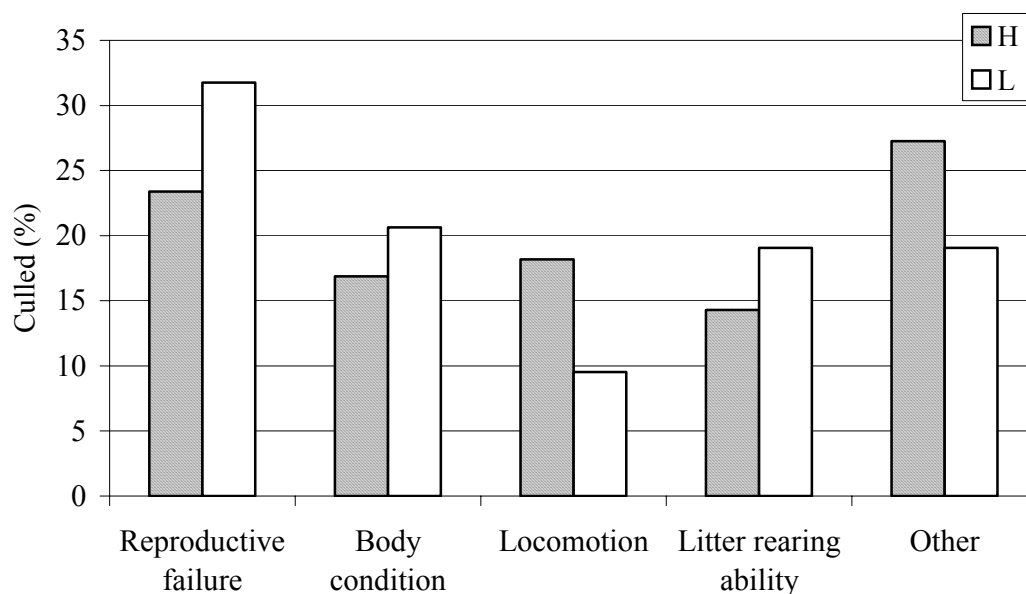
In conclusion, this study has shown no lifetime or total 6 parity litter productivity benefits from increasing fatness in lean gilts at first mating by dietary adjustment of protein intake during rearing. Dietary achieved increases in fatness were transient. Any residual effects disappeared by weaning of the first litter. The potential protective benefits to sow longevity from feeding a low protein diet during gilt rearing are probably the result of the long-term reduction in sow body weight and in turn reduced risk of foot and leg injury rather than any cushioning role of fatness. The research points to the potential benefits of rearing gilts on diets formulated to meet protein requirements for the early attainment of puberty,

accumulation of lean mass for body condition and during first pregnancy higher protein diets to meet lean growth requirements for body condition and increased number born alive. However adjustments in intake may be required to control rapid gains in body mass and limit the risk of lameness under this strategy.

**Figure 6. Percentage of sows remaining in the herd by parity according to high (H) and low (L) lysine dietary treatment before first service.**



**Figure 7. Culling pattern according to high (H) and low (L) lysine dietary treatment before first service.**



Our conclusions would support the work of the Alberta group recently summarised by Foxcroft et al. (2005) in that from a fertility and prolificacy perspective, fatness is simply not the key risk factor and in contrast, lean tissue mass is a key consideration for correct management of the gilt, and the lactating and weaned sow.

## **FITNESS**

It is tempting to suggest that historic and to some extent continued focus on fatness has been detrimental to our thinking over the importance of other factors which may exert greater influence on sow longevity and productivity. A more holistic approach would be to consider how we could improve the overall well being and fitness of gilts and sows and therefore their robustness against environmental factors, which may predispose them to premature reproductive failure and lameness. Two important components of fitness that will be considered in this paper are body condition and the soundness of legs and feet.

### **Body Condition**

Whilst body condition scoring (BCS) may not be an ideal substitute for weighing and measuring fatness in sows, BCS is a very easy and practical method for assessing the fitness of each animal at critical stages of its reproductive life. Scoring at gilt selection, mating, mid-pregnancy, after farrowing and weaning enables timely adjustments in feeding allowances or modifications to diet formulations to avoid subsequent problems associated with poor condition scores. Sows with high scores (e.g.  $\geq 4$ ) will be at increased risk of lameness, reduced appetite during lactation and excessive weight loss, resulting in an extended weaning to conception interval. Pre-weaning mortality of pigs was found to be higher on farms with sows scoring 4 or 4.5 for body condition (Defra, 2005). Sows with low scores (e.g.  $\leq 2$ ) may fail to return to oestrus, have prolonged weaning-to-oestrus intervals, reduced conception rates and may be at increased risk of physical damage such as the development of shoulder sores during nursing of their piglets.

In pigs, BCS provides an overall assessment of muscularity together with a general but poor indication of the amount of subcutaneous fat cover on the animal. Unless there is an excessive layer of fat present, it is extremely difficult to accurately assess fatness or fat depth in pigs by visual assessment or feel. The potential for confusing fatness with muscularity is illustrated in the photographs (Figures 8 and 9) of pre-pubertal gilts on the MLC study described above. Gilts visually considered to be 'thin' and in poor body condition (e.g.  $<2$ ) were on the low-protein rearing diet with P2 values around 4 to 5 mm greater than their contemporaries which were fed the high-protein diet giving increased lean deposition, greater muscularity and a rounder 'fatter' appearance with a condition score of around 3. The body lipid content of the poorer scoring gilts was around 4 to 8% higher than in the better scoring gilts.

Potential misconceptions over BCS and fatness can lead to incorrect management interventions with potentially serious consequences for the well being and productivity of the overall herd. For example, young sows in poor body condition score (e.g.  $<2$ ) after weaning their first litter may be fed low protein diets during pregnancy to encourage fatness or limit

body gain, a strategy which is exactly in reverse of the need to increase protein intake to support the continued requirement for lean growth, muscle mass and improved body condition at farrowing. Under this situation sows already lacking muscle mass may further lose body condition as an essential protection from the physical environment, predisposing them to shoulder sores in farrowing crates.

**Figure 8. Gilts fed low lysine diets during rearing.**



**Figure 9. Gilts fed high lysine diets during rearing.**



The general advice, when using a typical BCS ranging from 1 to 5 (Figure 10), is to aim for a body condition score of 3 at farrowing, which may fall to 2.5 at weaning with adjustments in individual feeding allowances according to an individual's condition score over the subsequent pregnancy for all sows to return to a score of 3 again at farrowing.

**Figure 10. Body condition scores for sows (typical 1 to 5 scale)**



Score 1



2



3



4



5

## Sound Legs and Feet

After reproductive failure, lameness is the second cause of premature culling of young sows, with around 16 to 17 % of first and second litter sows removed for this reason (Dagorn and Aumaitre, 1979; D'Allaire et al., 1987; Dijkhuizen et al., 1989; Stein et al., 1990; Lucia et al., 2000). In one survey of farm records (Boyle et al., 1998), problems with locomotion accounted for nearly 32% of all first parity disposals.

Lameness may also be the underlying problem explaining a proportion of young sows removed for failure to show heat and conceive as the reproductive physiology of an animal may be impaired by stress and pain. At insemination pain may interfere with the release of oxytocin for uterine contractions and effective transport of sperm to the site of fertilisation. Lamé sows may be less reluctant to stand for feeding and drinking, predisposing them further to body condition loss, urinary and genital infection and reproductive failure. Additionally, lame sows represent a significant risk factor in the mortality of piglets before weaning from overlying (Defra, 2005) as lameness reduces agility and the sow's ability to move away from piglets at risk and respond rapidly to distress calls from piglets during crushing.

Rapid growth and increased body weight before mating and excessive body condition scores (>4) predispose gilts and young sows to lameness, presumably because of skeletal immaturity and the additional body weight burden on legs and feet. In these sows, natural mating may further increase the risk of foot and leg injury as the sow may support up to 50% of the boar's weight on her hind legs.

Sow body weight and skeletal maturity as risk factors for leg and foot injury cannot be taken in isolation of the interaction and impact of the physical environment, particularly floor type, quality and repair. In a comparison of two contrasting flooring types, MLC research found a significant increase in bursitis scores and the prevalence of lameness in finishing pigs housed on fully-slatted compared with straw based housing. The number of pigs removed for lameness was almost two-fold greater from the fully-slatted compared with the straw based system. Flooring type was associated with different patterns of foot damage; pigs on straw had poorer scores for toe erosion, while those kept on fully-slatted flooring had more severe sole and heel erosions (Scott et al., 2006). Field experience further suggests that with liquid feeding, spillage of feed containing high levels of soluble non-starch polysaccharides onto plastic slats can create a hazardous flooring surface resulting in high levels of leg injury from slippage.

These studies and observations suggest that gilts reared on different flooring systems may go on to develop different forms and severity of lameness on transfer to the breeding herd after mating and that flooring type in the breeding unit represents an additional risk factor for the premature disposal of sows due to locomotion. Boyle et al. (1998) concluded that lameness was a major welfare problem, possibly resulting from gilts failing to adapt to changes in housing and flooring system following transfer from the gilt pool to the breeding herd.



## **Attainment of Reproductive Function**

It is not within the scope of this paper to review many of the various factors which can influence the attainment of puberty in maiden gilts as these have been addressed comprehensively in the published literature (e.g. Gordon, 1997). One aspect within the theme of this paper is to consider if there are any secondary factors that may interfere with the expression of reproductive function, for example failure to show heat, and result in the premature disposal of gilts which are otherwise fit for breeding.

A number of studies have shown that the quality of the aerial environment can influence the attainment of puberty. For example, Malayer et al. (1987) found that a reduction in aerial ammonia concentration from 21 to 5 ppm significantly increased the percentage of gilts reaching puberty by 29 weeks of age (20 vs. 35%). Higher ammonia concentrations were considered to depress the gilt's ability to detect boar olfactory signals, as hormonal patterns associated with the onset of puberty were not affected. In a subsequent study (Malayer et al., 1988), a higher proportion of gilts attained puberty within 7 to 10 days after boar contact from 26 weeks of age when exposure to aerial ammonia was reduced from 20 to 6 ppm from 10 weeks of age. Sensitivity to ammonia in pre-pubertal gilts declines with age but exposure to high concentrations (35 ppm) from 18 to 24 weeks of age can reduce body weight at puberty and potentially number born alive (Diekman et al., 1993). These studies also raise the possibility that other undersirable aerial gases and dust may interfere with sensory receptors for boar olfactory cues and the attainment of puberty in gilts. Where aerial ammonia concentrations are potentially interfering with the gilt's sensory detection of male pheromones, earlier attainment of puberty and the quality of the insemination process could be improved by strategic use of low protein amino acid supplemented diets as this is known to reduce effluent ammoniacal nitrogen content and ammonia emissions (Portejoie et al., 2004; Leek et al., 2005; MLC, 2005a). However it is important that such diets are formulated to meet amino acid requirements for lean gain and subsequent productivity.

## **GENERAL RECOMMENDATIONS**

One size does not fit all and this is very much a universal conclusion when making recommendations for pig production, including feeding and management of gilts to optimise longevity and lifetime productivity. The recommendations that follow (Table 2) are intended to assist producers in working towards the goal of achieving fitness in gilts from the point of first mating and management through to weaning of the first litter, the first critical steps in establishing the young sow to produce 60 or more born alive.

## **CONCLUSIONS**

Premature culling of young sows for reproductive failure and lameness remains a barrier to achieving a lifetime productivity of 60 or more born alive per sow lifetime. With the development of lean genotypes, current recommendations may need to shift from a focus on fatness to one of fitness, where fitness includes feeding for body condition as a practical

indicator of lean mass and to a lesser extent fatness, and the development of sound feet and legs. Management of the young sow to avoid extreme fluctuations in body condition and the negative effects this has on reproduction and locomotion is central to the goal of improving lifetime productivity. In future, we may have to take a more holistic approach in managing replacement breeding stock and young sows as a precious resource in the sustainable production of pork and pork products.

**Table 2. Recommendations to assist producers in working towards fitness in gilts.**

Stage	Recommendations
Rearing (30 kg to 100 kg)	Gilts should be fed <i>ad libitum</i> standard grower (30 to 60 kg BW) and finisher (60 to 100 kg BW) diets. They should be housed on good quality flooring, preferably solid concrete with bedding, with floor space that encourages exercise and the development of sound feet and legs.
Selection to first service (100 kg to around 135 kg BW)	Gilts should be fed a finishing diet (0.8% lysine, 13.5 MJ DE/kg) to support continued requirements for lean (and fat) deposition but intake should be restricted to around 80 to 90% of appetite to control rapid weight gain and reduce the risk of lameness. The aim should be to achieve a body condition score of 3 at first service at either the 2 <sup>nd</sup> or 3 <sup>rd</sup> oestrus. Leg and foot injury must be prevented by housing on good quality solid flooring and the provision of adequate bedding for physical comfort. Space allowance should allow exercise and movement for the development of sound feet and legs. Ammonia levels must be controlled to optimise olfactory communication between gilts and boars, to stimulate the attainment of puberty and a high quality insemination. The importance of a well managed Gilt Development Unit to ensure a consistent flow of high quality gilts into the breeding herd and the positive impact this has on herd parity profile and key indicators of performance has been discussed at a previous London Swine Conference by (Foxcroft, 2005).
First pregnancy	During first and into the second pregnancy, the young sow is still genetically programmed to gain lean mass. She should be fed a diet containing 0.7 to 0.8% lysine and 13.5 MJ DE/kg, and daily allowance controlled to ensure that a body condition score of 3 is held through to farrowing. Avoid over feeding, as sows scoring higher than 3.5 will have difficulty farrowing, reduced appetite during lactation, excessive weight loss and delayed return to oestrus. Flooring quality must promote sound locomotion.

... continued on next page

First Lactation	High feed intake at this time is critical to meet litter demands and avoid excessive weight loss and subsequent reproductive problems. A diet containing 1.0% lysine and 14.5 MJ DE/kg should be fed to meet protein and energy requirements. Daily feed allowances should follow the developing appetite curve of each sow, based on day of lactation and number of piglets nursed, as in the MLC's Stotfold Sow Feeding Strategy (MLC, 1998).
Weaning to rebreeding	Sows can continue to be fed the lactation diet at around 3 to 4 kg per day.
Second pregnancy	For sows that have lost excessive body weight during lactation, this is a critical time to re-condition them using a diet that helps the recovery of body mass, largely consisting of lean in lean genotypes. A diet containing 0.7 to 0.8% lysine and 13.5 MJ DE/kg will help lean recovery with daily allowances adjusted to achieve a body condition score of 3 at farrowing. Failure to re-condition sows will increase the risk of shoulder sores developing during the ensuing lactation. In subsequent parities, lysine content should be dropped to 0.6% with feeding allowances always targeting a return to a body condition score of 3 at farrowing.

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# **BREAK-OUT SESSIONS**





# ALTERNATIVE FEED INGREDIENTS FOR PIGS

Hans Stein<sup>1</sup> and Kees de Lange<sup>2</sup>

<sup>1</sup> Department of Animal Sciences, University of Illinois, Urbana, Illinois 61801 USA

<sup>2</sup> Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario  
N1G 2W1 Canada

Email: hstein@uiuc.edu or cdelange@uoguelph.ca

## ABSTRACT

Largely due to the demand for grains for the bio-fuel industry, the cost of feed energy will increase worldwide. Therefore, alternative energy supplying pig feed ingredients should be explored, including distillers dried grains with solubles (DDGS), field peas, wheat shorts and liquid co-products from the bio-fuel and food industry. The inclusion of DDGS in diets is limited by the fiber concentration in DDGS and for finishing pigs, also by the concentration of unsaturated fatty acids. However, most groups of swine can be fed at least 20% DDGS and sometimes, greater concentrations can be used. The concentration of available energy in DDGS is similar to corn, but some sources of DDGS have low concentrations of digestible lysine. To avoid feeding these sources, it is recommended that only DDGS that has a lysine to crude protein ratio that is greater than 2.80% is used in diets fed to swine. Field peas also contain available energy in amounts that are similar to corn and the pea protein has a high concentration of lysine, but a low concentration of methionine, cysteine, threonine, and tryptophan. Crystalline sources of these amino acids are, therefore, often required, if field peas are included in the diets. Diets fed to weanling pigs and sows may contain at least 20% field peas without changing pig performance. If the peas are extruded or micronised prior to feeding, greater concentrations may be used. Diets fed to growing-finishing pigs, may contain up to 70% field peas and no soybean meal is needed in these diets. Wheat shorts have been available for use in swine diets for many years. The available energy content of wheat shorts is lower than that of corn, but it contains more digestible amino acids and phosphorus than corn. If diets are formulated carefully, growing-finishing pig diets may contain 40% wheat shorts without compromising pig performance. Liquid feeding allows the use of liquid co-products such as whey, whey permeate, corn distillers solubles, brewers yeast, sugar syrup, and corn steep water. The nutritional value of these co-products has been characterized and recommendations for their use in pig diets are made. These co-products are generally more variable in nutritional value, which should be considered carefully when formulating and costing swine diets.

## INTRODUCTION

Largely due to the demand for grains for the bio-fuel industry, the cost of feed energy will increase worldwide. It has been estimated that the cost of feed energy will likely increase by approximately 10%, while the cost of feed protein is likely to decline by more than 20% between 2006 and 2012 (Hickling, 2006). Feed protein will become cheaper because of increased supply of protein containing co-products from the bio-fuel industry, such as

distillers grains and distillers solubles. In this contribution the nutritional value and use of a select number of alternative pig feed ingredients is addressed.

## **DISTILLERS DRIED GRAINS WITH SOLUBLES**

Distillers dried grains with solubles (DDGS) is a co-product from the fuel ethanol industry. Barley, wheat, sorghum, or corn may be used in the production of ethanol and the resulting DDGS is characterized by the grain that was used. However, even when the same grain is used, variability in the chemical composition of DDGS may be observed.

### **Energy and Nutrient Concentration and Digestibility**

Analyzed concentrations of energy, phosphorus, and amino acids in DDGS are presented in Tables 1 and 2 along with measured contents of digestible energy, digestible phosphorus, and digestible amino acids. The average concentration of gross energy in DDGS is approximately 5,530 kcal GE per kg dry matter (**DM**). This value is greater than in corn. However, the digestibility of energy in DDGS is lower than in corn and the measured concentration of digestible (**DE**) and metabolizable (**ME**) energy in DDGS is 4,140 and 3,897 kcal per kg DM, respectively (Pedersen et al., 2007). These values are not different from the DE and ME in corn (Table 1).

**Table 1. Concentration and digestibility of energy and phosphorus in corn and 10 samples of DDGS fed to growing pigs <sup>a,b</sup>**

Item	Ingredient:	Corn	DDGS			
			Average	Standard deviation	Lowest value	Highest value
Gross energy, kcal/kg DM		4,496	5,434	292	5,272	5,592
Apparent total tract digestibility, %		90.4	76.8	2.73	73.9	82.8
Digestible energy, kcal/kg DM		4,088	4,140	205	3,947	4,593
Metabolizable energy, kcal/kg DM		3,989	3,897	210	3,674	4,336
Total P, %		0.20	0.61	0.09	0.51	0.74
Apparent digestibility of P, %		19.3	59.0	5.2	50	68
Digestible P, %		0.04	0.36	0.06	0.28	0.47

<sup>a</sup> Data from Pedersen et al., 2007.

<sup>b</sup> All data are based on 11 observations per treatment.

The phosphorus concentration in DDGS is approximately 0.61%, and the apparent total tract digestibility of phosphorus in DDGS is approximately 59% (Table 1). The corresponding value for corn is 19.3% (Pedersen et al., 2007). Therefore, if DDGS is included in diets fed to swine, the utilization of organic phosphorus will increase and the need for supplemental inorganic phosphorus (i.e., dicalcium phosphate or monocalcium phosphate) will be reduced. This will not only reduce diet costs but also reduce the quantities of phosphorus that are excreted into the manure from the animals.

The concentration and standardized ileal digestibility of amino acids (Table 2) varies among sources of DDGS (Stein et al., 2005; Pahm et al., 2006a and b; Stein et al., 2006c; Urriola et al., 2007). This is true in particular for lysine that is more variable than all other indispensable amino acids in terms of digestibility (Fastinger and Mahan, 2006; Stein et al., 2006c). The reason for this variation is believed to be that lysine may have been heat-damaged in some of the samples of DDGS, which has lowered the calculated digestibility of lysine in these samples. To reduce the risk of utilizing sources of DDGS that have a low digestibility of lysine because of heat damage, the lysine to crude protein ratio can be calculated. If the ratio is 2.80% or greater, then the product will have an average or above average quality, but if the ratio is lower than 2.80, then the product has a reduced quality. Because lysine is usually the first limiting amino acid in diets fed to swine, DDGS samples with a lysine to crude protein ratio that is less than 2.80 should not be used.

**Table 2. Crude protein and amino acid concentration and digestibility in 36 samples of DDGS fed to growing pigs<sup>a</sup>**

Item	Concentration, %				Standardized ileal digestibility, %			
	Average	Low	High	SD	Average	Low	High	SD
CP	27.5	24.1	30.9	1.8	72.8	63.5	84.3	5.33
Indispensable AA								
Arg	1.16	0.95	1.41	0.10	81.1	74.1	92.0	5.18
His	0.72	0.56	0.84	0.07	77.4	70.0	85.0	4.58
Ile	1.01	0.87	1.31	0.09	75.2	66.5	82.6	4.77
Leu	3.17	2.76	4.02	0.32	83.4	75.1	90.5	3.85
Lys	0.78	0.54	0.99	0.09	62.3	43.9	77.9	7.61
Met	0.55	0.46	0.71	0.08	81.9	73.7	89.2	4.12
Phe	1.34	1.19	1.62	0.11	80.9	73.5	87.5	3.94
Thr	1.06	0.89	1.71	0.20	70.7	61.9	82.5	5.26
Trp	0.21	0.12	0.34	0.04	69.9	54.2	80.1	6.98
Val	1.35	1.15	1.59	0.11	74.5	65.8	81.9	4.72

<sup>a</sup>Data from Stein et al., 2005; Pahm et al., 2006a and b; Stein et al., 2006c; Urriola et al., 2007.

### Formulating Diets Using DDGS

When formulating diets for growing pigs or lactating sows using DDGS, it is recommended that energy values that are similar to corn are used for DDGS. Diets should be formulated based on standardized ileal digestible amino acids and digestible phosphorus. Because the protein in DDGS is relatively low in lysine, additional crystalline lysine needs to be included in the diet when DDGS is used. As a rule of thumb, for each 10% DDGS that is used, the inclusion of crystalline lysine should be increased by 0.10% (Table 3). By following this principle, approximately 4.25% soybean meal and 5.70% corn can be removed. Because of the greater concentration and digestibility of phosphorus in DDGS than in corn and soybean meal, approximately 0.20% monocalcium phosphate can also be removed from the diet for each 10% DDGS that is used, but additional limestone is needed to maintain a proper concentration of calcium.

**Table 3. Replacement value of 10% DDGS.**

Item	Diet:	Gestation diets	All other diets
Corn		↓ 7.40	↓ 5.70
Soybean meal, 48%		↓ 2.40	↓ 4.25
MCP, %		↓ 0.22	↓ 0.20
Fat		↓ 0.10	↓ 0.05
L-Lysine HCL		↑ 0.03	↑ 0.10
Limestone		↑ 0.09	↑ 0.10

If diets for gestating sows are formulated with DDGS, less soybean meal can be removed from the diet because gestating sows have a relatively greater requirement for digestible tryptophan than lactating sows and growing pigs. Because DDGS has a low concentration of tryptophan, it is possible to maintain a proper tryptophan concentration in gestation diets only if the reduction in soybean meal is limited to 2.40% for each 10% DDGS that is included in the diet. As a consequence, if 10% DDGS is included in gestating diets, the concentration of corn in the diet can be reduced by 7.40%.

### **Inclusion Rates of DDGS in Diets Fed to Swine**

Recent research has shown variable results in pig responses to the inclusion of DDGS in the diets. Excellent performance has been reported from many experiments (DeDecker et al., 2005; Cook et al., 2005; Spencer et al., 2007), but in other cases, pig performance has been reduced (Linneen et al, 2006; Whitney et al., 2006b). Nevertheless, based on current knowledge it is recommended that diets fed to lactating sows, to nursery pigs after two weeks post-weaning, and to growing finishing pigs may contain at least 20% DDGS and diets fed to gestating sows may contain at least 40% DDGS. These inclusion rates will not compromise pig performance if the diets are carefully formulated using the principles outlined above and if a source of DDGS that has a lysine to crude protein ratio that is greater than 2.80% is used (Table 4).

In a recent experiment in which these principles were followed, no negative effect on pig performance was observed (Table 5). It is also possible that greater inclusion rates can be used if a good source of DDGS is available and some producers are successfully using up to 35% DDGS in diets fed to growing pigs, but the research to support such inclusion rates has not yet been conducted.

### **Other Consequences of Using DDGS**

The relatively high concentration of fat in DDGS may increase problems with feed bridging in bins and feeders. In some cases, therefore, it may be necessary to modify storage and delivery systems if DDGS is used in the diets. Diets containing DDGS are also bulkier than diets without DDGS. As a rule of thumb, for each 10% DDGS that is included in the diet, the volume of the diet will increase by approximately 3% compared with a corn-soybean meal diet.

**Table 4. Recommended and maximum inclusion levels in diets fed to different categories of swine.**

Category	Recommended <sup>a</sup>	Maximum <sup>b</sup>
Gestation	30	50
Lactation	20	30
Nursery, week 0-2	0	20
Nursery, after wk 2	20	30
Grower	20	35
Early finisher	20	35
Late finisher	20	20

<sup>a</sup>Recommended inclusion levels based on a review of experiments in which DDGS was included in diets fed to swine.

<sup>b</sup>Maximum levels of DDGS that have been successfully used under field conditions. These inclusion levels may not always maximize pig performance.

**Table 5. Effects of including 0, 10, or 20% DDGS in diets fed to growing-finishing pigs<sup>a</sup>**

Item	Diet:	Control	DDGS		SEM	P-Value	
			10%	20%		Linear	Quadratic
Initial wt, kg		22.1	21.85	22.47	0.48	0.82	0.40
Final wt, kg		124.1	127.7	124.9	2.77	0.77	0.23
Average daily gain, kg		0.89	0.93	0.90	0.02	0.76	0.22
Average daily feed intake, kg		2.57	2.75	2.60	0.08	0.78	0.11
Gain to feed ratio, kg/kg		0.35	0.34	0.35	0.01	0.94	0.32
Hot carcass wt, kg		88.3	91.7	88.7	2.54	0.91	0.25
Dressing, %		71.1	71.8	71.0	0.48	0.85	0.23
Lean meat, %		51.30	50.15	51.17	1.20	0.92	0.31
10 <sup>th</sup> rib backfat, cm		2.50	2.60	2.40	0.21	0.70	0.46

<sup>a</sup>Data from Widmer et al., 2007.

The fat in DDGS has a relatively high concentration of unsaturated fatty acids, which may cause increased belly softness of pigs fed diets containing DDGS (Whitney et al., 2006b). This may become a problem if the finishing diet contains more than 20% DDGS. The inclusion of DDGS in diets fed to nursery and growing pigs may improve intestinal health and reduce problems with ileitis. Many producers, therefore, prefer to have 20% DDGS in all diets fed to these categories of pigs, but research to demonstrate the health benefits of using DDGS has been inconclusive (Whitney et al., 2006a). Increased litter sizes of sows fed diets containing DDGS has also been reported from one experiment, but more research in this area is needed to verify the positive effects of DDGS on litter size.

## FIELD PEAS

Field peas (*Pisum sativum L.*) have been grown for centuries in many parts of the world. Historically, field peas have been produced mainly for human consumption, but during the last 25 years, the industry has also found markets for field peas in livestock feeding. In Canada, Australia, and Western Europe, the use of field peas in diets fed to swine has increased during this period. In the US, field peas have been included in diets fed to swine in the Pacific Northwest for several decades, but in the Midwest, where the majority of the pigs are produced, very few field peas have been used.

### Nutrient and Energy Concentration and Digestibility

Field peas have a nutrient profile that is intermediate between corn and soybean meal. The digestibility of most amino acids in field peas is similar to that in soybean meal (Table 6), but pea protein has a relatively low concentration of methionine, cysteine, and tryptophan. Therefore, these amino acids may become limiting if peas are included in the formulations.

**Table 6. Amino acid composition of the protein and amino acid and protein digestibility in field peas and soybean meal (as fed basis)<sup>a</sup>**

Ingredient:	Field peas			Soybean meal		
Item:	% of ingredient	% of crude protein	SID <sup>b</sup>	% of ingredient	% of crude protein	SID <sup>b</sup>
Nutrient						
Crude protein	22.8	100	79.9	47.5	100	84.5
Arginine	1.87	8.20	92.8	3.48	7.32	93.0
Histidine	0.54	2.37	88.3	1.28	2.70	89.7
Isoleucine	0.86	3.77	83.4	2.16	4.55	86.3
Leucine	1.51	6.62	85.7	3.66	7.71	86.1
Lysine	1.50	6.58	88.1	3.02	6.36	88.4
Methionine	0.21	0.92	77.9	0.67	1.41	89.1
Cysteine	0.31	1.36	67.3	0.74	1.56	83.9
Phenylalanine	0.98	4.30	86.9	2.39	5.05	86.9
Tyrosine	0.71	3.11	84.7	1.82	3.83	87.2
Threonine	0.78	3.42	80.2	1.85	3.90	85.9
Tryptophan	0.19	0.83	54.3	0.65	1.37	78.5
Valine	0.98	4.30	78.2	2.27	4.78	82.7

<sup>a</sup>Data for amino acid concentration and composition are from NRC (1998). Data for SID of protein and amino acids are from Stein et al., 2004.

<sup>b</sup>SID = standardized ileal digestibility (%).

The concentration of digestible energy (3,864 kcal DE per kg DM) in field peas is similar to that in corn, but peas contain slightly less metabolizable energy (3,741 kcal ME/kg DM) compared with corn (Stein et al., 2004). The digestibility of energy may be improved by 3 – 4 percentage units upon extrusion at 115°C. Likewise, the digestibility of most nutrients will

also be improved if the peas are extruded prior to feeding (Stein et al., 2007). The concentration of phosphorus in field peas is approximately 0.44% and the apparent total tract digestibility of phosphorus in field peas is 55 and 65%, respectively, in diets without or with microbial phytase (Stein et al., 2006a).

### **Diet Formulation with Field Peas**

Lysine and tryptophan are the first limiting amino acids in diets based on corn and field peas, but because of the relatively low concentrations of digestible methionine, cysteine, and threonine in field peas, it is also necessary to pay careful attention to the concentrations of these amino acids. It is often necessary to include crystalline sources of methionine, threonine, and tryptophan in diets based on field peas to formulate a diet balanced in all indispensable amino acids. In contrast, the inclusion of crystalline lysine and inorganic sources of phosphorus may be reduced because of the relatively high concentrations of these nutrients in field peas. The concentration of most nutrients in field peas is intermediate between the concentration in corn and soybean meal. Therefore, if field peas are included in the formula, corn and soybean meal is reduced. As a rule of thumb, 3% field peas will replace approximately 2% corn and 1% soybean meal if crystalline sources of methionine, threonine, and tryptophan are included to balance concentrations of indispensable amino acids. At the same time, the inclusion of crystalline lysine and monocalcium phosphate (or dicalcium phosphate) is reduced. In experiments where field peas were successfully included in diets fed to swine, these principles for diet formulation were followed.

### **Inclusion Rates of Field Peas in Diets Fed to Swine**

Pigs tolerate field peas well and the feed intake is not affected by the presence of field peas in the diets. Recent research with field peas indicates that field peas may be included in diets fed to nursery pigs from two weeks post-weaning at an inclusion level of 15 to 20% (Stein et al., 2004). At this concentration, no negative effects on pig performance have been reported (Table 7). In contrast, the inclusion of 30% field peas in diets fed to weanling pigs resulted in a reduced gain:feed ratio during the initial 2 weeks after weaning, but not during the remaining nursery period (Owusu-Asiedu et al., 2002). Based on these results, it is recommended that field peas should not be included in diets fed to weanling pigs during the initial 2 weeks post-weaning. If the field peas are extruded or micronized, it may be possible to include greater concentrations without any impact on pig performance (Landblom, 2002; Owusu-Asiedu et al., 2002).

In diets fed to growing and finishing pigs, field peas may be included in concentration of up to 60 to 70% of the diets without influencing pig performance (Petersen and Spencer, 2006; Stein et al., 2006b). At these inclusion levels, all of the soybean meal is replaced by field peas. Field peas do not influence feed intake, average daily gain, or the gain to feed ratio (Table 8). Lower carcass drip losses and a more desirable color of the longissimus muscle have been reported for pigs fed diets containing field peas, but other carcass characteristics have not been influenced by field peas in the diets. Likewise, the palatability of pork chops and ground pork patties are not changed by the inclusion of field peas in the diets (Stein et al., 2006b).

**Table 7. Growth performance of weanling pigs fed diets containing field peas <sup>a</sup>**

Field peas, %:	0	6	12	18	SEM	<i>P</i> -value	
						Linear	Quad.
Response							
Average initial weight, kg	7.81	7.81	7.79	7.79	0.68	0.98	0.99
Average finished weight, kg	19.65	20.02	19.90	19.17	1.33	0.79	0.68
Average daily gain, kg	0.423	0.436	0.433	0.407	0.025	0.64	0.44
Average daily feed intake, kg	0.66	0.66	0.70	0.64	0.05	0.91	0.54
Average gain:feed, kg/kg	0.62	0.64	0.62	0.64	0.015	0.66	0.67

<sup>a</sup>Data from Stein et al. (2004). Six pens per treatment and five pigs per pen.

**Table 8. Growth performance and carcass quality of growing-finishing pigs fed diets without or with field peas <sup>a</sup>**

Field peas (%) <sup>b</sup> :	0/0/0	36/36/36	66/48/36	SEM	<i>P</i> -value
Response					
Initial weight, kg	22.9	22.7	22.7	0.55	0.49
Average daily feed intake, kg	2.74	2.60	2.82	0.079	0.12
Average daily gain, kg	0.872	0.860	0.889	0.0247	0.59
Average gain:feed ratio, kg/kg	0.319	0.332	0.318	0.0087	0.38
Final weight, kg	129.0	124.1	129.2	3.18	0.59
Dressing, %	76.2	75.4	75.8	0.34	0.20
10 <sup>th</sup> rib back fat, cm	2.32	2.40	2.41	0.134	0.81
Lean meat, %	51.8	51.0	51.3	0.636	0.67
Drip loss, %	3.38	2.51	1.95	0.322	0.02

<sup>a</sup>Data from Stein et al. (2006b). Each mean represents eight observations with two pigs per pen.

<sup>b</sup>Values represent the inclusion rate (%) of field peas in diets fed from 22 to 50 kg, 50 to 85 kg, and 85 to 125 kg, respectively.

Research conducted at North Dakota State University suggested that the inclusion of 10% field peas in diets fed to lactating sows resulted in increased litter weight gain and a tendency for reduced pig mortality during the lactation period (Landblom et al., 2001). This experiment also showed that there is no negative effect of including up to 30% field peas in diets fed to lactating sows. There are no data available from studies in which field peas grown in North America have been fed to gestating sows. However, data from France suggested that the inclusion of 16% field peas in gestating diets and 24% in lactating diets had no negative effects on sow or pig performance (Gatel et al., 1987).

It is, therefore, concluded that field peas may be included in diets fed to gestating and lactating sows at levels of 20 to 30%, but more research in this area is needed.



## **WHEAT SHORTS**

Wheat shorts, often called wheat middlings in the USA and a co-product from the wheat flour industry, have been available for use in swine diets in Ontario for many years. Numerous nutrient analyses, digestibility and performance studies have been conducted to explore its nutritional value for pigs (Young, 1980; Erickson et al., 1985; Huang et al., 1999; Cromwell et al., 2000; Shaw et al., 2002). These studies indicate that the nutritional value of wheat shorts is comparable to barley and lower than corn, largely because of the lower starch and higher fiber content. In spite of extensive research there is still some resistance among pork producers and nutritionists to accept the use of substantial amounts of wheat shorts in pig diets. The latter may be attributed to various factors, including variability between different batches, low bulk density, variable inclusion of high-fiber wheat bran, high mycotoxin levels in the product, or (negative) interactive effects of high dietary fiber and fat levels on digestive function in pigs.

### **Energy and Nutrient Concentration and Digestibility**

Like any co-product, the nutritional value of wheat shorts varies between batches of ingredients. Therefore, nutrient analyses should be conducted routinely to monitor differences between suppliers and changes over time, and to adjust estimated nutritional values. In particular, close attention should be paid to the fiber content of wheat shorts. For example in a survey in the US of 14 sources of wheat shorts, the NDF content varied from 29.9 to 40.1% (Cromwell et al., 2000). In that survey the crude protein content varied between 14.6 and 17.8%, total lysine content varied between 0.62 and 0.72%, and the phosphorus content varied between 0.70 and 1.19%. Based on an average DE content of 3075 kcal per kg and an average NDF content of 35.7% (NRC, 1998), the estimated DE content of wheat shorts may be reduced with 22 kcal per kg per % increase in NDF content (Zijlstra et al., 1999). For example, when the NDF content is increased to 40.7%, the estimated DE content would be reduced to 2965 kcal per kg. However, given the poor utilization of energy supplied by digestible fiber (and digestible protein), relative to starch, the use of net energy feed formulation systems will more accurately reflect the available energy content of wheat shorts than conventional DE and ME systems (Libao-Mercado et al., 2004).

The negative effect of fiber on energy utilization may be overcome partly by adding fiber degrading enzymes to the diet (Barrera et al., 2004). On the other hand, additional dietary fiber may enhance the feeling of satiety and thereby benefit the well-being of gestating sows fed wheat shorts containing diets. It should be noted, though, that different types of fiber have varying effects on satiety and that no fiber source has been proven as affective as beet pulp to reduce activity levels in gestating sows.

In terms of phosphorus, both the content (0.93 vs. 0.28%) and relative availability (41 vs. 14%) is higher in wheat shorts than corn (NRC, 1998). Even though the content of key essential amino acids is nearly twice as high in wheat shorts as in corn, the amino acid availability in wheat shorts is rather low. This reduced amino acid availability and effect of fiber on increases in amino acid requirements of pigs should be considered carefully when wheat shorts are included in pig diets (Huang et al., 1999; Libao-Mercado et al., 2006).

## Diet Formulations and Inclusion Rates of Wheat Shorts in Diets Fed to Swine

In typical Ontario pig diets wheat shorts is used primarily to replace corn, but it will also reduce the use of soybean meal and inorganic phosphorus. In order to maintain energy density of the feed some additional fat needs to be included when replacing corn with wheat shorts. However, when fat is relatively expensive and increases the feed cost per unit energy (i.e., \$ per MJ or kcal DE in the diet) the use of additional fat is not recommended, and slight reductions in feed efficiencies should be accepted when feeding wheat shorts to pigs.

When the nutritional value of wheat shorts is considered carefully in feed formulation, the use of substantial amounts of wheat shorts in the diet, will not compromise pig performance (Table 9). The maximum recommended inclusion level for wheat shorts is 10% of the diet for starter pigs and 40% of the diet for growing-finishing pigs and sows. However, when the nutritional value of wheat shorts is well defined - in terms of contents of available energy amino acids and phosphorus - inclusion levels may exceed these suggested maxima without compromising pig performance (Erickson et al., 1985).

**Table 9. Impact of including 30% wheat shorts in corn and soybean meal based diets on performance and carcass characteristics of growing-finishing pigs<sup>a</sup>**

	Control	Diet +30% wheat shorts	SEM	P-value
Daily gain <sup>b</sup> , kg	1.017	0.991		
Daily feed intake <sup>b</sup> , kg	2.874	2.812		
Gain:Feed <sup>b</sup> , kg/kg	0.353	0.352		
Dressing percentage <sup>c</sup>	73.9	73.3	0.42	0.10
Loin eye area <sup>c</sup> , cm <sup>2</sup>	38.3	39.5	1.17	0.67
Backfat depth <sup>c</sup> , cm	2.10	1.95	0.13	0.79

<sup>a</sup> Derived from Shaw et al. (2002). Diets were formulated to be similar in content of metabolizable energy, by including additional fat in the wheat shorts containing diet, and balancing calcium, phosphorus and lysine. Diets were fed in meal form to pigs between 28 and 107 kg body weight.

<sup>b</sup> Gain and feed intake data were calculated from data presented for each of three phases in the three phase feeding program, with diet switches at 65 and 79 kg body weight.

<sup>c</sup> Michigan State Meat Laboratory measurements; in contrast to the Canadian carcass grading system, carcass excludes the head.

Because of its low bulk density, the inclusion of wheat shorts in mash feeds can cause feed flow problems and some feed separation. For these reasons, wheat shorts are used more effectively in pelleted feeds. Additional benefits of pelleting are that the utilization of energy in wheat shorts is enhanced slightly and that wheat shorts enhance pellet quality (Young, 1980; Erickson et al., 1985).

A final consideration is that increased dietary fiber levels tend to increase gut fill and size of digestive organs, reducing carcass dressing percentage. Estimates of the effect of feeding

wheat shorts on reductions in carcass dressing percentage vary between 0.6 (Table 9) and 2.0 percentage units (Libao-Mercado et al., 2004).

## **LIQUID FEED INGREDIENTS**

Liquid feeding allows the use of liquid and inexpensive co-products from food and bio-fuel industry, such as whey, whey permeate, corn distillers solubles, brewers yeast, sugar syrup, and corn steep water. In research conducted during the last few years at the University of Guelph, the nutritional value of these products has been characterized. Moreover, laboratory-based studies have been conducted to enhance the nutritional value of corn distillers solubles, corn steep water, as well as high-moisture corn mixed with water, through steeping with enzymes or inoculation with beneficial bacteria. Results of these studies have been presented in detail elsewhere (Braun and de Lange, 2004; de Lange et al., 2006) and can be accessed at the website of the Swine Liquid Feeding Association (SLFA, 2007). A summary of estimated nutritional value of these co-products is presented in Table 10.

In general and when the nutritional value of these liquid co-products is estimated from dry matter content and levels of key nutrients (ash, crude protein, crude fat, starch, sugars, remaining organic material) within dry matter, these co-products can be used for growing-finishing pig diets at levels up to 15% of diet dry matter content without compromising pig performance, carcass or meat quality (de Lange et al., 2006). In some cases improvements in pig growth performance were observed: replacing dry corn with liquid whey permeate in phase III pig starter diet, or including 5% of corn steep water in growing pig diets, improved growth rate. Improvements in pig growth performance can also be expected when feeding liquid whey, but the availability of liquid whey will continue to decline. Whey is increasingly further processed to isolate specific whey proteins that are marketed as value added and functional foods for humans.

Utilization of liquid feed ingredients requires specialized liquid feeding equipment and ingredient storage capacity, which should be considered when conducting cost-benefit analyses. Moreover, liquid feeding tends to increase the manure volume as compared to conventional dry feeding, largely because of increased water usage to move the mixed liquid feed to the feed troughs. Finally, additional expertise is required to adjust liquid feed formulations - when supplies or nutritional values of liquid feed ingredients change, or to account for extremely sodium, chloride and potassium levels in some liquid co-products - and to manage computerized liquid feeding systems.

**Table 10. Determined nutrient content (% in dry matter), estimated digestible energy, amino acid and phosphorus contents (in dry matter) for the main liquid pig feed ingredients in Ontario.**

	Corn distillers solubles (stored)	Whey (fresh)	Condensed whey permeate (fresh)		Corn Steep water (stored)	Sugar syrup (fresh)	Brewers Yeast (stored)
			#2	#3			
Dry matter, %	27.2	5.4	31.1	22.5	44.6	69.2	12.5
Nutrient composition, % of dry matter <sup>1</sup>							
Ash	10.0	12.3	11.06	7.62	18.8	0.42	7.55
Crude protein	25.2	13.3	8.18	2.97	50.0	0.32	52.42
Crude fat	22.4	0.3	1.06	0.29	0.3	1.83	2.62
Starch	6.8	-	-	-	4.7	0	5.7
Sugars	1.2	-	-	-	0.2	82.8	0.2
Lactose	0	60.6	62.6	67.9		0	0
Lactic acid	15.4	14.0	1.1	1.4	20.0	-	-
Rem. org. mat.	16.45	0	15.06	19.77	6.0	14.6	30.21
Minerals, % of dry matter							
Calcium	0.04	1.79	0.56	0.66	0.07	0.02	0.27
Phosphorus	1.43	1.26	0.65	0.70	3.03	0.01	1.58
Sodium	0.21	0.74	1.42	0.78	0.84	0.03	0.05
Potassium	2.31	2.77	2.68	1.93	4.87	0.05	2.15
Chloride	0.36	1.63	2.29	1.37	0.74	0.02	0.16
Digestible energy, MJ/kg of dry matter							
Calculated <sup>2</sup>	17.2	15.0	14.7	14.8	14.5	16.8	16.7
NRC (1998)	15.1	14.54	-	14.97	-	-	14.96
Standardized ileal digestible amino acid content, % of dry matter							
Lysine	0.44	0.89	0.45	0.13	1.06	0	3.35
Threonine	0.65	0.71	0.36	0.10	1.09	0	2.25
Methionine	0.37	0.17	0.08	0.02	0.95	0	0.68
Cysteine	0.29	0.26	0.12	0.03	0.97	0	0.37
Tryptophan	0.13	0.18	0.08	0.02	0.07	0	0.55
Isoleucine	0.85	0.55	0.31	0.11	0.97	0	2.15
Avail. Phosphorus	0.21	1.26	0.65	0.70	0.61	0.01	0.79

<sup>1</sup> Values from survey of Ontario samples (Braun and de Lange, 2004).

<sup>2</sup> Based on digestible nutrient content and GE content of nutrients (Braun and de Lange, 2004).

## CONCLUSIONS

Diets containing DDGS, field peas, wheat shorts, liquid whey, whey permeate, corn steep water, and brewers yeast may be fed to pigs without reducing animal performance. It is always important to monitor the nutritional quality of the ingredients and diets containing these ingredients need to be carefully formulated to make sure that all nutrient needs of the animals are met. However, if a few simple rules are followed in diet formulations, excellent results may be obtained on diets containing these ingredients.

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# **ALTERNATIVE ENERGY SOURCES – BIOGAS PRODUCTION**

**Harold House, P.Eng.  
Engineer, Dairy and Beef Housing and Equipment  
Ontario Ministry of Agriculture, Food, and Rural Affairs  
Box 159, 100 Don St., Clinton, Ontario N0M 1L0  
E-mail: harold.house@ontario.ca**

## **INTRODUCTION**

Rising energy prices and concerns about long term sustainability have once again brought renewable energy sources to the forefront

On Monday August 21<sup>st</sup> a group organized by the Ontario Large Herd Operators left from Toronto Airport bound for Amsterdam. The next seven days were spent travelling by bus through the Netherlands, Germany, and Denmark to study anaerobic digestion technology. The tour objective was to visit anaerobic digestion systems that demonstrated the following characteristics:

- The production of biogas at a variety of agricultural locations, with an emphasis on dairy farms
- Different inputs: manure, corn silage and other energy crops, food processing by-products, and household organic waste
- On-farm and community digesters: ownership, partnerships, manure transport
- Standardized design and companies with proven track-records
- Maintenance experience and down time
- The use or sharing of excess heat, including partnerships with greenhouses

The 32 participants were quite a diverse group, made up of dairy, beef, swine, vegetable and cash crop producers, research and extension people, waste haulers, industry people, plus a financial advisor, and a representative from Hydro One, and the Ontario Power Authority (Figure 1). Although a diverse group, they all had a common goal of seeing and learning as much as they could in seven short days. Or perhaps the group would say seven long days, as the tour started early every morning, and ended late every night.

Many hours were spent riding the bus, but each stop managed to give the group something new to talk about between Amsterdam in the Netherlands to Ribe, Denmark in the North and then back again. In all, the group visited 16 anaerobic digester installations, or biogas plants as they are more commonly referred to in Europe. Each stop was unique in some way either by the technology installed at the facility, or because of the goals that the owners were trying to achieve.

**Figure 1. European biogas study group.**



## **BASICS OF BIOGAS PRODUCTION**

Biogas is a mixture of mainly methane gas ( $\text{CH}_4$ ) and carbon dioxide gas ( $\text{CO}_2$ ). Natural gas is about 90-95% methane, but biogas is about 50-65% methane. So biogas is basically low grade natural gas.

Biogas is produced when bacteria convert organic matter to methane gas. This process is similar to what takes place in the rumen of a cow, so we often hear biogas plants referred to as anaerobic digesters, or anaerobic fermenters.

Four ingredients are needed for biogas production:

1. Organic Matter
2. Bacteria
3. Anaerobic Conditions
4. Heat

Organic matter is the food source for methane producing bacteria. The primary organic matter source for farm-based biogas production is manure. Biogas can be produced using manure as the only organic source, but the gas production can be greatly increased by adding certain types of food wastes with the manure. Energy crops such as corn silage can also be added to increase gas production. The OMAFRA InfoSheet “Calculations and Information for Sizing Anaerobic Digestion Systems” contains a table with typical biogas outputs from various organic sources.

The second ingredient that is necessary for biogas production is bacteria. Bacteria are necessary to convert the fats, carbohydrates and proteins in the organic matter to simple acids such as acetic and propionic acid. Then, a second type of bacteria transform the acids to methane and carbon dioxide. This process takes place simultaneously. The bacteria are commonly present in manure, and under the right conditions they thrive and multiply.

Two conditions that are necessary for the bacteria are an anaerobic atmosphere (no oxygen) and the right temperature. Most digesters operate in the mesophylic range of 35-40°C, but others are designed to operate in the thermophylic range of 50-60°C, and a few are designed to operate at 15-25°C or the psychrophylic range.

Biogas contains moisture and hydrogen sulphide, so before it is used in an engine the moisture must be condensed out, and the hydrogen sulphide removed to reduce maintenance problems. Biogas can be used directly to produce thermal energy, or it can be used to power a gas or diesel engine to run a generator to produce electrical energy.

## **POSITIVE REASONS FOR PRODUCING BIOGAS**

Not only is biogas a fuel for producing green energy, but it has many other advantages both for the producer, and for society as a whole. Biogas production offers an alternate use for food by-products. Instead of food by-products taking up costly space at land fill sites, they can be used to further boost the biogas production from manure.

The fermentation of manure in biogas production greatly reduces the pathogen content of the manure. It also greatly reduces the odour of the manure, as in the end, all the volatile gases have been removed. The process also serves in homogenizing the manure, so that it is easier to agitate, pump, and spread.

The other major spin-off advantage is rural economic development. The expansion of biogas production in Europe has resulted in expansion in all the related industries leading to the increase in jobs, and millions being poured into the rural economy.

## **THE EISSEN DAIRY**

The first biogas plant visited in the Netherlands was the Eissen Dairy. It served as a good model of how a typical biogas plant operated. Manure from the dairy was pumped into an insulated above ground concrete manure tank. Hot water heating tubes wrapped around the tank kept the contents at about 40°C. At this temperature anaerobic bacteria in the manure are quite active converting the organic matter in the manure into methane gas (CH<sub>4</sub>), more commonly referred to as biogas. The biogas was collected off the top of the digester and used to fuel 2- Jenbacher diesel engines running a pair of 625 kW electrical generators. Heat from the engines was collected and used to heat the hot water to keep the digester warm (Figure 2).

Before the biogas could be used in the engines, the hydrogen sulphide and moisture were removed. A small amount of oxygen was added in the head space of the digester to combine with the hydrogen sulphide to produce a precipitate thus removing most of the hydrogen sulphide from the biogas. The biogas was then transferred to the engines underground, so most of the moisture would condense out of the gas.

**Figure 2. Heat recovery from Genset.**



The majority of biogas was removed directly in the anaerobic digester, but biogas continues to be produced even after the effluent was transferred to the long term storage, and started to cool. Therefore, this tank was also covered so the biogas could be collected and pumped to the engine.

The effluent in the long term storage was eventually applied on adjacent fields. Anaerobic digestion preserves the nutrient content of the manure, so that it can continue to be land applied as a fertilizer. Anaerobic digestion also greatly reduces the pathogen content of the manure, and greatly reduces the odour. This was most evident when the group visited the Futterkamp Research Station. While the group stood and viewed the digester, 50 ft away, the long term storage tank was being agitated and manure was being hauled to the fields. There was no smell, other than what was coming from the cows in the barn!

The group quickly learned that a variety of other ingredients were added to the digesters to increase the output of biogas. The most notable ingredient was corn silage (Figure 3). Many digesters used a modified TMR mixer to meter corn silage into the mix to increase the gas production. At one stop, a German engineer remarked that you had to “Love her like a cow”, when referring to the digester. This helped the group to understand that you have to “feed” the digester very similar to how you would feed a cow. You need to concentrate on providing lots of energy feedstocks, and to make changes gradually when you introduce new feeds. The group also saw installations that were further processing the energy crops added to the digester to make the energy more available to the bacteria, in order to increase gas production. One company also added grain to the long term storage to try to keep the digestion process going after the effluent had left the main digester.

The biogas digesters which the group saw were basically of two types. The most common was the vertical totally mixed digester (Figure 4), while the group also saw several horizontal digesters (Figure 5). The horizontal digesters were usually used for feedstocks with higher dry matter content, like poultry litter. There did not seem to be a clear right or wrong, in terms of digester designs. The biogas companies would design the digester to meet the individual needs of the producer. The design would be based on feedstocks available, intended use for the biogas, alternate uses for heat, etc.

**Figure 3. Feeding corn silage to the digester.**



**Figure 4. Vertical anaerobic digester.**



**Figure 5. Horizontal digester.**



**Table 1. Farm based biogas plants.**

<b>Biogas Plant</b>	<b>Company</b>	<b>Feedstock</b>	<b>Digester</b>	<b>BG Production m<sup>3</sup>/day</b>	<b>Methane Content %</b>	<b>Genset kW</b>	<b>Energy Production kWh/day</b>
<b>Eissen Dairy</b>	PlanET	50% hog manure 50% dairy manure corn silage	vertical		54%	2 X 625	20,000
<b>Beeston</b>	Lipp	75% hog manure 25% beef cattle ground corn	vertical	1680	52%	190 250	10,000
<b>Spargelhof Querdl</b>	Bio Energy	turkey manure corn silage	horizontal		52%	120 190	
<b>Bioenergie Ahden</b>	Biogas Nord	30% hog manure 70% food waste	vertical		65-70%	750	
<b>Hohne</b>	Archea	corn silage wheat in secondary	horizontal			500	
<b>RWG Jameln</b>	Biogas Nord	manure corn silage	vertical	7000	53%	250 300	
<b>Agrarenergie Kaarben</b>	BioConstruct	dairy manure corn silage	vertical	28800	51-52%	2 X 1416	
<b>Hegndal</b>	Skaaning	hog manure fish waste	vertical	3600		300	11500
<b>Skovbaekgaard Diary</b>	SKaard	dairy manure vegetable fats glycerine	vertical			625	8000
<b>SNO</b>	PlanET	dairy manure hog manure vegetables	vertical	1600		200	

**Table 2. Community and co-operative biogas plants.**

<b>Biogas Plant</b>	<b>Company</b>	<b>Feedstock</b>	<b>Digester</b>	<b>BG Production m<sup>3</sup>/day</b>	<b>Methane Content %</b>	<b>Genset kW</b>	<b>Energy Production kWh/day</b>
<b>Bio Energie Haestal</b>	Schmack	manure corn silage	horizontal & vertical	10000	52-55%	10 X 80	19200
<b>Wertle</b>	Krieg & Fischer	60% manure 40% food waste	vertical	25000	60-65%	2 X 1250	10,000
<b>Ribe</b>	Kruger	manure food waste	vertical	13150		2 X 1000	
<b>Juhnde Village</b>	Haas Anlagenbau	dairy manure corn silage ground corn	vertical	7800	50-52%	700	

**Table 3. Other biogas plants.**

<b>Biogas Plant</b>	<b>Company</b>	<b>Feedstock</b>	<b>Digester</b>	<b>BG Production m<sup>3</sup>/day</b>	<b>Methane Content %</b>	<b>Genset kW</b>	<b>Energy Production kWh/day</b>
<b>Futterkamp Research Station</b>	Envitec	dairy manure corn silage	vertical			330	
<b>Nij Bosma Zathe</b>	Krieg & Fischer	dairy manure silage crops food wastes	plug flow		up to 75%	37	

## **CATEGORIES OF BIOGAS PLANTS**

The biogas plants studied were in one of two categories. The first was farm based plants (Table 1), and the other was community based, or co-operative plants (Table 2). The farm based plants were located on farm, but some were solely operated by the farm owner, while others involved partnerships between two or three farm owners. Others were located at the farm site, but were owned and operated by companies separate from the farm. The community and co-operative sites were large commercial sites collecting manure from as many as 200 farms, digesting it, and then returning it to the farms to be land applied. Two research station plants were also visited (Table 3).

## **INNOVATIVE USES FOR HEAT AND ELECTRICITY**

The group saw several creative uses for the additional heat captured from the engine-generator sets or gensets. Most biogas plants were using excess heat to heat hot water for the barn or house, but three of the biogas plants were actually selling the heat for use by others. One plant in particular was using the excess heat to provide hot water heating to a nearby airport, and two others were supplying a portion of home heating requirements in adjacent villages, such as Jühnde.

Jühnde is a small German village where all the energy to the village is supplied by the adjacent biogas plant. The plant supplies the electricity from the diesel engines operating on biogas running generators, and then excess heat from the engines is used to heat hot water which is supplied to the villagers for water and heating needs. In the winter when excess heat from the gensets is not enough to provide the homes with heat, extra boilers are fired with wood chips. Plans are currently under way to dry the wood chips with extra heat that is available in the warm summer months.

Another unique stop was to a “gas” station that offered its customers the option of filling up with biogas (Figure 6). The biogas supplied to the gas station was produced at a nearby plant similar to the others, but it had an extensive refining process to concentrate the gas to a level that could be used in natural gas powered vehicles.

Most of the biogas plants visited with the tour had multiple partners. Having multiple partners allowed different feedstocks to be brought together for processing. For instance the group saw several plants where the manure from cattle and hogs was mixed into the same digester. As well different food by-products were also added at several sites. Co-operatives ranged in size from two to three farmers up to one large plant that managed the manure from 300 farms in a 50 km radius from the plant. 20 tanker trucks were used to pick up the manure at the farms and transport it for processing at the centralized biogas plant. After processing the treated manure would be stored in tanks in the area for land application, or spread directly onto fields depending on availability. Not all biogas plants are large scale. If the group could have travelled south to Switzerland, Austria, and southern Germany, biogas plants that were individually owned and operated would have been more evident.



**Figure 6. Biogas station.**



## **WHY DOES IT WORK IN EUROPE?**

The group also had several opportunities to visit with technology suppliers, and leaders in the biogas industry. One leader from the German Biogas Association noted that, in Germany, direct benefits from the biogas sector included:

1. 650 MW of installed electrical capacity
2. A reduction of 4 million tonnes/yr of CO<sub>2</sub> emissions
3. \$960 million spent in construction in 2005
4. Revenues of \$500 million to farmers from electricity sales each year

He also noted that the anaerobic digestion/biogas sector in NW Europe is a mature industrial sector with over 200 businesses (8000 employees) offering services to farm-based, cooperative, and industrial biogas facilities. The vast majority of biogas facilities are farm-based systems.

## **WILL IT WORK HERE?**

The European farms visited were similar in many ways to what the producers had at home. So why don't we have a proliferation of biogas plants here in Ontario? There are two main factors that have made biogas generation in Europe wide-spread:

1. European governments have made a commitment to have electricity prices that reflect the cost of producing renewable power. (Table 4)
2. Guaranteed access to the electricity grid with few restrictions or fees.

European governments have made a commitment to have electricity prices that reflect the cost of producing renewable power from different technology systems (biogas, wind, etc), and

specifically for biogas systems using different inputs (manure, energy crops, food-based inputs), and with different scales (higher prices for smaller systems). A bonus is also given for making use of the extra heat generated.

**Table 4. European energy pricing.**

Average Power	Guaranteed Feed-in Tariff CAD¢ / kWh			Total Price (2006)
	Base Price (2006)	Bonus for Using Ag Inputs	Bonus for Heat Usage	
0 – 150 kW	17	+ 9.1	+ 3	29.1
150 - 500 kW	14.6	+ 9.1	+ 3	26.7
500 – 5,000 kW	13.1	+ 9.1	+ 3	25.2
> 5.000	12.5	+ 9.1	+ 3	24.6

At present electrical prices in Ontario offered to farmers producing electricity from biogas are not sufficient in most cases to make biogas production economically feasible. The Standard Offer Contract (SOC) program announced last March is one step in the right direction to having a biogas industry in Ontario. Hopefully this can be improved in the future to provide incentives to increase production of biogas by using energy crops in the mix, and to use excess heat recovered from the generator engines. Let us not forget that anaerobic digestion also greatly reduces the pathogen content of the manure, and greatly reduces the odour for the benefit of society. Anaerobic digestion also gives an opportunity to use food by-products that are presently going to landfill sites.

The technology used by the biogas plants that the group visited in Europe, would apply in Ontario as well. Many companies there are looking to partner with companies here, so if the electricity price paid for biogas improves, the technology is ready to go.

Biogas production in the future could provide farmers with an additional source of income, while providing society with an alternative use for food by-products, and reduced pathogens, and odours from manure, not to mention the tremendous potential for rural economic development. The potential exists for a “win-win” situation.

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# ALTERNATIVE ENERGY SOURCES - A HOG PRODUCER'S PERSPECTIVE OF ON-FARM ANAEROBIC DIGESTERS

Gilbert Vanden Heuvel  
From the Hill Farms Ltd.  
Huron County Anaerobic Digester Group  
RR#2 Goderich, Ontario N7A 3X8  
E-mail: gilbertv@hurontel.on.ca

## BACKGROUND

First some background to the farm that has lead me to this bodacious idea. Not everyone wakes up one morning and says, "Hey, I think I'm going to invest three quarters of a million dollars and make electricity and hot water from pig manure."

My father, Kase Vanden Heuvel, really set the foundation for all this to happen. He started a construction company 10 years after he emigrated from Holland with \$100 in his pocket. Ten years later, 1972, he started pig farming for some unknown reason. Due to an error in communication with OMAF who designed the farrowing barn, the sow farm that was supposed to support a 500 head finishing barn turned into almost 500 sows. Not wanting to waste any foundation wall, he kept the 128 farrowing spaces and just built around it. 500 sows in 1972 was not the norm. That's the style of farming that I know. Not necessarily normal. I've grown up feeling very comfortable farming in a 'not-so-normal' way. It's really **all** I know. The really amazing thing is that my father is not a pig farmer. He never took any training in pig husbandry, the only chores he ever did was feed that original 500 head finishing barn after he got home from the construction site. And as soon as he could he had staff take that job over too.

He understood what **could** be possible after some research and talking to knowledgeable people he trusted. He surrounded himself with good people, used quality equipment and embraced technology that made sense to the farm.

The most important part of that is seeing what COULD be possible. Some stay focused on what HAS BEEN possible, some see only what IS possible, but at our farm we are always looking at what the next thing is to help us farm better. When I say better I don't just mean only for more profit. Better can mean less manual labour, safer working conditions, more information to make better decisions, easier on the environment and on and on.

When I purchased the farm from my father five and a half years ago I developed the most important document of a business that I'm going to be running. What's your most important document? It's not a projected cash flow (sorry bankers), it's not the share cropping contract, it's not the mortgage, and it's not our staff benefits package. The most important document is our Mission Statement. My staff needs to know what I stand for, my banker needs to know what kind of business man I am, and even my feed company needs to understand what's important to me so we stay on the same page.

**Values: (core beliefs)**

- Be honest even if it hurts
- Treat all with respect and encouragement
- Our work environment should be a positive one
- Look for new/better ways to do things
- Listen, look and learn
- When you need to make a decision, make one, and go from there
- Treat associates fairly and expect the same in return

**Mission: (T-shirt summary)**

Believe in what you do, Do what you believe

**Vision: (picture of the future)**

- To be an organization that
  - Is true to my Christian beliefs
  - Is an enjoyable and learning place for me and all employees
  - Makes a profit to support all families involved, create reserve for low price years, to sustain growth and to stay competitive
  - Is in the top 5% in industry for production levels
  - Optimizes technology and skills of all involved to improve production and minimize waste
  - Leaves this land better for the next generation

This document isn't just nice words. As an organization we use this to guide our decisions. Examples:

- What types of companies we deal with is guided by our expectation to be treated fairly and always looking to improve.
- How we handle manure is guided by our commitment to leaving the land better for our children.
- The amount of lighting in the barn must be in line with our belief that our workplace needs to be an enjoyable place to be.

That's a lot of background but it's important to understand that installing and running an Anaerobic Digester isn't just a financial decision. Taking on a project like this one has to have a deeper meaning than just money to make it through the rough patches and get it working in the long run. We all need to know that there will be some times when you are pulling your hair out and wonder why you ever got into this in the first place. You need to believe in it, really believe deep down that this is the right thing to do.

In 2004, I hired an engineering company to find the break-even point in cents per kWh to produce electricity at our farm. The number by their calculations was a little over 20 cents per kWh. A lot has been learned since 2004. We have been looking at many manure treatments to reduce our manure spreading costs. Just about all of them cost us money, not saved us money. After listening to the first bunch of manure treatment ideas, I found a question that would cut through all the "money making" schemes. The first question you should ask is,

“How will this make me / save me money?” if the salesman doesn’t have a direct answer then you need to move on.

An Anaerobic Digester has the potential to make money. Good money. At the same time it leaves all the nutrients in place to feed your soil without the smell, the methane that normally escapes to the environment is harnessed and the pathogens are 98% gone.

To me there are too many pluses to pass this by.

I am part of the Huron Anaerobic Digester Working Group. This is a sub committee of Huron County Water Protection Steering Committee. The group believes that Anaerobic Digestion is a technology that will work.

**Purpose Statement:**

The County of Huron, with its partners on the Huron County Water Protection Steering Committee, is interested in facilitating the development of an on-farm demonstration project of an anaerobic digester using manure as feedstock to produce electricity for sale to the grid.

Working in this group gives the project much higher chances of success. I saw the value with surrounding the project with highly qualified people instead of trying to do this alone. Having OMAFRA engineers, Huron County planning heads, and local citizens that see the connection between water quality and such a project around the table at planning meetings is a huge asset.

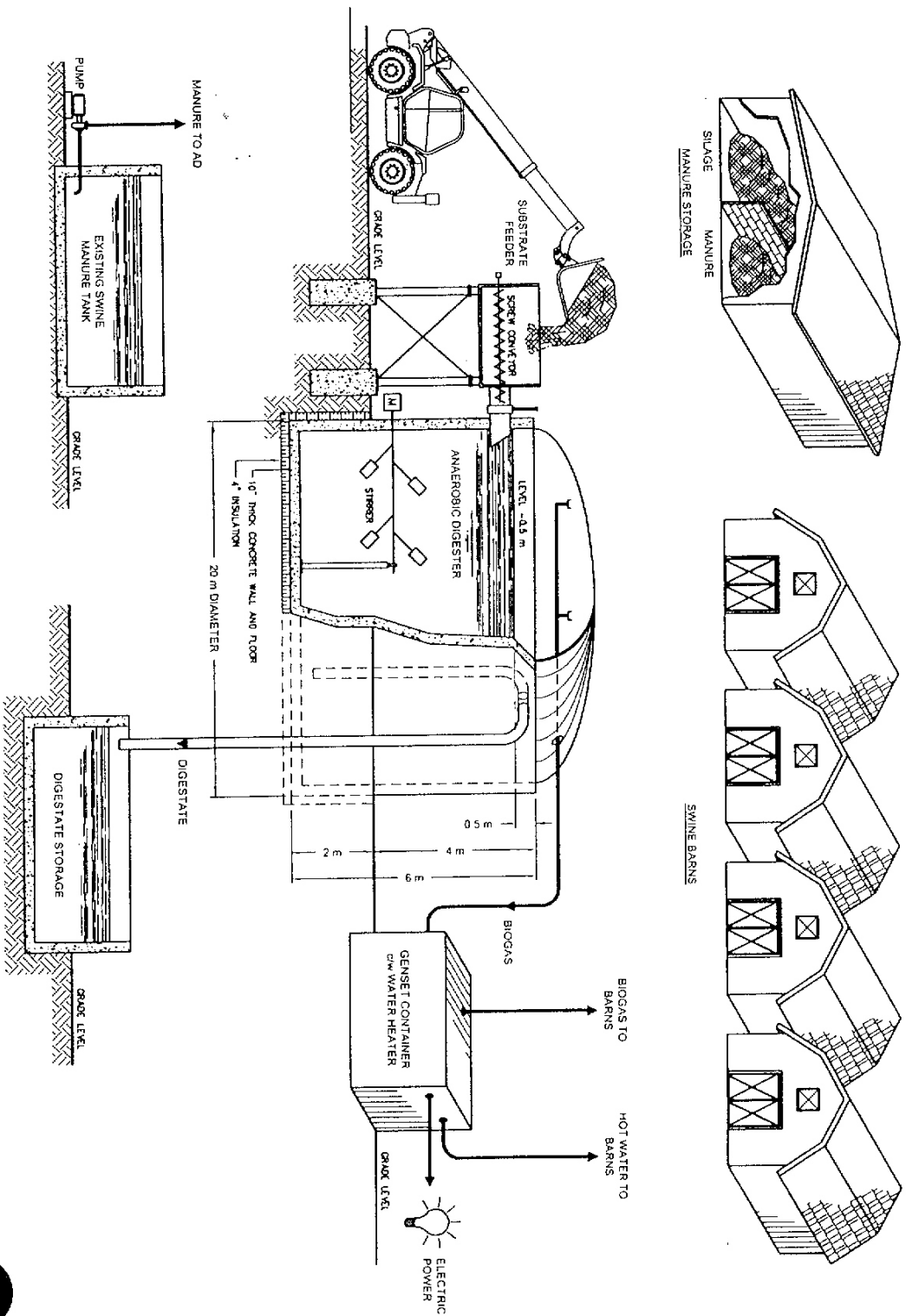
The project is shaping into a 250 kW generator. We are looking at this size since this is where a good return on investment starts. Any smaller really doesn’t work financially. Ontario has put a moratorium on anything bigger than 250 kW in our area.

We will be using the raw manure from a 3200 head finishing barn as our base product. That is nowhere close to producing enough methane to run the engine for 250 kW. To top up the nutrients to create this methane we will be separating the manure at our sow farm and transport the solids to the Anaerobic Digester. We still need about 15% more product from an outside source. I’m very confident that we will be able to find an agricultural or food industry by-product or grow a crop that will fill in the last 15%.

**DETAILS FROM OUR FEASIBILITY STUDY (Refer to 5 pages that follow)**

Done by Martin Lensink, P. Eng. of CEM Engineering

# ANAEROBIC DIGESTER COMBINED HEAT AND POWER SYSTEM



FROM THE HILL FARMS LTD.  
HURON COUNTY

## Sensitivity Analysis on Main Variables



### 3.5 Sensitivity Analysis on Main Variables in Option #4 (250 kW<sub>e</sub>)

Variable	Price Paid for Power (\$/kW.h)	Biomass Cost Delivered (\$/tonne)	Capital Cost and Grant % (\$000's)	10 Year IRR After Tax* (%)
Base	0.116	25	912	6
1A	0.128 (+ 10%)	25	912	10
1B	0.139 (+ 20%)	25	912	13
2A	0.116	15	912	12
2B	0.116	5	912	17
2C	0.116	-5	912	22
3A	0.116	25	730 (- 20%)	10
3B	0.116	25	547 (- 40%)	17
Best Case	0.128 (+ 10%)	15	730 (-20%)	20%
Worst Case	0.116	35	1,003 (+ 10%)	-2%

\* but before Financing

## Technical and Financial Assumptions

### Scenario #1:

Tech Assumptions											
AD CHP Electrical Output	250	kW									
AD CHP Thermal Output	260	kW									
AD CHP Thermal Output	887,120	Btu/hour									
Biogas Consumption by CHP (@50% CH <sub>4</sub> Content)	112	m <sup>3</sup> /hour									
Efficiency of Existing Boilers Assumed	80%	HHV									
Parasitic / Auxiliary Power	1%										
Pilot Oil Used by ICE	2.3	liter / hour									
Pilot Oil Used by ICE	19,044	liters / year									
System operation	360	days / year									
Net Power Generation	2,115,000	kW.h / year									
Purchased Power Displaced	0	kW.h / year									
Surplus Power Sold	2,115,000	kW.h / year									
Potential Propane Displace Via Energy / Heat Recovery	393,466	L / year									
Biogas Needed	967,680	m <sup>3</sup> /hour									
Biogas From one site Swine Manure	90,720	m <sup>3</sup> /hour									
Biogas from separated swine manure	876,960	m <sup>3</sup> /hour									
Biogas from Additional Organic Matter (bean pods)	750	m <sup>3</sup> /hour									
Organic Matter needed to Supple ICE	1,186	tonnes / year									
Financial / Economic Assumptions											
Avoided Cost of Electricity	0.122	\$ / kW.h									
Value of Surplus Power Sold	0.12	\$ / kW.h									
Delivered Cost of Propane	0.45	\$/Liter									
% Recoverable Heat Actually Used	10%										
Cost of Biomass (Delivered)	10	\$ / tonne									
Unit Cost of Lube / Pilot Oil	0.65	\$ / liter									
Escrow Account for Engine Maintenance	0.009	\$ / kW.h									
Corporate Income Tax Rate	30%										
Unit Capital cost Assumed (Supply and install - no grant)	4000	\$ / kWe									
Discount Rate (for NPV Analysis)	10%										
Operation / Repair Labour	0.009	\$ / kW.h									
Escalation on Propane Costs	4%	per year									
Escalation on Electricity Cost	2%	per year									
Escalation on Other Costs	1.5%	per year									
Proforma Analysis -- \$000's per year (CAD)											
Year	0	1	2	3	4	5	6	7	8	9	10
Calendar	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Purchased Power Displaced											
Surplus Power Sold		254	259	264	269	275	280	286	292	297	303
Propane Displaced Via Enigne heat Recovery		12	12	13	13	14	15	15	16	16	17
Hot water Revenue		0	0	0	0	0	0	0	0	0	0
<b>Total Gross Savings and Revenues</b>		<b>266</b>	<b>271</b>	<b>277</b>	<b>283</b>	<b>289</b>	<b>295</b>	<b>301</b>	<b>307</b>	<b>314</b>	<b>320</b>
Cost of Biomass Delivered		10	10	10	10	11	11	11	11	11	11
Lube and Pilot Oil		12	13	13	13	13	13	14	14	14	14
Engine Maintenance Reserve		19	19	20	20	20	21	21	21	21	22
Operation and Repair labour		19	19	20	20	20	21	21	21	21	22
Transportation of Digestate											
<b>Total Annual O&amp;M Expenses</b>		<b>60</b>	<b>61</b>	<b>62</b>	<b>63</b>	<b>64</b>	<b>65</b>	<b>66</b>	<b>67</b>	<b>68</b>	<b>69</b>
<b>Earnings Before Interest and Taxes</b>	<b>\$</b>	<b>205</b>	<b>\$ 210</b>	<b>\$ 215</b>	<b>\$ 220</b>	<b>\$ 225</b>	<b>\$ 230</b>	<b>\$ 235</b>	<b>\$ 240</b>	<b>\$ 246</b>	<b>\$ 251</b>
Capital Cost (supply, install and commission)	\$	1,000									
Grant Income	\$	-									
<b>Net Capital Costs</b>	<b>\$</b>	<b>1,000</b>									
Capital Cost Allowance (Class 43.2)		220	343	192	108	60	34	19	11	6	3
Corporate Income Tax		0	0	4	21	31	36	40	43	45	46
Interest costs (6%)		60	47	26	15	8	5	3	1	1	0
<b>Earnings After Taxes</b>	<b>\$</b>	<b>145</b>	<b>\$ 163</b>	<b>\$ 184</b>	<b>\$ 184</b>	<b>\$ 186</b>	<b>\$ 189</b>	<b>\$ 192</b>	<b>\$ 196</b>	<b>\$ 200</b>	<b>\$ 205</b>
Simple Payback	\$	145	309	493	677	863	1,051	1,244	1,440	1,640	1,845
With current returns on electricity sales and no grant \$ and no hot water revenue payback is almost 6 years											



## Scenario #2:

Tech Assumptions											
AD CHP Electrical Output	250 kW										
AD CHP Thermal Output	260 kW										
AD CHP Thermal Output	887,120 Btu/hour										
Biogas Consumption by CHP (@50% CH4 Content)	112 m3/hour										
Efficiency of Existing Boilers Assumed	80% HHV										
Parasitic / Auxiliary Power	1%										
Pilot Oil Used by ICE	2.3 liter / hour										
Pilot Oil Used by ICE	19,044 liters / year										
System operation	360 days / year										
Net Power Generation	2,115,000 kW.h / year										
Purchased Power Displaced	0 kW.h / year										
Surplus Power Sold	2,115,000 kW.h / year										
Potential Propane Displace Via Energy / Heat Recovery	393,466 L / year										
Biogas Needed	967,680 m3/hour										
Biogas From one site Swine Manure	90,720 m3/hour										
Biogas from separated swine manure	876,960 m3/hour										
Biogas from Additional Organic Matter (bean pods)	750 m3/hour										
Organic Matter needed to Supply ICE	1,186 tonnes / year										
Financial / Economic Assumptions											
Avoided Cost of Electricity	0.122 \$ / kW.h										
Value of Surplus Power Sold	0.16 \$ / kW.h										
Delivered Cost of Propane	0.45 \$/Liter										
% Recoverable Heat Actually Used	10%										
Cost of Biomass (Delivered)	10 \$ / tonne										
Unit Cost of Lube / Pilot Oil	0.65 \$ / liter										
Escrow Account for Engine Maintenance	0.009 \$ / kW.h										
Corporate Income Tax Rate	30%										
Unit Capital cost Assumed (Supply and install - no grant)	4000 \$ / kW.e										
Discount Rate (for NPV Analysis)	10%										
Operation / Repair Labour	0.009 \$ / kW.h										
Escalation on Propane Costs	4% per year										
Escalation on Electricity Cost	2% per year										
Escalation on Other Costs	1.5% per year										
Proforma Analysis -- \$000's per year (CAD)											
Year	0	1	2	3	4	5	6	7	8	9	10
Calendar	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Purchased Power Displaced											
Surplus Power Sold		338	345	352	359	366	374	381	389	396	404
Propane Displaced Via Engine heat Recovery		12	12	13	13	14	15	15	16	16	17
Hot water Revenue		0	0	0	0	0	0	0	0	0	0
<b>Total Gross Savings and Revenues</b>		<b>350</b>	<b>358</b>	<b>365</b>	<b>373</b>	<b>380</b>	<b>388</b>	<b>396</b>	<b>405</b>	<b>413</b>	<b>421</b>
Cost of Biomass Delivered		10	10	10	10	11	11	11	11	11	11
Lube and Pilot Oil		12	13	13	13	13	13	14	14	14	14
Engine Maintenance Reserve		19	19	20	20	20	21	21	21	21	22
Operation and Repair labour		19	19	20	20	20	21	21	21	21	22
Transportation of Digestate											
<b>Total Annual O&amp;M Expenses</b>		<b>60</b>	<b>61</b>	<b>62</b>	<b>63</b>	<b>64</b>	<b>65</b>	<b>66</b>	<b>67</b>	<b>68</b>	<b>69</b>
<b>Earnings Before Interest and Taxes</b>	<b>\$</b>	<b>290</b>	<b>\$ 296</b>	<b>\$ 303</b>	<b>\$ 309</b>	<b>\$ 316</b>	<b>\$ 323</b>	<b>\$ 330</b>	<b>\$ 337</b>	<b>\$ 345</b>	<b>\$ 352</b>
Capital Cost (supply, install and commission)	\$ 1,000										
Grant Income	\$ -										
<b>Net Capital Costs</b>	<b>\$ 1,000</b>										
Capital Cost Allowance (Class 43.2)		220	343	192	108	60	34	19	11	6	3
Corporate Income Tax		0	0	21	38	48	54	58	61	63	65
Interest costs (6%)		60	47	26	15	8	5	3	1	1	0
<b>Earnings After Taxes</b>	<b>\$</b>	<b>230</b>	<b>\$ 249</b>	<b>\$ 256</b>	<b>\$ 257</b>	<b>\$ 260</b>	<b>\$ 265</b>	<b>\$ 270</b>	<b>\$ 275</b>	<b>\$ 281</b>	<b>\$ 287</b>
Simple Payback	\$	230	479	735	993	1,253	1,518	1,787	2,063	2,344	2,631
With higher returns on electricity sales and no grant \$ and no hot water revenue payback is almost 4 1/2 years											

### Scenario #3:

Tech Assumptions											
AD CHP Electrical Output	250	kW									
AD CHP Thermal Output	260	kW									
AD CHP Thermal Output	887,120	Btu/hour									
Biogas Consumption by CHP (@50% CH4 Content)	112	m3/hour									
Efficiency of Existing Boilers Assumed	80%	HHV									
Parasitic / Auxiliary Power	1%										
Pilot Oil Used by ICE	2.3	liter / hour									
Pilot Oil Used by ICE	19,044	liters / year									
System operation	360	days / year									
Net Power Generation	2,115,000	kW.h / year									
Purchased Power Displaced	0	kW.h / year									
Surplus Power Sold	2,115,000	kW.h / year									
Potential Propane Displace Via Energy / Heat Recovery	393,466	L / year									
Biogas Needed	967,680	m3/hour									
Biogas From one site Swine Manure	90,720	m3/hour									
Biogas from separated swine manure	876,960	m3/hour									
Biogas from Additional Organic Matter (bean pods)	750	m3/hour									
Organic Matter needed to Supple ICE	1,186	tonnes / year									
Financial / Economic Assumptions											
Avoided Cost of Electricity	0.122	\$ / kW.h									
Value of Surplus Power Sold	0.12	\$ / kW.h									
Delivered Cost of Propane	0.45	\$/Liter									
% Recoverable Heat Actually Used	10%										
Cost of Biomass (Delivered)	10	\$ / tonne									
Unit Cost of Lube / Pilot Oil	0.65	\$ / liter									
Escrow Account for Engine Maintenance	0.009	\$ / kW.h									
Corporate Income Tax Rate	30%										
Unit Capital cost Assumed (Supply and install - no grant)	4000	\$ / kWe									
Discount Rate (for NPV Analysis)	10%										
Operation / Repair Labour	0.009	\$ / kW.h									
Escalation on Propane Costs	4%	per year									
Escalation on Electricity Cost	2%	per year									
Escalation on Other Costs	1.5%	per year									
Proforma Analysis -- \$000's per year (CAD)											
Year	0	1	2	3	4	5	6	7	8	9	10
Calendar	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Purchased Power Displaced											
Surplus Power Sold		254	259	264	269	275	280	286	292	297	303
Propane Displaced Via Enigne heat Recovery		12	12	13	13	14	15	15	16	16	17
Hot water Revenue		10	10	10	10	10	10	10	10	10	10
<b>Total Gross Savings and Revenues</b>		<b>276</b>	<b>281</b>	<b>287</b>	<b>293</b>	<b>299</b>	<b>305</b>	<b>311</b>	<b>317</b>	<b>324</b>	<b>330</b>
Cost of Biomass Delivered		10	10	10	10	11	11	11	11	11	11
Lube and Pilot Oil		12	13	13	13	13	13	14	14	14	14
Engine Maintenance Reserve		19	19	20	20	20	21	21	21	21	22
Operation and Repair labour		19	19	20	20	20	21	21	21	21	22
Transportation of Digestate											
<b>Total Annual O&amp;M Expenses</b>		<b>60</b>	<b>61</b>	<b>62</b>	<b>63</b>	<b>64</b>	<b>65</b>	<b>66</b>	<b>67</b>	<b>68</b>	<b>69</b>
<b>Earnings Before Interest and Taxes</b>	<b>\$</b>	<b>215</b>	<b>\$ 220</b>	<b>\$ 225</b>	<b>\$ 230</b>	<b>\$ 235</b>	<b>\$ 240</b>	<b>\$ 245</b>	<b>\$ 250</b>	<b>\$ 256</b>	<b>\$ 261</b>
Capital Cost (supply, install and commission)	\$	1,000									
Grant Income	\$	500									
<b>Net Capital Costs</b>	<b>\$</b>	<b>500</b>									
Capital Cost Allowance (Class 43.2)		110	172	96	54	30	17	9	5	3	2
Corporate Income Tax		0	0	24	33	38	41	44	46	47	48
Interest costs (6%)		30	23	13	7	4	2	1	1	0	0
<b>Earnings After Taxes</b>	<b>\$</b>	<b>185</b>	<b>\$ 197</b>	<b>\$ 188</b>	<b>\$ 190</b>	<b>\$ 192</b>	<b>\$ 196</b>	<b>\$ 200</b>	<b>\$ 204</b>	<b>\$ 208</b>	<b>\$ 213</b>
Simple Payback	\$	185	382	570	759	952	1,148	1,347	1,551	1,760	1,972

With current returns on electricity sales but significant grant payback is less then 3 years

# **ALTERNATIVE ENERGY SOURCES - WHAT WE LEARNED FROM EUROPEAN TECHNOLOGY AND A PRACTICAL LOOK AT POSSIBLE ONTARIO ON-FARM APPLICATIONS**

**Martin Van Raay  
Van Raay Farms Ltd.  
R.R. #3 Dashwood, Ontario N0M 1N0  
E-mail: vanraay@hay.net**

Van Raay Farms Ltd. is a 500 sow farrow to finish operation which crops 600 acres of land, mainly corn, soybeans and wheat. We grow half of corn needed for feed and purchase the remaining as high moisture corn. The set up is two locations. On one site we have our 500 sow farrow & 8 week weaner operation. The second site, which is within 2 kms., is a 3500 head “motel style” finishing barn. This is the site of the proposed methane digester. We produce about 3,000,000 gallons of manure annually.

## **Why are we Investigating a Methane Digester for our Farm?**

We are a relatively small hog farming operation and want to be self sufficient. Lowering or stabilizing our cost of production is key. Heat and hydro costs run between 5 & 7% of our expenses annually. There is no indication that this cost will be getting lower.

During investigation, it became apparent that self-sufficiency alone wouldn't make the project viable. Size being a major consideration, work to maintain a 100, 250 or 500 kW system would all be the same. Also, in my travels I have learned there could be several income streams from a digester.

1. Electricity
2. Heat
3. Tipping fees
4. Digestate

## **Electricity**

Ontario 11.2 cents and 3.5 cents for demand.

## **Heat**

60% of Methane energy comes off as heat. A 500 kW generator is about \$450,000.00 gross income in electricity in Ontario.

- Therefore, is there more than \$500,000 of heat value that can be used for something else?
- What other project could use low temp heat, 70 degrees Celsius and for what purpose?

## **Tipping Fees**

Manure alone doesn't produce great volumes of methane. There are a number of products that can be added to manure to bring volumes up. These come in two categories.

- Nutrients that create lots of methane that have marginal or no costs.
- Nutrients that produce very little methane but some one is willing to pay large tipping fees to dispose of.

Examples:

Corn Silage - or corn in Germany. Corn silage alone with manure could bring a digester's methane volume up 2 – 3 times. The cost of corn silage in Ontario last year was about \$25.00/tonne to grow. The future value of corn silage from 2007 to 2010 is unknown. At these costs and with 11.2 cents for electricity this is not a great return on investment.

At the other end certain abattoir waste streams costs \$90/tonne to be removed from the plant. The amount of methane that this would generate could be off set by the tipping fee.

During the early years of the methane digester industry in Germany, (before competition for the by-products was a problem) earlier innovators received 50% of their income from tipping fees.

## **Digestate**

The volume of digestate should be nutritionally unchanged. The manure portion of the digestate will be nutritionally unchanged and actually enriched by whatever organic matter was added. The digestate would result in an organic, less odorous material. The nitrogen content of the digestate would be more readily available and therefore it is more important to apply closer to plant needs. Can we sell the digestate for more then it costs to transport or at least for transport costs as it is an environmentally more friendly product?

## **These 4 Factors on the Income Side also have an Expense Side**

**Electricity** costs 11.4 cents/kW to deliver hydro to our farm.

Questions remain:

- Will Ontario Hydro allow us to use our own generator use pre-meter or do I have to buy electricity for more then I am paid?
- Does the inflation factor make the 20 year contract (which is the duration of the Standard Offer Contract) not economically sustainable for the farm in 5, 10, 15 or 20 years?
- Is the cost of Central Metering economically viable today or is that a tomorrow project? (combining our two sites together)
- Can I get 8000 hours of generation time out of the system annually?

- As an anaerobic digester is alive with sensitivities to temperatures and diet, minor changes in the diet could affect the methane output. Digesters need daily monitoring and maintenance and a “farmers” hand to get the maximum output.

**Heat** recovery has its own challenges.

- If we bring in material from a slaughter house, as organics (non feed ingredient types) they will need to be pasteurized. The standard in Europe would normally be 1 cm size at 70 degrees Celsius or 24 hours at 55 degrees Celsius to pasteurize material. Does this consume most of the excess heat from the methane? On a 500 kW plant 5% of the heat could be used to heat the hog barn.
- Do we need a secondary business located on site to utilize the heat? Is there some drying process or greenhouse growing operation that could make use of this heat? Again the challenge of starting 2 new businesses at once and the time and energy to monitor them could be overwhelming. What is the right size of business to be viable? How big of a greenhouse do you need to be viable? Can we dry a product year round, 24/7 because heat is low volume and continually produced?

### **Tipping Fees**

Digesters are custom built depending mainly on what you are feeding them.

- Do we need a 2 stage digester to get the maximum methane output? Consideration needs to be given to what we feed the digester.
- Do we need 20 days retention time (corn silage) or 65 days (wheat straw) to get the methane out of the feedstock? With our daily manure production of 35 tonne/day, digester size may vary from 180,000 to 500,000 gallons for the manure portion alone. If we add a bulky organic material, these may make the project not viable. Some organic materials may need to be pasteurized which would require extra equipment; a) to pasteurize b) to pump, c) to store.
- Equipment to add corn silage doesn't work to add grease trap waste. Licenses to accept non feed organics on site need to be applied for. Rules to apply digestate, made from non traditional organics may need neighbourhood and Ministry of Environment approvals. At what point do we change from farm to industrial and will be regulated by industrial rules?
- Availability and supply balancing becomes a new challenge. Are we large enough to get a good supply or too small to take the entire output from a factory? Will large companies work with a small entrepreneur or will they depend on large disposal companies intent on maintaining their margins and leaving us with no margins?

Again the challenge of working with an unknown industry (organic waste) and achieving economic viability at the same time.

**Digestate** storage costs money.

- Where and what type of storage do we build? VRFL is nutritionally balanced to the rich side at this point. The 2006 season was the first year where manure was exported off the farm.
- If we add more organic material to the mix will we be able to sell digestate as a nutritionally known bacterially stable (no *E. coli*) product to our neighbours and at what % of commercial fertilizer prices? Is this an opportunity or a liability? Does the nitrogen become more leachable as digestate vs. manure and does that require us to apply all the digestate in the spring, requiring more storage and more application requirements?

Those are some of the opportunities and challenges of anaerobic digesters for my situation as I understand them from my travels and research. The challenge in general is to develop a plan to meet many different needs from many different organizations which in the end will be a very specific specialized project capable of doing only one thing.

Good luck on your project.

## **ON-FARM HEALTH MANAGEMENT**

**François Cardinal, DVM, M.Sc.**  
**Les Consultants Avi-Porc**  
**1320 Boul. Jean de Brebeuf, Drummondville, Quebec J2B 4T6**  
**E-mail: francoiscardinal@sympatico.ca**

### **HISTORY AND DIAGNOSTIC**

#### **Pig Production System**

This herd is mycoplasma and PRRS free (eradicated in 2002). Piglets are produced at two sow farms (1500 sows total). There are four barns on one nursery site. The nursery barns are operated all-in all-out (AIAO). There are many finisher sites operated AIAO by room or by barn depending of the size of the barn (500 head to 3000 head). Gilts are entering quarantine at 95 to 120 kg and come from an external genetic company.

In spring 2005, we began to see some palor, wasting, grey diarrhea and increase in culled pigs in some finisher barns. Mortality increased from 3% to 5%. Not so much attention was given to this since we knew that it was probably PMWS and that investments to reduce the mortality would easily overcome the potential benefit. Injection of sick animals with Nuflor and Excenel was tried but with mitigated results.

In fall 2005, acute fever, anorexia, coughing and nasal discharge were seen on many sows in one of the two sow herds. PRRS PCR conducted on serum from sows with fever was negative. Another serology was performed 3 weeks later: no seroconversion to PRRS but clear seroconversion to Influenza H3N2.

Sows were vaccinated prefarrowing with an Influenza H1N1 and H3N2 vaccine. However, flu remains a problem in nurseries where mortality averaged 4%.

Later in fall 2005, mortality increased to 8 to 12% in finisher. Mainly palor, mild dyspnea and wasting were noticed 5 to 7 weeks after placement. At this time, pigs were submitted several times for complete necropsy. In almost all pigs PMWS was diagnosed with *Streptococcus suis* infection being a common finding.

### **INTERVENTIONS (FIRST STEPS)**

During the following 6 months, many possibilities were considered at some point in time:

1. Flu vaccine to piglets
2. Batch farrowing to do AIAO in all finisher barns
3. Single source raising
4. Reducing crossfostering
5. Reducing pig mixing
6. Increase hygiene in sow barns

7. Disinfection with Glut+Quat or Virkon
8. Change the male genetic line (was Duroc)
9. Longer gilts acclimatization (5 or 20 kg gilts)
10. Sow herd closure
11. Autogenous PCV2 vaccine (spleen homogenate)
12. Vaccination with circovac (available at some point)
13. PCV2 vaccine (available later on)

Since influenza problems were beginning at the 4<sup>th</sup> week in nursery, it was chosen not to vaccinate piglets and to keep going with sow vaccination.

Size of nurseries did not fit to do 3 week batch farrowing. It was the same problem for single source raising. The producer did not want to go to 2 or 4 weeks batch farrowing because of the labor concern.

Management change in sow herds was applied:

- Reducing crossfostering
- Reducing pig mixing at their first day of life
- Increase hygiene
- Disinfection with Glut+Quat or Virkon

Changing the male genetic line was not an option because the producer was participating in a niche market and had to use a specific boar line.

Gilts were purchased at 5 kg and raised in the same nurseries as the commercial pigs. The goal of this procedure was to make them exposed to the Influenza, PCV2, H. parasuis and Strep suis strains of the herd. They were then shipped to a designated finisher barn operated in continuous flow. For the transition period, F2 gilts were selected in some commercial batches of growing pigs. Serological tests confirmed that they were PRRS, myco and Influenza H1N1 free. These tests are also repeated before each transfer to quarantine.

Given the risk and the cost of doing Spleen-homogenate vaccination this technique was not used.

When it became available, it was chosen not to vaccinate sows with Circovac (PCV2 sow vaccine) because pigs were sick relatively old in finisher. I expect that a sow vaccine would be of little value in this situation.

## **RESULTS (FIRST STEPS)**

Unfortunately, despite these numerous changes, no substantial improvements were observed. However, change in the tendency were hard to see because of the great variability in mortality between batches.



## **INTERVENTIONS (SECOND STEP)**

The producer began to preserve litter integrity when he weaned piglets and transferred them to nursery. Also, pen integrity was preserved when the pigs were transported to finisher barns. The producer accomplished this by dividing the trailer used to transport the pigs in small pens.

Because pens in different finisher barns did not have the same size, the sow farm personnel should know at weaning where those pigs were planned to be raised. Indeed, the goal was to reduce mixing of pigs as much as possible so the groups were made at weaning time and remained the same until slaughter. For example, if piglets were planned to be raised in a finisher barn where the pens had a capacity of 23 pigs, piglets were weaned in groups of 23. Those 23 piglets may come from 2 or 3 litters. They were kept by group in the hallway awaiting loading and transport to the nursery. Down there, pigs were unloaded by groups and allocated to a pen. The same thing was done when transfer to finisher: pigs were loaded, unloaded and allocated to a pen by group.

## **RESULTS (SECOND STEP)**

Mortality went back to less than 4% in the first batch of pigs and remains between 2 and 4% since. PCV2 piglet vaccine became available: clinical trial in half of the pigs of 2 barns: no effect. Only one batch had clinical signs that could be related to PCVAD afterwards. It caused about 1% mortality and lasted about 7 days. Average daily gain and feed conversion also improved significantly.



# **BEST MANAGEMENT PRACTICES USED IN THE CONTROL OF PRRS**

**George Charbonneau, DVM  
Swine Services Group Ltd.  
225 Oak Street, Stratford, Ontario N5A 8A1  
E-mail: gcharbon@swineservices.ca**

## **ABSTRACT**

Because there are few therapies that can be used for the treatment of viruses, the viral diseases present a disease control challenge. The control of viral diseases is therefore much more dependent on the immune system. In order for the immune system to function properly stress must be at a minimum. A complete viral disease control plan should include the implementation of best management practices that will reduce viral challenge while promoting the establishment of immunity to both specific PRRS isolates and the co-infections that complicate the disease. A best management practice checklist is presented as a review of the thought process that should be involved when managing viral diseases such as PRRS.

## **DIAGNOSTICS**

Initially PRRS must be identified through a thorough diagnostic work up. The preliminary diagnosis is most often based on a review of herd history and clinical signs. Gross post mortem findings then help to confirm the suspicions. Serology, histological lesions, immunohistochemistry, and PCR will firm up the diagnosis. Because of the genetic diversity of the PRRS virus it is important to characterize the farm specific PRRS isolates using genetic typing such as PRRS RFLP or preferably gene sequencing. This allows for characterization of any new PRRS virus.

## **FEED**

Energy and amino acids must be balanced. This is essential in providing the energy required to power the immune system as well as the basic building blocks of antibodies. Minerals and vitamins are required in quantities sufficient to optimise immune function. Fibre may be helpful in controlling gastric ulcers that are secondary to the empty stomachs associated with disease.

Feeders must be managed such that the feeder will provide adequate access for each pig. The feed needs to be free of mould and mildew. Immune suppression caused by exposure to mycotoxins can lead to increased incidence of pneumonia. Immune suppressing toxins can be bound to toxin binding agents or diluted with toxin free grains.

## **WATER**

Water is an essential nutrient. Well capacity, water flow rates, pressure, drinker number, type and placement should allow for optimal water intake. Water flow metres can be used to monitor water consumption. An experienced electrician can check for “stray voltage” if no other cause of reduced water consumption can be found. Factors such as mineral content, hardness, total dissolved solids, and pH should be considered.

Water sources and delivery systems may become contaminated with disease causing organisms such as *E.coli*. Total coliforms and fecal coliforms should be assessed at least yearly or when problems arise. Water sanitation can be maintained using chlorine or hydrogen peroxide added to the drinking water. The use of chlorine should be monitored by testing for levels of free chlorine.

## **ENVIRONMENT**

Air exchange rates impact disease control through removal of contaminants. Increased ventilation rates may increase air speed which will in turn reduce the “effective environmental temperature” potentially causing chilling. Increased relative humidity may increase the survival time of bacteria in the room environment. Minimum ventilation rates are established and maintained by measuring the relative humidity (RH) and then adjusting the minimum ventilation rate in order to maintain 65 % RH in the late fall, winter and early spring. Control of RH in the summer is not practical and the room RH is going to be very close to RH outside the barn. In the summer the rapid air exchange rates that are used for temperature control will provide for pathogen dilution.

Chilling due to wide daily temperature fluctuation, as well as rapid small temperature fluctuations contributes significantly to the increased prevalence of disease by increasing stress levels in affected pigs. Chilling may also be caused by drafts, damp floors, damp pigs or insufficient floor, wall and ceiling insulation. Ventilation and temperature controllers should be adjusted so as to ensure that they are set to control temperature fluctuation and daily variability. Inlet placement and control, as well as thermostat cleanliness, sensitivity and placement are important.

The use of simple environmental testing equipment such as humidity monitors, data loggers, air speed and gas testers have allowed for more detailed analysis of the barn environment. This equipment has allowed for more objective ways of measuring environmental quality.

## **SANITATION**

Improperly cleaned pens are a source of pathogens for the next group of pigs. Rooms should be washed thoroughly using hot water and a high pressure sprayer such that all visible organic matter is removed from floors, walls, feeders and drinkers. Pre-soaking and the use of detergent will assist in reducing washing time. Washing should be done as early as possible

during the downtime period. This will allow for the maximum clean and dry period possible prior to arrival of the next pigs.

The PRRS virus can be killed with appropriate disinfectants, heat and specific pH levels. PRRS virus is stable at pH 6.5 to 7.5 but infectivity is rapidly lost at pH below 6 and above 7.5. A product designed to kill viruses and bacteria on barn surfaces should be used at the appropriate concentration. Equipment used to apply disinfectant must be calibrated. Water lines should be sanitised between batches of pigs. After a disinfectant in a liquid form is applied the room can be further disinfected using a thermal fogger. A disinfectant product applied with a thermal fogging technique disperses widely throughout the room and kills pathogens in hard to reach areas such as manure pits. Thermal fogging is not a replacement for application of liquid disinfectant.

Leaving a room to completely dry with or without supplemental heating is one of the most effective ways of killing viruses and bacteria. Cleaned and disinfected pens should be left to dry a minimum of 24 hours before pigs are placed. Barns should be allowed to dry for a minimum of 7 and preferably 14 days between batches where PRRS elimination is required.

## **CONCURRENT DISEASE**

A PRRS control strategy will include a plan for the control of diseases that act as PRRS co-infections. Co-infections have the ability to increase both the severity and duration of disease associated with PRRS.

The damage caused by Ascarid (Roundworm) larvae migrating through the lungs can potentiate the damage of Mycoplasma and viral pneumonias such as Swine Influenza. The presence of mature internal parasites in the intestines can compromise absorption of nutrients. Ensure that the piglets are not exposed to a significant internal parasite burden. Ascarid (Roundworm) control should be reviewed. Sows should be routinely dewormed and washed prior to farrowing. Growing pig pens should be thoroughly washed after each group in order to remove parasite eggs. Strategic worming of all growing and finishing pigs should help to control roundworm infections especially in barns that are not easily washed.

Mange infestation predisposes pigs to respiratory disease. Mange and lice can reduce the effectiveness of the pig's immune system. In herds that are positive for external parasites the sows should be routinely treated for external parasites prior to farrowing. Mange and lice eradication programs should be investigated.

## **HOSPITAL PEN/RECOVERY PEN**

“The sick are the greatest challenge to the healthy!” A pig with active PRRS is a source of infection for pen-mates and if removed promptly the spread of PRRS to the “at risk” pigs in the pen can be reduced. If a pig is seen with PRRS pneumonia it should be removed to a hospital pen. Once pigs are no longer sick they can be moved into a recovery pen. In more

severe PRRS outbreaks involving a large proportion of the pig population, the use of hospital pens will have obvious limitations.

Unidirectional flow of pigs is important. Do not leave poor doing, sick or recovered pigs with new incoming pigs. All in / All out must be followed very closely.

## **MEDICATION**

Injectable antimicrobials will be of minimal help in PRRS cases. At best, the antimicrobials will help to minimise the effect of secondary bacterial infections. The PRRS virus may be spread from pig to pig via contaminated needles. Anti-fever drugs can be used on viremic sows that are at risk of aborting due to fever.

Water soluble antimicrobials can be selected based on the sensitivity pattern of the secondary bacteria. Anti-fever drugs may be used to decrease the negative effects of fever. Fever may lead to depressed appetite, abortion in sows, and decreased milk production. Acetylsalicylic Acid (ASA or Aspirin) is used in combination with Sodium Bicarbonate. Acetaminophen has also been used.

Feed medications can be selected based on the sensitivity pattern of the secondary bacteria. Feed medications must be provided at the earliest possible time post infection in order to maximise efficacy.

## **VACCINATION**

“Heterologous Immunity” is the immunity that is provided against a particular PRRS isolate when the animal has been previously exposed to a different PRRS isolate. The level of protection provided through heterologous immunity is quite variable. The use of a commercial PRRS vaccine to provide protection against a field strain is an example of heterologous immunity.

“Homologous Immunity” is the immunity that is provided against a PRRS isolate when the animal has been previously exposed to the same PRRS isolate. The protection provided by homologous immunity is more consistently effective. Homologous immunity may be provided to the breeding herd through exposure during an outbreak or under more controlled circumstances such as intentional feedback of tissue that contains PRRS virus or injection of serum that contains PRRS virus.

## **BIOSECURITY**

Biosecurity should be reviewed with attention to both internal and external biosecurity. External biosecurity deals with the risk of introduction of new isolates of PRRS or other co-

infections from outside of the farm. Internal biosecurity deals with the spread of PRRS virus within the farm after the virus has been introduced from outside.

Avoid moving the PRRS virus from animal to animal via needles used for injection by changing needles more often. ie; 1 needle/litter at piglet processing. 1 needle/5 sows or even 1 needle/sow.

Piglet processing equipment such as tail dockers or tooth nippers can spread PRRS virus. Multiple containers of disinfectant for piglet processing equipment will increase contact time with disinfectant. One set of processing equipment should be disinfecting while the other is in use.

Boots, hands and coveralls should be kept clean. Avoid tracking the manure and urine from aborting or sick sows from sow to sow. A good quality garden hose can be used to remove potentially contaminated manure from boots prior to walking from contaminated to non-contaminated areas. Disposable gloves can be used between litters.

Separate shovels, brooms and scrapers should be used for the manure passage and the feed alley at all times in order to reduce the risk of viral spread from behind affected sows to the at risk sows via the feed alley.

Until the herd stabilises for PRRS, discontinue any pre-farrowing manure feedback programs such as those used for E.coli control as this may spread PRRS to uninfected late pregnant animals.

Review and implement a “McRebel” program. The “McRebel” program includes protocols for cross fostering. There have been some adjustments to the original McRebel program. Some modified McRebel programs have increased the intensity of the program by eliminating all cross-fostering at the time of a PRRS until PRRS virus circulation in farrowing has stopped. In these strict programs even if there is a litter of 14 piglets and a litter of 4 piglets there will not be any cross-fostering. In addition, some of these programs call for euthanising any piglets that show signs of scours, respiratory distress, or are weak at birth. During the initial stages of an outbreak, if you foster PRRS viremic piglets into the litter of a non-exposed sow you will make that sow get sick. The sow becomes feverish, does not milk well and does not come back in heat. The costs of McRebel with respect to losses associated with starvation have not been documented. It has been suggested that the farrowing room losses associated with a strict McRebel program are far outweighed by the improved nursery performance. When the McRebel program is discontinued it is important that the farrowing room operator reports any increased scours or sows off feed after fostering. This will indicate that it is probably too early to adopt a more liberal cross-fostering program again.

Agricultural calcitic lime or other dry disinfectant powders can be used in alleyways and hallways in order to reduce the transmission of infection between rooms. The lime is inexpensive and primarily works through its effect on pH.

## CONCLUSIONS

Control and prevention of PRRS should be based on a balanced approach that includes minimizing PRRS virus and co-infection pathogen loads as well as maximizing immunity. Clear communication of a properly designed disease control plan allows for successful control of PRRS in many cases. Attention to detail of the best management practices will allow for a basic platform of disease control.



# **KEY MEASURES OF PERFORMANCE IN THE GROWING-FINISHING BARN FOR INFORMED DECISION MAKING**

**Mike Tokach, Bob Goodband, Joel DeRouchey, Steve Dritz, and Jim Nelssen**  
**Kansas State University**  
**246 Weber Hall, Manhattan, KS 66506 USA**  
**E-mail: [mtokach@ksu.edu](mailto:mtokach@ksu.edu)**

## **INTRODUCTION**

Excellent record keeping systems for sows have been around for over 20 years. High quality, reliable data management systems for growing-finisher pigs are only starting to become publicly available. Thus, producers are less familiar with the key performance measurements, how they are calculated, what they mean, and what constitutes a good number. In this paper, the key performance measures and minimum data required to collect them are briefly discussed. Management changes that should be considered to improve financial return for the individual group of pigs and how to prepare the barn for another group also are addressed. Finally, methods to evaluate and reward the person in the barn on their management abilities are presented.

## **KEY MEASURES OF PERFORMANCE**

### **What Measures of Performance Should be Routinely Measured in the G/F Barn for Effective Management?**

Although we are in the information age and numerous tools are available to collect and store information, we need to be careful not to overload barn workers, accountants, or owners with collection and analysis of information that can not be easily summarized, interpreted and used to improve the management and financial return from the finishing barn.

The key performance measures that I encourage producers to collect on all grow-finish groups include:

- Normal growth performance (ADG, ADFI, F/G, average initial and market weight)
- Marketing information (total weight marketed, Average weight of top market pigs (those not going to a cull market, number of culls and value of culls)
- Mortality (total mortality and weekly pattern)
- Feed usage (cost and use by diet compared to feed budget)
- Facility utilization (Open days and turn days)
- Other expenses (Pharmaceutical and other expenses per pig)
- Current inventory

Numerous other measures can be collected in the barn as part of routine management. Some people make excellent use of these measures to improve their management; however, most

simply collect the data because they are told that it is important to know. These could include measures such as high/low temperature, number of daily treatments, water usage, cough scores, etc. If these data don't provide useful management improvement, they shouldn't be collected.

### **Can the Key Performance Measures be Obtained Practically and Routinely?**

If you don't overwhelm yourself with collecting data that isn't needed, the answer is yes. Good information takes time to collect, but doesn't need to be overwhelming. The most important aspects of the data collection are: 1) accuracy; and 2) that it must be collected routinely on a daily basis and input into the record keeping system on at least a weekly basis. The information that must be recorded to calculate all the key performance measures includes:

- Dates, number, weight of pigs entered
- Dates and number died
- Dates, number, and weight marketed
- Dates, amount, and cost of feed delivered
- Total pharmaceutical or other expenses incurred by the group.

If the data is not entered into the record system within a week of the event occurring, the likelihood of errors occurring increases rapidly. Finding and fixing errors in the data is very hard when the memory of the event has diminished.

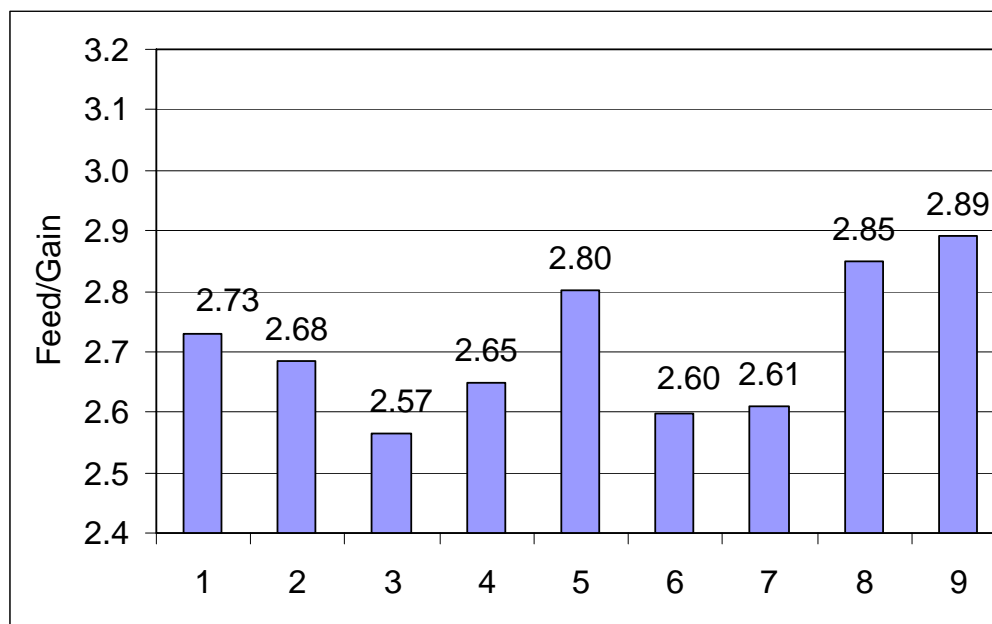
The other key component of data collection and retrieval is the data management system that is used. This can be as sophisticated as a web-based system with elaborate graphing capabilities or as simple as a home-made spreadsheet. The important components of the system are that it allows for easy data entry, finding errors is relatively easy, and summaries can be generated that are easily understood and contain the key performance measures. Every production system that I know prefers to summarize their data in a little different format. To truly understand the numbers, you need to have confidence that they are correct and be familiar with them, thus, consistency in reporting format is very important to improve communication. Some people can see a page full of numbers and easily understand which are important and where to focus, while others need to see it in more graphical form to find trends and problems.

There are numerous good examples that could be used to illustrate data summaries and methods of using data. Only a few will be presented here. Some of the data collected is shared as close to the end of the close out as possible (Example in Table 1). After enough data is collected, data can be graphed to clearly show the differences between barns or producers (Example in Figure 1) or compared in comprehensive tables (Example in Table 2) to enhance communication with employees in the barn or with the owners when comparing data between farms. Another very useful exercise is to determine opportunity areas where efforts should be focused, especially for producers that are part of a group that shares data with each other (Example in Figure 2). Producers often want to know how their performance or economic numbers compare to other producers. By being part of a data sharing group, these comparisons are made much more easily.

**Table 1. Example of close out data shared with the grower in one production system.**

Wean to Finish	Group 1206
Wean-finish ADG	1.76
Wean-finish ADFI	4.78
Wean-finish F/G	2.72
Wean-finish feed cost/lb gain, \$	\$ 0.159
Wean-finish mortality, %	6.6%
Nursery ADG	0.99
Nursery ADFI	1.51
Nursery F/G	1.52
Nursery feed cost/lb gain, \$	\$ 0.147
Nursery mortality, %	4.3%
Finisher ADG	2.16
Finisher ADFI	6.48
Finisher F/G	3.01
Finisher Feed cost/lb gain, \$	\$ 0.162
Finisher mortality, %	2.5%
Avg finisher days	104.0
Turn days for finisher	109.0
Avg market wt	295.0
Ave live price, \$/cwt	50.03
Adjusted wean to finish F/G	2.49

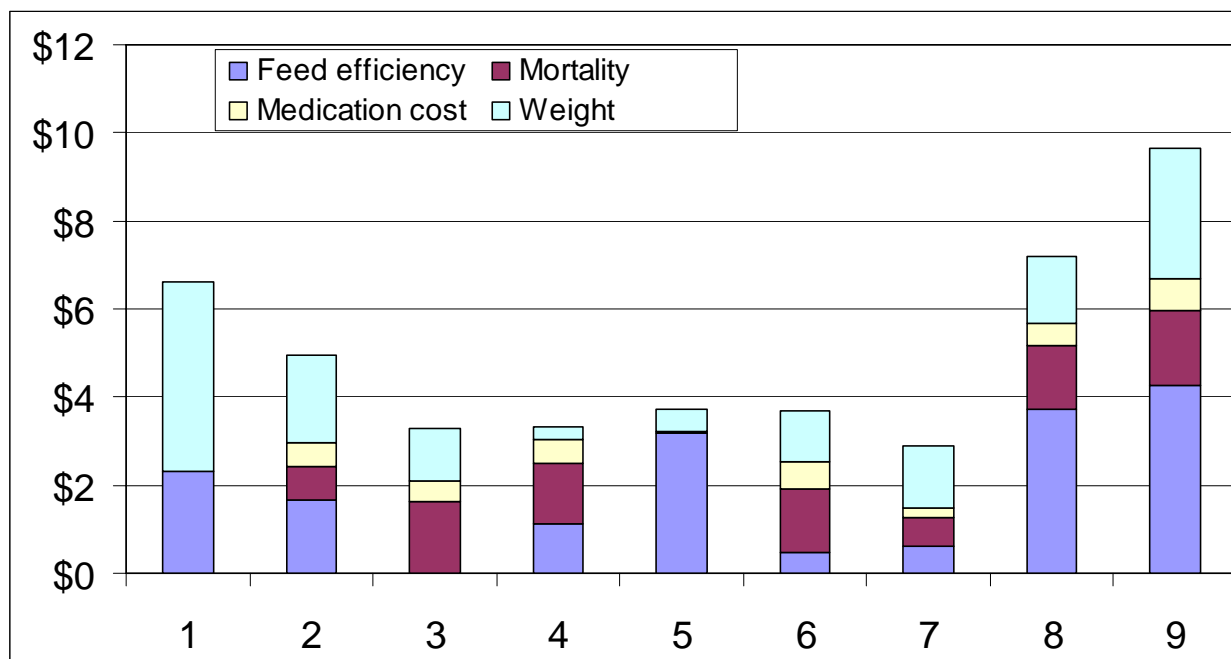
**Figure 1. Example of an annual feed efficiency comparison for nine producers in a producer group.**



**Table 2. Example of comparison of annual closeout data for five producers in a data sharing group (Performance leaders in several categories are highlighted).**

	Owner				
Data	1	2	3	4	5
Average of Weight In:	60	69	58	59	67
Average of Avg. Daily Gain, lb	1.76	1.77	<b>1.98</b>	1.87	1.86
Average of Feed Efficiency	2.80	2.85	2.69	2.79	2.98
Average of Adjusted F/G	2.73	2.68	<b>2.57</b>	2.65	2.80
Average of Weight Out, lb	256	263	266	<b>269</b>	268
Average of % Mortality:	<b>1.88%</b>	2.45%	3.09%	2.88%	<b>1.88%</b>
Average of Cost / Head, \$	\$39.48	\$40.11	\$35.97	\$37.48	\$40.35
Average of Med Cost / Head, \$	<b>\$1.21</b>	\$1.75	\$1.68	\$1.76	\$1.23
Average of Feed Cost, \$/lb of gain	\$0.204	\$0.206	\$0.173	\$0.180	\$0.201
Average of Avg. Daily Intake, lb	4.90	4.99	5.29	5.19	5.49
Average of Avg. Days on Feed	112	110	105	113	108
Average of Turn Days	126	110	110	125	125
Average of Open Days	14	<b>0</b>	5	12	16

**Figure 2. Opportunity areas (\$/pig) for nine producers in one data sharing group.**



Of course, when making any comparisons between producers or even between barns within the same system, care must be taken to account for differences in season, diet formulation, final market weights, placement weights, or other factors. As more data is collected, the

expected impact of each of these factors on performance can more easily be determined and used to adjust the data to a common point for comparison. Without adjustment, it is sometimes difficult to determine whether a difference in performance is real or not. For example, if feed efficiency for one group is 0.1 lower than another group, but they started 4 kg lighter and finished 5 kg lighter than another group, both groups would have almost identical feed efficiency after adjustment.

### **What Management Changes Should be Reconsidered on a Routine Basis?**

Different management strategies may need to be considered for each group of pigs within a production system or farm because of differences in starting weight, seasonal growth rate, health status, fill time, and facility capabilities. In this section, a few of the routine considerations will be discussed.

**Diet changes.** Certainly as a nutritionist, I am going to list reviewing diets towards the top of items that should be considered on a routine basis. In reality, diets should be reviewed, but I don't advocate making lots of frequent diet changes unless there is a sound financial reason to make the change. Many people chase small diet cost reductions that end up causing themselves difficulty either with pigs going on and off feed because of the change in ingredients or because they can't compare their finishing groups performance to each other very well because of the differences in diets.

That being said, you do need to consider whether dietary changes will enhance profitability for each group of pigs. For example, if an increase in dietary energy will improve average daily gain, you need to include the importance of market weight in your dietary economic decision. We find that the economics of energy density changes seasonally for most production systems. Most systems are short on the space needed for pigs to achieve the optimal market weight in the summer months, but have ample time to meet market weights in the winter. Thus, diets that may increase the feed cost per pound of gain may be economical in the summer because they generate enough revenue to pay for the extra feed cost. This would rarely be the situation in the winter because there wouldn't be the additional revenue to offset the higher feed cost.

Many people think Paylean fits into the same category as dietary energy because of the impact of Paylean on growth rate. In reality, the pricing and use of Paylean has made it economical to use in almost all situations. Thus, our producers decision whether Paylean is going to be used or not is based on the relationship with their marketing partner (i.e. Does their packer pay them not to use it?), more than anything. The economic advantage to Paylean will change with the importance of ADG. If the optimal market weights are easily achieved without Paylean, the value of Paylean is much lower, but it is still profitable. If the optimal market weight cannot be easily achieved due to insufficient facility space (days on feed), the value of Paylean usually triples for most of our producers.

**Feed budgets.** Allocation of feed, especially the first diet, needs to be considered for each group of pigs. Because diets are targeted for specific weight ranges and the initial weight of pigs at entry will vary from group to group, the quantity of the first diet to deliver has to be

altered with each group. Because of the difficulty in communicating the correct budget for each group of pigs, the feed budgeting responsibility has been removed from the barn and placed in the feed mill for most producers. Thus, the person in the barn simply notifies the mill when feed is needed and the mill consults the feed budget to determine the appropriate diet based on prior deliveries, initial weight, and placement numbers. Some systems are sophisticated enough to adjust the feed budget for mortality; however, few systems are making this adjustment.

**Medications, vaccinations, and feed-grade antibiotics.** The decision on medication protocols is made on a group to group basis between the producer and veterinarian based on the current situation in the source herd, history in the facilities, economical response, and the ability to implement the program. Partial budgeting should be done when considering each intervention strategy to ensure that the proposed benefits will outweigh the treatment costs. This exercise will at least clearly illustrate the level of benefit required to pay for each intervention.

**Marketing plan.** Although the optimal market weight doesn't change dramatically from group to group, the marketing plan (when to make the first pull and how many pigs to pull) will often change between groups. Because growth rate is variable between groups, producers need some tools to help determine when enough pigs of the optimal market weight are available for marketing. The three main options that I see working in the field to make this determination include: 1) test weighing or using a weight tape on a sample of pigs starting at a designated time post placement; 2) using an auto-sort system; or 3) using feed delivery and an estimate of the amount of feed that should have been consumed by a certain weight. Some systems use the feed delivery and a standard growth curve with a seasonal adjustment to provide two estimates of when pigs should be nearing market weight. Then test weighing is used to more accurately estimate the actual weight in the barn. Number of pulls and number of pigs marketed at each pull is adjusted, mainly based on the amount of time remaining before the barn must be emptied.

We are often asked if there are practical means to improve, control, or monitor uniformity in pig weights. I will discuss this section in detail in my other paper in this publication. In short, once pigs are placed, the only things that can be done to improve uniformity are altering the diets or weighing pigs. Higher energy diets or higher use of Paylean can be used with the gilts to make them grow closer to the same rate as the barrows. Recently, some producers have split pigs by initial weight at entry instead of sex and fed the higher energy diets to the lightest 50% of the pigs to increase their growth rate. These techniques require the barn to have two feed lines and coordinated feed delivery, but they do work to help reduce some of the variation in final weight in the barn. Of course, the other method to improve uniformity of weights at marketing is by weighing pigs at market to ensure that pigs are marketed before they become too heavy and to prevent light pigs from being marketed too soon.

### **What Needs to be Done to Prepare to Receive a New Group of Pigs?**

**Thoroughly washed, disinfected, and dried facility.** Cleaning barns is an area that has received renewed discussion in many production systems. Few argue that cleaning barns is

important to improve pig performance. However, the area of discussion is whether barns can adequately be cleaned and, especially, dried during winter months. Most swine pathogens only survive for a brief amount of time outside the host in the absence of organic material or moisture. Up to 99% of bacteria can be removed by cleaning alone under experimental conditions. The relative importance of stages of sanitation in the field include: 1) 90% of bacteria removed by removing organic matter; 2) 6 to 7% killed by disinfectants, and 3) 1 to 2% killed by fumigation. When we cannot adequately dry the facility, viruses, such as PRRS, survive for extended periods of time. When dried, they die very quickly. Because they are unable to adequately dry facilities, some production systems are experimenting with not washing finishing barns in the winter months in northern climates and doing a thorough cleaning in the summer. In this area, I would advise watching and learning from the experiences of others. I would continue washing until data indicating others have been successful with a seasonal cleaning protocol.

When washing, one of the frequent errors is not adequately cleaning feeders and waterers or not removing disinfectant from feeders or waterers. Because many feeders and waterers are not easily removed for cleaning, other methods must be used to remove water and dry them. Many producers now use leaf blowers to remove the water from feeders and waterers that are not removable.

**Conduct preventative maintenance.** The best time to do maintenance is when the barn is empty. Most good producers have a mental list of items that must be done between groups, but it is helpful to keep a log of items that need to be fixed, replaced, or serviced when the barns are empty. These could include items such as greasing bearings on augers or repairing waterers, gates, feeders, inlets, curtains, or insulation.

**Make sure necessary supplies are on hand.** Make sure any needed supplies, such as medication, syringes, needles, pig markers, or equipment parts, are on site before the pigs arrive.

**Check and set ventilation system.** Ventilation controllers, probes, fans, and curtains should be checked to make sure they are operational and set for the number and weight of pigs being received and the barn temperature. The barn should be warmed as possible to be in the thermo neutral zone for the weight of the pigs that are arriving.

**Have feed and water available.** Before pigs are placed, the proper diet for the weight of pigs being received should be placed in the feeders and all watering devices should be checked to ensure they are operating correctly and with adequate flow.

**Don't sort pigs on arrival.** Unless the pigs are being split to have the gilts on one feed line and barrows on another or lightest 50% of the pigs on one feed line and heaviest on another, pigs should not be sorted at entry to the barn. Pigs should be "gate cut" into pens to allow the normal variation within each pen. If they are sorted into tight weight groups within each pen, they will develop the normal variation over time to market and lower the average growth rate in the barn.

## **How Can the Barn Manager be Evaluated and Rewarded for Good Management?**

Another question that often arises in the finishing area, centers on evaluating and rewarding the person that is in the barn providing daily care for the pig. Most contract production systems have some sort of feed efficiency bonus system where they reward managers that achieve excellent feed efficiency numbers relative to their peers within that same production system. Of course, the dietary energy level and diet form must be considered in making feed efficiency comparisons within a production system. If the production system has consistent genetics and diets, feed efficiency is one of the economically important factors that is least affected by seasonality and health status. Thus, using it as a bonus tool is not without merit. Other performance measures, such as sort loss bonuses or mortality bonuses, are used by some production systems as a means of rewarding good management. Unfortunately, much of the variability in sort loss or mortality is outside of the hands of the person in the barn. Thus, great caution should be used before implementing a bonus strategy based on these parameters. Mortality is often dictated more by the health status of pigs being delivered than management ability of the person in the barn. When selling on U.S. packer grids, the person with the lowest sort loss will have lighter market weights, excess trips to the packer, and lower facility utilization. While low sort loss may be desirable, focusing on it rather than maximum profitability will decrease net return in most situations.

To truly evaluate whether the person in the barn is doing a good job, continual routine oversight is needed. Most of our contract production systems have a field service person that visits the barn on an every week or every other week basis to monitor pig care and barn management. The factors that they check include pig treatments, feeder adjustment, barn upkeep and maintenance, temperature, ventilation, pig quality, office cleanliness, pig handling, and whether records are being maintained and turned in to the right person. The same type of system that is used for contract producers can be used with employees to monitor whether they are doing a good job.

The optimal reward system for good management depends on the person. For some, financial rewards are most important. For most people, making a difference and being important to the overall business is most important. One of the lowest cost, highest payback rewards that is often overlooked is a simple pat on back and recognition that somebody is doing a good job. Feedback needs to be timely, frequent, and meant to be meaningful to the person receiving it.

## **SUMMARY**

Collection of key performance data allows the production system to make strategic decisions on the direction of the entire production system and for the individual group of pigs. The collection of data that is not used reduces the value of the entire data collection process in the eyes of the person in the barn. Thus, care must be taken to not collect unnecessary data. Performance results can be used to evaluate the person in the barn, but routine oversight is required to truly evaluate the quality of pig care and barn management.



## MANAGING AND MONITORING THE FINISHING BARN - SIX THINGS NOT TO DO

Mark Yungblut  
Synergy Swine Inc., Molesworth Farm Supply Ltd.  
RR # 1 Listowel, Ontario N4W 3G6  
E-mail: myungblut@mfsltd.ca

There are many factors that constantly need to be monitored, assessed and juggled to successfully grow and market finishing pigs. Instead of discussing all of the various factors that one should focus on, I thought I would briefly highlight six things **not** to do to when attempting to improve overall finishing pig efficiencies. In the workshop, examples will be provided in support of these six items. These six items are in no particular order of importance:

- 1) **Do not** limit feed intake. Easy to say, difficult to do. There is nothing you can do to increase a pig's feed intake; unfortunately, there are a number of negative things you can do to decrease or limit a pig's feed intake – eliminate these negative factors.
- 2) When utilizing feed budgets, **do not** always assume that “more feeds are better”. There is a fine balance to over-feeding the bigger pigs vs. underfeeding the smaller pigs. If you utilize very lean genetics, default to over-feeding the bigger pigs if you have to make a choice – lean genetics usually respond to the elevated level of nutrition. If possible, know the different requirements between your barrows and gilts. The differences are not consistent across genetic lines.
- 3) **Do not** underestimate your non-feed production costs – they are bigger than you may think. Do not make yourself feel better by conveniently forgetting or neglecting some of them when talking about your “cost of production”.
- 4) **Do not** always assume that you are getting a huge “bang for your buck” if you use growth promotants. Do you really need them? Try to determine the actual level of benefit received – unfortunately this is easier said than done.
- 5) **Do not** always assume that bigger is better: bigger barns, bigger pens, bigger pigs. Target for manageable group sizes that are just big enough to maximize the production, costing, and marketing efficiencies within your operation.
- 6) If utilizing grow/finish contract barn services, if possible, **do not** keep all of the reward or assume all of the risk. The sharing of rewards and risk enhances sustainability and often works as a good incentive program. Good barns are good; good people are better. Be careful not to not put too much weight on incentives that barn managers have limited control over.

There are many other “**do not’s**” that one could discuss. These six cover very big subject areas. These factors could also be applied to nurseries as well.

“**Do not**” sounds very negative; however, focusing on some of the above mentioned “negatives” can lead to some more “positive” results. We all can use some more positives.

# **BENCHMARKING... SHOW ME THE MONEY!**

**Ken McEwan**

**University of Guelph Ridgetown Campus**

**120 Main Street East, Ridgetown Ontario N0P 2C0**

**E-mail: [kmcewan@ridgetownc.uoguelph.ca](mailto:kmcewan@ridgetownc.uoguelph.ca)**

## **ABSTRACT**

Benchmarking is a process that has been happening since the beginning of time. It is a method used to measure one's strengths and weaknesses against others doing the same thing. A group of farmers who get together over coffee and discuss the costs of raising pigs or prices received per pig are, essentially, benchmarking themselves against others in the group. Even this informal setting provides an environment to compare individual results and identify ways to "keep up with the Jones".

## **BENCHMARKING**

### **Why Benchmark?**

In agriculture, benchmarking is a method that allows comparison of variables between producers. It helps to determine who the best is and what the average is. The result is a management tool that can be used to pinpoint what an individual enterprise is doing well and where improvements could be made. This is a learning process because if you don't know what the average is you don't know how you compare with others.

### **How to Get Started**

It is important to determine what you are planning to benchmark and how. Will it be only production data that is benchmarked, financial data or both? Will the results be shared in a group setting or will an unbiased third party collect the data and then disseminate results? Benchmarking in a group setting can be beneficial to all involved as it allows an opportunity for discussion. Producers can ask each other what they did to achieve certain results. In this situation, however, it is important to find producers who are similar to you (i.e. similar production system), and who you are comfortable sharing your information with. It is easier to start with a small committed group who are able to work together and share information openly.

Starting with a few variables first is recommended because it ensures everyone is providing data in a similar fashion, identifies any flaws in the template, and provides an opportunity for participants to determine how comfortable they are sharing data. More variables can be added when the group is ready.

## Setting Up a Benchmark Template – Things to Keep in Mind

- What will be the unit that is reported? \$/sow? \$/pig weaned or marketed? \$/ckg pork?
- How do you account for producers that may not quite fit the group criteria? For example what if a farrow to finish producer sells some weaners? This can throw off the results because the weaners have not reached full market weight. Weaner pigs can not be considered equal to a market hog in terms of cost of feed/pig, revenue/pig and etc.
- Definition of sow/breeding female – It is important to have criteria regarding when a female is counted as part of the breeding herd because this will affect all productivity numbers.
- Allocate income and expenses at the enterprise level.
- Don't give up after the first attempt. The key is to stick with benchmarking over time because trends are valuable tools. All farms go through cycles (i.e. disease) and comparing your results from one time period to another also provides insight into your operation.

## Results for the Swine Enterprise

The Ontario Data Analysis Project (ODAP) can be used as a benchmarking tool to investigate Ontario's cost of production for raising market hogs<sup>1</sup>. This data set contains farm level financial and production information from a group of Ontario farrow-to-finish farms. The participants consider themselves to be full-time farmers and they report little, if any, off-farm income. Most of the farms rely on family labour to fill additional labour needs.

This discussion focuses on the swine enterprise and does not take into account other farm activities (i.e. cash cropping). Family labour has not been included in the expenses. ODAP provides analysis on a per pig produced basis<sup>2</sup>. Some of these farms had SEW or weaner pig sales as well as market hog sales.

The average number of pigs produced per farm in 2005 was 3,559. The average number of sows on these farms in 2005 was 212. Table 1 displays results for some production variables for 1995, 2001 and 2005.

Figure 1 shows average revenue per pig produced over time<sup>3</sup>. Also plotted on the graph is the average yearly market price (\$/ckg). Revenue/pig has fluctuated with events such as the price crash in late 1998. The average revenue for the time period of 1995 to 2005 was \$148.37.

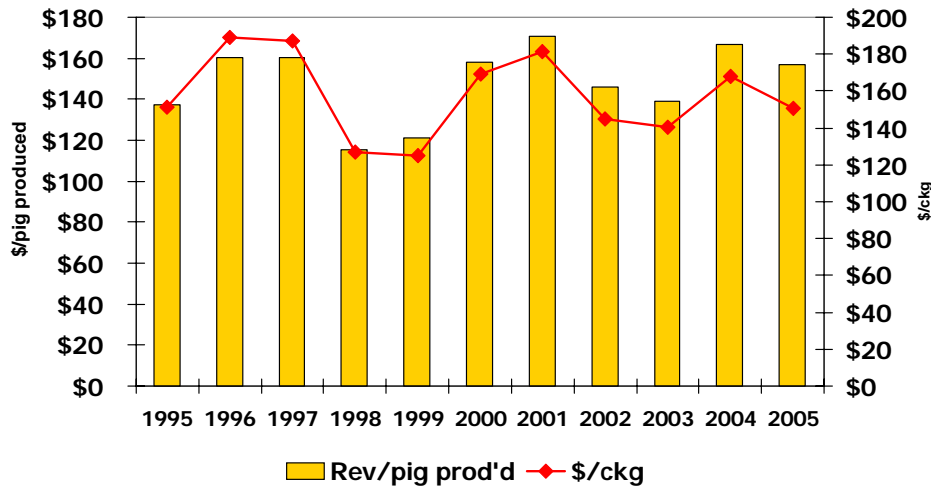
<sup>1</sup> Participation in ODAP varies each year. Results are for discussion purposes and are not assumed to represent an Ontario average.

<sup>2</sup> This is a calculated number that converts all pigs produced and sold to market hog equivalents taking into account all production and inventory changes. Weaner pigs are converted to market hog equivalents using a factor of forty percent and SEW pigs are given a factor of twenty-five percent.

<sup>3</sup> Revenue accounts for premiums/discounts, cull pig sales, and changes in accounts receivable and inventory.

**Table 1. Production variables.**

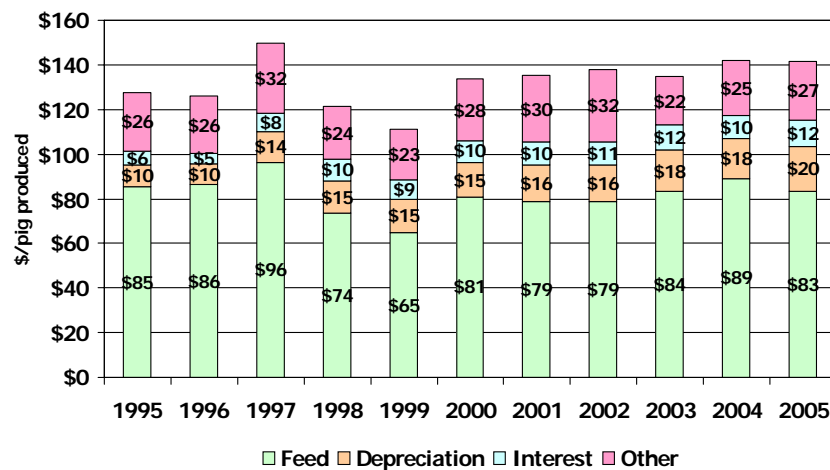
	1995	2001	2005	% Change 05 vs 95
Avg # of Sows	133	254	212	59%
Weaned/litter	9.1	9.1	9.14	3%
Litters/crate	9.6	12.2	12.0	25%
Litters/sow	2.24	2.33	2.31	3%
Weaner mortality	2.7%	3.0%	3.2%	19%
G/F mortality	3.0%	3.3%	4.9%	63%
Days to market	177	170	166	-6%

**Figure 1. Average revenue per pig produced.**

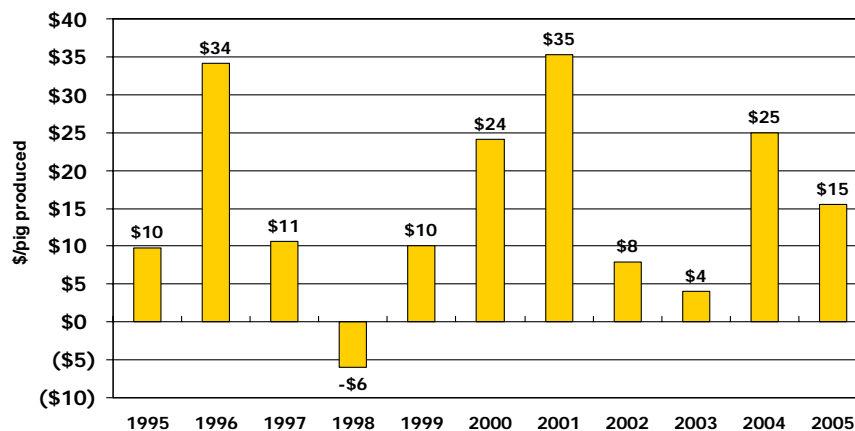
Expenses per pig produced as shown in Figure 2 have been fairly consistent averaging \$132.89 over the 11 years. Feed makes up approximately 62% of total expenses each year. Depreciation expense has grown steadily from \$9.61 to \$19.90 during the years depicted. This is due to increased building and equipment investment that has occurred with expansion and/or renovation of these farms over time. Average interest costs were \$9.19/pig during the 11 years and “other” expenses were generally in the \$26/pig range each year. “Other” expenses reflect health costs, building and equipment repairs, hired labour and any other expenses associated with the swine enterprise.

The resulting profit per year is shown in Figure 3 below and the average over this time period is \$15.49 per pig produced. This graph shows a trend of 3 years of increasing profits followed by a year of small to negative profits. Year to year profits are very volatile due to fluctuating market prices and rising input costs.

**Figure 2. Expenses per pig produced.**



**Figure 3. Average profit per pig produced.**



## The Balance Sheet

The average total assets per farm amounted to \$2.7 million in 2005 up from \$1 million in 1995 indicating that these farms have invested significantly in their farm businesses. Some of the growth in farm assets is due to increases in livestock and building values but much of it is due to rising land prices. Table 2 shows average balance sheet values per sow for ODAP participants between 1995 and 2005. This balance sheet summary takes into account all aspects of the farm operation. In 2005, the average total assets per sow per farm were \$12,674 and the average amount of debt per sow was \$4,206.

**Table 2. Average ending balance sheet (\$/sow).**

		<b>1995</b>	<b>2000</b>	<b>2005</b>
<b>Assets</b>	Market Livestock	\$590	\$542	\$736
	Breeding Livestock	306	332	327
	Buildings	1,568	2,147	2,626
	Land	2,179	2,902	5,387
	Other	2,912	2,415	3,598
	<b>Total Assets</b>	<b>\$7,555</b>	<b>\$8,338</b>	<b>\$12,674</b>
<b>Liabilities</b>	Current	811	740	1,059
	Medium	466	127	189
	Long Term	1,488	1,891	2,958
	<b>Total Liabilities</b>	<b>\$2,764</b>	<b>\$2,758</b>	<b>\$4,206</b>
	<b>Equity</b>	<b>\$4,791</b>	<b>\$5,580</b>	<b>\$8,468</b>

## **CONCLUSIONS**

In summary, benchmarking is a tool to compare one farm against other farms as well as year-to-year comparisons for individual farms. It provides an opportunity to identify the areas a farm business does well, where improvements should be made and what the “average” is. ODAP results for the 11 years examined showed average expenses to be \$132.89 per hog produced, not including family labour. Feed makes up about 62% of total expenses and depreciation has doubled reflecting investments in facilities and equipment.

## **ACKNOWLEDGEMENTS**

Thanks and appreciation is extended to Agriculture and Agri-Food Canada for their generous financial support of the ODAP research and to the farm participants for sharing their time and information.

## **ADDITIONAL SOURCES OF INFORMATION**

Manitoba Agriculture, Food and Rural Initiatives – Budgets, cost of production, software  
<http://www.gov.mb.ca/agriculture/financial/farm/software.html>

Kansas State University – Budgets  
<http://www.agmanager.info/farmmgmt/fmg/livestock/default.asp>

Iowa State University – Budgets  
<http://www.extension.iastate.edu/agdm/livestock/pdf/b1-21.pdf>





## BENCHMARKING... SHOW ME THE MONEY!

**Bev Hill  
Hill & Hill Farms Ltd.  
RR#1 Varna, Ontario N0M 2R0  
E-mail: hillhill@tcc.on.ca**

### Farm Background:

- In 1995, became part of a 3 site production system involving five sow herds totaling 3000 sows, 4 different genetics, with blood testing to determine vaccination regime that would be required to be able to co-mingle piglets.
- Unsuccessful due to health issues.
- Moved to common source of genetics.
- Some improvements but health issues continued to add to our problem of eroding margins.
- In 2001, I was invited to participate in a benchmarking group of 8 different Ontario hog operations that now range in size from 500 sows to over 25,000 sows. This group has since been expanded to include a producer from Manitoba, one from Ohio and, most recently, one from Iowa.
- Within our own production group, our farm measured above average in terms of productivity. Within the CIPHER group, however, our farm measured below average in terms of productivity and above average in terms of cost.

Table 1 illustrates some of the main cost line comparisons between our herd and the CIPHER group from January 2002 to June 2005.

**Table 1.**

	CIPHER High	CIPHER Low	CIPHER Ave.	H&H	Difference
Health Cost per Weaned Pig		\$1.35	\$2.06	\$2.80	+\$1.45
Pigs Weaned per Female	23.8		23.8	21.0	+\$5.14(1)
Nursery Feed Cost		\$9.35	\$12.50	\$14.10	+\$1.60
Nursery Health Cost		\$1.03	\$1.96	\$3.92	+\$1.96
Finish ADG	870		808	778	-10%
Finish F/C		2.56	2.85	3.06	+\$3.96(2)
Finish Health Cost		\$ .34	\$2.20	\$4.18	+\$1.98
<b>TOTAL</b>					<b>\$16.09</b>

(1)  $23.8 - 21.0 = 2.8 \text{ pigs} \times 700 \text{ sows} @ \$38 / 14,500 = \$5.14$

(2)  $3.06 \text{ vs } 2.85 = 18 \text{ kg. of feed} @ \$221/\text{mt} = \$3.96 \text{ (on farm)}$

Comparisons between our herd and the CIPHER group clearly illustrated that we were a high cost producer and that we were competitively disadvantaged by a minimum of \$16.00 per market pig. As everyone knows, there is not sufficient margin in this business to allow that kind of inefficiency **and** survival.

We decided to depop / repop and weaned our last **old** pigs in September, 2005 and farrowed our first new pigs in December of 2005.

With slightly over one year of **new** production behind us, using the same genetics, the same nutrition and the same staff, we are pleased with our results.

**Table 2.**

			Jan-Jun/05	Difference
Pigs Weaned per Mated Female (PigChamp)	(last quarter)	27.9		
Per Inventoried Female (CIPHER)	@ 2.4 Parity	26.4	20.1	(\$11.55)
Health Cost per Weaned Pig	(12 months)	\$1.76	-\$2.71	(\$0.95)
Nursery Feed Costs	(Oct/Nov/Dec)	\$13.05	\$14.00	(\$0.95)
Nursery Health Costs	(12 months)	\$0.80	\$6.00	(\$5.20)
Finish ADG	(3 crops)	912	776	
Finish F/C (on-farm prep.)	(3 crops)	2.73	3.14	(\$7.79)
Finish Health Cost (Tylan)	(3 crops)	\$1.80	\$7.98	(\$6.18)
				(\$32.60)

While the decision to depop / repop would have been forced upon us in any event due to increasing health costs and declining productivity, the comparative performance from CIPHER partners certainly hastened the process.

My participation in the CIPHER benchmarking project has been extremely gratifying and this project is successful for a number of reasons:

- The steering committee identified and structured the initial reporting parameters and made recommended changes as we progressed.
- The facilitator Ken McEwan and his associate Randy Duffy, through perseverance, have been able to get us reporting similarly and consistently.
- The participants, large and small, have developed a level of comfort and confidence that allows for a free exchange of data and a sharing of techniques and philosophies. The contribution of producers from different jurisdictions has added immensely to the project.

The following is a list of parameters that we record:

**Farrowing:**

- Revenue per weaned pig
- Feed cost per weaned pig
- Total kg of feed per breeding female
- Health, labour and utility cost per weaned pig
- Pigs born, born alive and weaned per litter
- Prewaning mortality
- Litters farrowed per breeding female and per crate
- Farrowing rate
- Average non productive sow days\weaning age
- Herd parity
- Breeding female culls and deaths %
- AI cost per weaned pig

**Nursery:**

- Start and end weights (adjusted to 63 days)
- Age in / age out
- Mortality and culls
- Ave daily gain and feed conversion
- Feed cost per pig and per kg of gain
- Health cost per pig
- Nursery contract cost
- Nursery transportation cost

**Market Hog:**

- Start and end weights
- Age in / age out
- Mortality
- Average daily gain and feed conversion
- Feed cost per hog and per kg.
- Health cost
- Contract cost – feeder pig cost
- Full value hogs marketed as % pigs placed
- Revenue per hog and per kg.
- Ave dressed weight
- % of hogs in desired weight range
- Ave fat muscle, yield and index
- Margin (Revenue – Feed Cost)
- Total dressed pork produced per pig space and per square foot



# MANAGING REPRODUCTION - CRITICAL CONTROL POINTS IN EXCEEDING 30 PIGS PER SOW PER YEAR

Pinder Gill  
Meat and Livestock Commission  
P.O. Box 44, Winterhill House, Snowdon Drive, Milton Keynes, UK, MK6 1AX  
E-mail: [pinder\\_gill@mlc.org.uk](mailto:pinder_gill@mlc.org.uk)

## ABSTRACT

Producing 30 pigs weaned per sow per year (PSY) is now within the reach of many progressive pig units in Europe, Canada and the USA, with some enterprises already achieving this output. If the current rate of progress continues, then 30 PSY will become the average output for Denmark by around 2020. In Denmark, genetic selection for number born alive has been the key driver of increased sow productivity, but this has come at a price with pre-weaning mortality rates of 14%, as one of the highest amongst EU countries. Improvements in sow productivity will be achieved in most countries by a combination of measures, which include reductions in non-productive days through better management of the insemination step, adoption of higher standards for AI, timely introduction of gilts and culling of barren sows, combating seasonal infertility, reducing piglet losses before weaning, protecting high health status and having in place trained, skilled, rewarded and motivated stock people.

## INTRODUCTION

In Rick Stein's French Odyssey (2005), his opening for cassoulet begins:

*A recipe of cassoulet is a bit like a recipe for bouillabaisse: difficult because everyone has their own version and much intolerance abounds. The essence of it seems to me to be the symbiosis of pork, duck fat, beans and garlic, and as with other famous dishes I see my job mainly as removing unwanted ingredients to get back to the essence of what the original dish was about.*

This sentiment could equally apply to the plethora of published protocols on sow breeding, insemination, natural or artificial, nutrition and feeding to maximise piglet output on units aspiring to reach the lofty 30 weaned per year seen on a small but increasing number of enterprises in countries like Denmark. Like successful recipes, successful sow-breeding protocols are based on a few key ingredients; an absence of one is a recipe for failure.

To get to the essence of achieving or even exceeding **30 pigs weaned per sow per year** (30 PSY), the critical components are:

1. Fit, fertile and fecund females in oestrus.

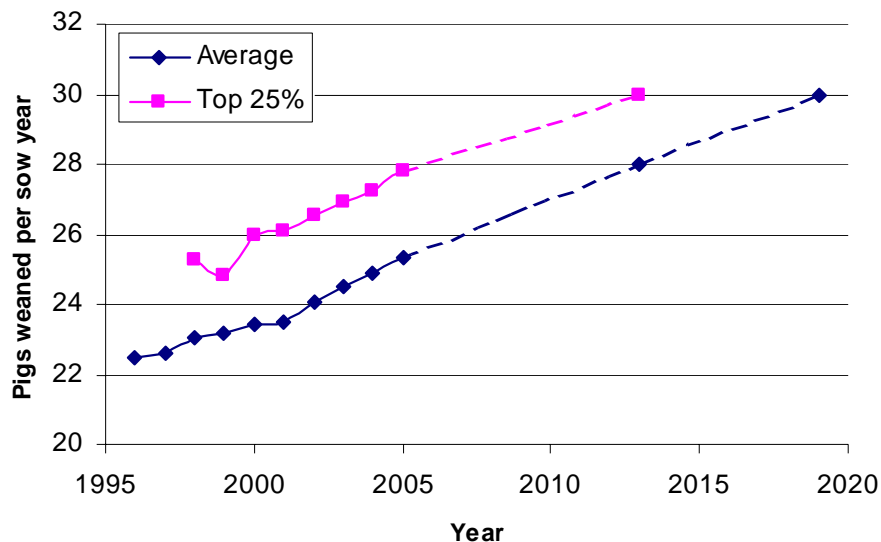
2. Delivery of fertile sperm in the right number, at the right time and in the right place to guarantee conception and maximum number born alive and viable.
3. Minimum number of non-productive or empty days.
4. Maximum number weaned and ultimately finished.

The collective contribution and responsibility of farm staff, vets, geneticists, and nutritionists is to ensure that these components are in place if the objective of 30 PSY is to be met. The importance of disease control, health and welfare management, genetics, nutrition and feeding and staff training will be considered briefly in this context.

### 30 PSY: The Race Is On

The national average number of pigs weaned per sow per year remains a key statistic in comparing how well a particular country is performing in the pig productivity race. If 30PSY is the winning line then at present there is little doubt that at current progress of around +0.5/year weaned, Denmark will be first to cross it in 2020 (Figure 1). Within Denmark and in other advanced pig producing countries there will be examples where individual producers have already reached 30PSY (Jensen, 2004) and as industry leaders they will take the top 10 or 25% of producers to reach the winning line earlier. These data provide assurance that the 30PSY is a realistic goal for many advanced pig producing countries.

**Figure 1. Current and projected sow productivity trends in Denmark.**



### Resolving 30PSY

The average number of pigs weaned per sow per year (PSY) in a herd is a function of empty days (E), number of piglets born alive per litter (N), % pre-weaning mortality (M), lactation length in days (L), the weaning to conception at first oestrus interval in days (W) and the constant ( $K_1$ ) gestation length in days where:

$$PSY = (((365 - E)/(L + W + K_1)) \times N) \times ((100 - M)/100)$$

On most farms W is a variable but holds considerable potential for reduction and control to a constant ( $K_2 \leq 7$ ) through correct management of sows during lactation to limit weight loss. As  $K_1$  is fixed at 114, and changing L has operational and throughput consequences and can influence N, the major drivers of PSY are E, N and M. If  $PSY \geq 30$  then:

E must be  $\leq 30$ , giving a farrowing rate of  $> 90\%$ .

N must be  $\geq 14$ .

M must be  $\leq 8$ .

In other words with a lactation length of 21 days, to achieve 30 or more pigs weaned per sow per year, the number of empty or non-productive days per sow per year should be under 30 giving a farrowing rate exceeding 90%, number born alive per litter should exceed 14 and pre-weaning mortality should be less than 8%. At farm staff level, the greatest return on investment and effort will come from minimising E, then minimising M and in partnership with commercial geneticists, vets and nutritionists in maximising N.

## **READY TO BREED FEMALES FIT FOR PURPOSE**

This area has been covered in detail in the companion 2007 London Swine Conference paper: *Nutritional Management of the Gilt for Lifetime Productivity - Feeding for Fitness or Fatness?*

## **INSEMINATION AND CONCEPTION. ANY TIME, ANY PLACE, ANYWHERE?**

Not unless by accident, as evolution has defined a set of conditions or events under which spermatozoa and oocytes may unite to establish pregnancy. Although incremental advances in reproductive technology have been made, our understanding of these events has not changed fundamentally in over 30 years nor have the key management steps to improve sow productivity, for example as published by (English et al., 1982). These have been summarised below, with further detail on current practical know how covered in the joint paper by Doug Wey and discussed during Session 2 of the conference.

An important point is that there is considerable between animal variability around each reproductive event and an understanding of this is a vital element for the successful management of the reproductive process. For example, only a well-trained, skilled and experienced person can detect subtle differences in the stage, duration, expression and intensity of oestrus between individual sows and is therefore able to maximise conception rates and sow litter productivity.

**Table 1. Summary of reproductive events before conception and management inputs.**

Reproductive event	Brief description	Key management inputs to maximise sow output
Oestrus	Is the period during which the sow will allow service by a boar. The average duration of oestrus in sows is 50 hours, with a range of 32 to 69 hours. Signs of oestrus are widely documented.	Oestrus stimulation. Management (nutritional and environmental) to advance the attainment of puberty and rapid return to oestrus following weaning of the litter. Boar exposure. Accurate and timely detection of gilts and sows in oestrus <b>and</b> showing the standing reflex.
Ovulation	Shedding of oocytes (eggs) from the ovary into the oviduct and occurs around 70% into the duration of the standing heat. Oocytes remain viable for about 6 to 8 hours after ovulation.	Nutrition to optimise quality and number shed. Timely insemination.
Insemination	Delivery of sperm into the female reproductive tract, naturally or artificially	Timing and minimum stress.
Sperm transportation	Transport of sperm by uterine contraction to the oviduct, taking around 2 hours after insemination.	Timely insemination and minimum stress
Capacitation	Membrane and biochemical changes in sperm cells on exposure to sow reproductive fluids before conception can occur. Takes around 2 to 4 hours after insemination.	Timely insemination.

### **Timing is Everything**

Our understanding of the variation surrounding the timing of reproductive events in sows has helped greatly in targeting the timing of insemination to optimise conception rates and litter productivity. From a review of the literature (e.g. Weitze et al., 1994; Kemp and Soede, 1996; Steverink et al., 1999; Rozeboom, 2001) the key findings are:



- Boar exposure is critical to the timely detection of oestrus for AI but frequency and duration of exposure can influence the sow's oestrus response, for example the occurrence of refractory behaviour from excessive exposure.
- The average duration of oestrus in sows is 50 hours, with a range of 32 to 69 hours. At individual farm level, the range can be from 1 to over 90 hours.
- Duration of oestrus is farm specific, and can be predicted from month to month with a repeatability of 86%.
- Duration of oestrus decreases as the weaning to oestrus interval increases, from 56 hours at 4 days to 46 hours at 6 days.
- The high variation in duration of oestrus results in a high variation in the interval from onset of oestrus to ovulation. Onset of oestrus is therefore not a good predictor of optimal timing of ovulation.
- Sperm are only viable in the female tract for 24 hours.
- Majority of ovulations occur at the beginning of the last third of standing heat.
- Sows inseminated between 0 and 24 hours before ovulation show consistent high fertilization results with 91% normal embryos.
- Where only one insemination has taken place, insemination after ovulation decreases farrowing rate and litter size.
- Farrowing rate is 7% higher for double instead of single artificial inseminations.
- The negative relationship between the weaning to oestrus interval and litter size might be related to suboptimal AI timing relative to ovulation, rather than reduced fertility.

The implications are:

Precise knowledge of the timing of ovulation for each sow would be a powerful tool in the management of farm AI to optimise sow productivity but at this stage such a tool is not widely available.

Timing of AI should be tailored to the individual farm, as duration of oestrus and the weaning to oestrus interval is farm specific.

Farms with short oestrus durations should review factors that may be causing an extended weaning to onset of oestrus interval, such as boar contact and sow body weight loss in lactation. Short oestrus durations narrow the critical window for optimum AI timing relative to ovulation.

Where AI timing is compromising sow productivity, monitoring of the duration of oestrus in a proportion of the sows could retrospectively assist whole herd AI management, as duration of oestrus within farms has high repeatability from month to month.

### **Insemination Standards**

Investment in the gilt and sow is wasted if the quality of the semen is substandard, because the boar is infertile, or in the case of artificial insemination (AI) protocol standards have not been followed at any point between collection of the ejaculate and insemination of the sow.

Doug Wey will cover detailed practical aspects of good insemination standards in his paper, but for completeness they include the following principles:

- Boar nutrition, health, husbandry, housing, age and work load.
- Semen collection and extender protocols, covering biosecurity and hygiene, and temperature control.
- Semen quality assessment.
- Semen storage and transportation.
- Recording and traceability.
- Sanitation and hygiene during insemination.

## **FILLING EMPTY DAYS**

My glass is half full but for each day that a sow remains empty or non-productive costs nearly \$4.60 (Peet, 2004). For a herd achieving 30 PSY, limiting empty days is a critical control point, should each sow on average gain one non-productive day (NPD), then annual output for a 500 sow unit will fall by 45 piglets weaned. In herds where sow productivity is limited by empty days, one or more of the following weaknesses may apply:

- Delayed return to heat.
- Failure to detect heat.
- Failure to conceive.
- Failure to detect sows returning to heat.
- Failure to promptly cull non-productive or barren sows.

There may be many underlying causes for the above, but the effort for overcoming them is a point for further discussion and include:

- Maintaining all breeding stock in a healthy and fit condition, including the provision of housing and flooring that avoids physical injury to legs and feet and loss of body condition.
- Nutrition and feeding in lactation to avoid excessive weight loss and reduce the weaning to first service interval.
- Heat detection and timely insemination.
- Accurate identification of sows not in pig, based on careful observations for signs of discharge from day 14 to 15 after service, heat checking at days 18 to 24 using a mature boar, pregnancy diagnosis (PD) at 28 to 35 days and again at 49 to 56 days and daily visual PD beyond 70 days and up to farrowing.
- Aggressive culling policy for sows that fail to return and do not remain pregnant to a re-service.
- Management of the gilt pool to promote the onset of puberty, flow of replacement gilts into the breeding herd and minimise empty days from entry to conception.

The importance of nutritional management during lactation is often overlooked as shortfalls can have a profound effect on the ability of the sow to return to oestrus after weaning. Excessive maternal weight loss during lactation, resulting from inadequate feed intake and nutrient supply, is associated with an extended weaning to first oestrus or service interval, and a reduction in the size of the subsequent litter, particularly in first litter sows (King and Williams, 1984; King and Dunkin, 1986; Kirkwood et al., 1987; Koketsu et al., 1996; Eissen et al., 2003). Steverink et al. (1999) found that farrowing rate decreased by 2% and litter size by 0.4 for each day increase in the weaning to oestrus interval, additionally repeat breeders were found to have lower farrowing rates (73%) compared with sows inseminated during their first heat after weaning (86%). Concerted action here will pay dividends across the herd, as improvements in performance are likely to be seen in all animals.

The benefits of correct nutritional management during lactation are demonstrated (Table 2) by producer application of MLC's Stotfold Sow Feeding Strategy (MLC, 1998), which aims to enhance energy and protein intake using high nutrient diets (14.5 MJ DE/kg and 1% total lysine) and increasing daily feed allowance after farrowing in line with the appetite curve of each sow as a function of lactation day and numbers suckled.

**Table 2. Sow productivity benefits from application of the Stotfold feeding strategy.**

	Herds using Stotfold Feeding Strategy	All other herds
Number of herds	87	67
Av. Number of sows and gilts	218	216
Born alive per litter	11.05	10.79
Reared per litter	9.79	9.56
Reared per sow per year	22.5	21.6

Source: MLC (1997)

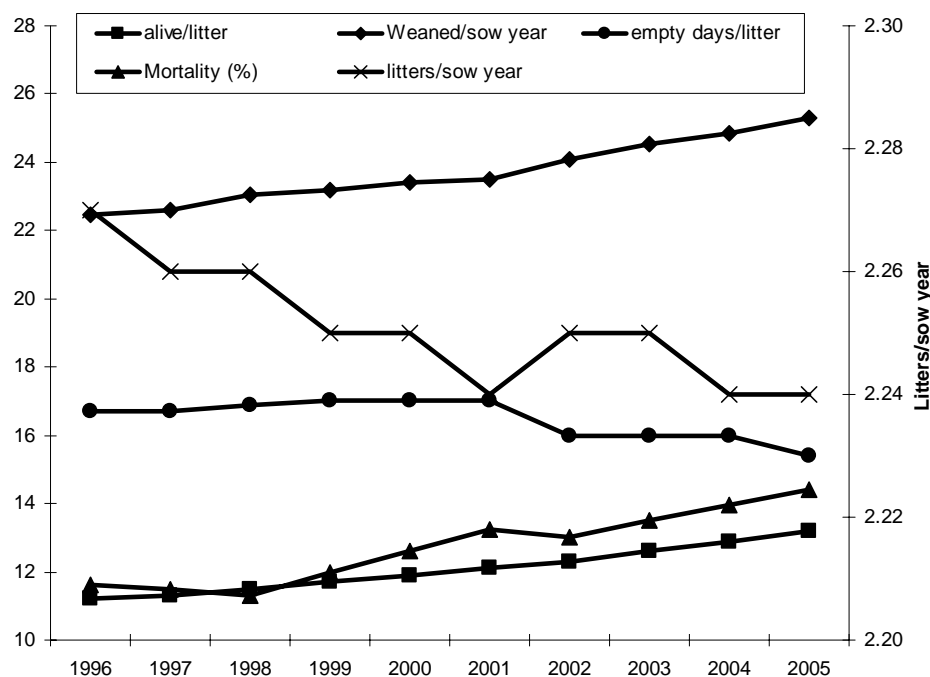
Having emphasised the importance of reducing empty days, it is interesting to note that in Denmark, improvements in sow productivity in the national herd have been mainly made through increasing number born alive, as nationally the average number of non-productive days per litter and litters per sow year have remained almost static since 1996 (Figure 2). Nevertheless herds in the top 25% achieving 2.3 litters per sow per year and 27.3 PSY have around 4 fewer NPDs per litter than the national average of 15.4 for 2005.

## **MAXIMISING NUMBER WEANED**

The number of piglets weaned per litter is a function of number born alive, number born viable and pre-weaning mortality. Many factors influence the out turn, some of which have been considered in this paper and others have been the subject of specific scientific papers and comprehensive chapters in generic pig textbooks. By far the greatest contribution to increasing number weaned has been genetic selection for number born alive as seen in sow

productivity trends for a number of countries such as Denmark, France, Canada and the USA. At farm level there is considerable scope on many units to reduce pre-weaning mortality.

**Figure 2. Trends in the components of sow productivity in Denmark.**



## Genetics

The success of Danbred's selection programme, using AI to create genetic relationships between breeding stock in different herds and enabling the efficient use of multi-trait BLUP, has underpinned Denmark's rapid improvement in sow productivity. The annual genetic gain of around +0.3 piglets born per litter reported in Danish Landrace and Large White purebred herds (Table 3) is a considerable achievement given that the mean heritability for number born alive is only 0.09 (Rothschild and Bidanel, 1998). Similar rates of genetic progress have been reported in France and the USA.

In 1997 the selection strategy in Denmark moved from total born alive to live at five days (LP5) and this has helped to decouple the unfavourable relationship between litter size and piglet weight at birth, and pre-weaning mortality. Genetic progress in LP5 averaged over 2001/02 to 2004/05 in Landrace and Large White purebred herds is reported at 0.17 and 0.23 per year respectively (Danske Slagterier, 2005).

## Reducing Pre-Weaning Mortality

Average pre-weaning mortality rates in select European countries plus Canada and the USA are given in Table 4. These show higher rates in countries making greater progress in

increasing litter size and a scope for reducing losses as demonstrated by performance within top herds.

**Table 3. Litter productivity (2002/03) and annual genetic gain in Danish purebred herds.**

	Piglets born per litter
Duroc <sup>b</sup>	9.8 (-) <sup>a</sup>
Hampshire <sup>b</sup>	8.1(-)
Landrace <sup>c</sup>	13.9 (0.33)
Large White <sup>c</sup>	12.9 (0.30)

<sup>a</sup>In parenthesis annual genetic gain.

<sup>b</sup>Sire lines.

<sup>c</sup>Dam lines.

**Table 4. Pre-weaning mortality (%) of live born piglets (2004/05).**

	Average	Top <sup>a</sup>
Denmark	13.95	11.9
GB	10.34	9.5
France	14.20	-
Netherlands	12.20	-
USA	12.88	12.87
Canada	11.74	9.40

<sup>a</sup> For Denmark top 25%, GB top third, USA and Canada top 10%.

Source: BPEX (2006); Danske Slagterier (2005); www.pigchamp.com

Much has been written on management techniques to reduce the loss of viable new born piglets before weaning. In essence the advice is based on:

- Determining the cause of loss, which in the absence of disease is mainly malnutrition and chilling.
- Corrective action, which mainly focuses on early access of underprivileged piglets to the sow's udder, the provision of thermal comfort and design of the physical environment to reduce the risk of sow crushing.

However, in a recent report on an epidemiological study of risk factors associated with pre-weaning mortality on commercial pig farms (Defra, 2005), crushing of healthy piglets was the major cause of loss (54%), with chilling and crushing of starved piglets accounting for less than 6% of total losses (Table 5). Most deaths (62%) occurred in the first 2 days after birth. The study concluded that the confinement of the sow in farrowing crates during lactation did not significantly decrease liveborn pre-weaning mortality and the most important factors in decreasing losses included the following:

- Stockperson characteristics.
  - Close attendance at farrowing.

- Monitoring of inter-birth intervals, mucus clearing, placing new born under heat lamps, teat provision, split suckling and cross-fostering within 24 hours after birth.
  - Checking pigs twice daily instead of once.
  - A positive stockperson-pig relationship.
- Good health and biosecurity.
  - Isolation of replacement stock before herd entry.
  - Avoid sows with excessive body condition scores (e.g. > 4.0).
  - Low incidence of lameness in sows.
- Temperature control of the farrowing unit.

**Table 5. Percentage of piglets dying from different causes in a survey 122 commercial GB farrowing units.**

Cause of Death	Number	Percent of deaths
Crushed healthy	1596	54.45
Low viability	399	13.61
Starved	197	6.72
Unknown	188	6.41
Crushed sick (secondary to starved or low viability)	135	4.61
Diarrhoea	107	3.65
Savaged	50	1.71
Lame	48	1.64
Accident	45	1.54
Suffocated in afterbirth	38	1.3
Congenital abnormality	38	1.3
Splay leg	29	0.99
Chilled	28	0.96
Disease	26	0.89
Navel ill	4	0.14
Tremors	2	0.07
Missing from sheet	1	0.03
Total	2931	100

Source: Defra (2005)

In the UK, the move to batch farrowing, pushed by the emergence of PMWS, has probably helped to reduce pre-weaning mortality by concentrating staffing effort, increasing the scope for cross-fostering and more importantly reducing the disease burden in farrowing units through improved sanitary and hygiene measures.

## HEALTH MATTERS

Nothing matters more to the wellbeing and productivity of farmed livestock than biosecurity and their health status. In Britain, the catastrophic impact, either directly of new pig diseases

(PRRS and PMWS) or indirectly from the loss of national biosecurity through notifiable disease outbreaks (CSF and FMD), on productivity and in turn competitiveness, sends a clear message that health and biosecurity status must be rigorously protected at farm and national level.

The importance of farm biosecurity is illustrated by the findings of a retrospective cohort study of PMWS on pig farms in Great Britain (Green, 2005). It concluded that factors associated with an increased risk of herd breakdown included purchase of gilts, large herd size, not requesting three or more days pig freedom from visitors, proximity to a grower unit and, towards the end of the epidemic, proximity to a farm with PMWS.

The emergence of PMWS in East Anglia in 1999 and its subsequent and rapid spread north into Yorkshire and eventually Scotland caused serious losses, with mortality levels in weaned pigs on some units reaching 20 to 25%. Animal movement restrictions applied during the FMD outbreak in 2001 disrupted sow replacement policy and herd parity profiles on many units and on some units the effects of this are still felt today. Reduced producer returns, lack of confidence and business investment, coupled with the devastating impact of PMWS and FMD have effectively placed Great Britain at the bottom of the 2005 European league table of sector productivity and profitability (Table 6).

**Table 6. Productivity and cost of production for 2005 in selected EU countries.**

	Denmark	Netherlands	France	Ireland	Great Britain
Litters/sow year	2.27	2.33	2.24	2.28	2.22
Weaned/sow year	26.1	24.5	24.2	23.1	21.5
Finished/sow year	24.3	23.4	22.4	21.9	19.4
Carcase weight (kg)	80.2	89.9	90.7	76.6	76.2
Lean meat/sow year (kg)	1161	1157	1206	969	880
Cost of production (p/kg dead weight)	91.66	85.71	90.57	93.96	104.41

Source: BPEX (2006)

## **SKILLED PEOPLE ARE THE MOST IMPORTANT RESOURCE**

The positive impact of trained and skilled stockpeople on the health and welfare, productivity and profitability of livestock, including pigs, often goes unrecognised. Training of new recruits and continuing education of all stockpeople is probably one of the most cost effective approaches to improving pig performance, (English et al., 1992). This is particularly true in the care and management of the sow, which requires a different set of complex skills at each stage of the breeding cycle to capture her reproductive potential and maximise litter productivity.

The value of training is demonstrated in a European study (English et al., 1999), which compared performance on commercial units before and after staff completed a structured

training programme. On all three units training increased the number of pigs reared per sow per year by an average of nearly 2, representing a 13% improvement in sow productivity. The significance of positive stock worker input in reducing piglet pre-weaning mortality as reported in a recent epidemiological study (Defra, 2005) has been covered earlier.

In the UK and in other western European countries it is becoming increasingly difficult to meet the pig industry's demand for trained and skilled stockpeople and the recruitment of new entrants to the sector. With a population of 60 million in the UK, it seems inconceivable that we cannot find people to resource a national herd of around 440,000 breeding sows, with an increasing number of jobs being filled by workers from the former Eastern European Block countries following recent enlargement of the EU.

## **CLIMATE CHANGE**

Next to disease outbreaks, climate change is potentially the most serious threat to pig productivity in temperate countries. In Britain around 25 to 30% of the breeding herd is managed on outdoor systems, where the provision of shade and wallows are the few effective means for relieving heat stress. The prediction is that 2007 will break last year's record of the hottest recorded to date. It is possible that long-term fertility levels under outdoor production may deteriorate under the effects of rising and extreme summer temperatures. Seasonal infertility can also affect indoor herds, for example in a herd of 1200, records over 4 years showed that the number of returns per month increased steadily from 60 in April to 120 in October (Mackinnon, 2006).

Future solutions for combating the negative effects of climate change on pig productivity are likely to be based on a number of approaches, such as housing design, genetic selection and nutritional management. One approach, which holds potential, is liquid feeding of lactating sows to maintain intake and reduce weight loss. Currently there are very few units in the UK which liquid feed lactating sows, and those which do report positive effects on sow body condition scores, rebreeding after weaning and piglet weaning weights. A number of UK producers are now experimenting with liquid feeding of outdoor sows, with some success. As well as reducing the impact of heat stress, this also eliminates the serious and widespread problem of feed loss through bird predation.

## **THE BRITISH PIG INDUSTRY**

Sow productivity is the cornerstone of a competitive pig industry. As Britain's gap with Denmark has increased from 1.2 to 4.6 weaned and 1.6 to 4.9 finished per sow per year from 1999 to 2005 respectively, the formation of the British Pig Executive (BPEX) in 1999 resulted in the implementation of a Road to Recovery Strategy. This has as one of its current aims to increase sow output by around 3.5 finished per year in line with a 2009/10 weighted average for Denmark, the Netherlands, France and Ireland. Underpinning this strategic target have been a number of BPEX led initiatives (see [www.bpex.org](http://www.bpex.org)) which include:



British Pig Health Scheme  
New Certificates of Competence for On Farm Training Initiatives  
New BPEX AI Standard  
Knowledge Transfer for Improving On Farm AI Techniques and Management  
New field based KT Team of 6 staff, including a pig reproductive specialist

## CONCLUSIONS

Thirty pigs per sow year is within the reach of many well managed and operated units as demonstrated by the few but increasing number of producers in advanced pig producing countries who are already achieving this level of output. The key to success includes a herd populated with fit, fertile and fecund females, timing and quality of each insemination, minimising empty days from gilt entry to first conception and thereafter for each weaning to conception interval and maximising number weaned. The tools required to achieve these objectives include expertise in genetics, nutrition, reproduction and health but these cannot substitute the skills and knowledge of experienced stockpeople who are at the coalface of delivering high performance targets.

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# **MANAGING REPRODUCTION - FACT AND FOLKLORE**

**Doug Wey**

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

**Guelph, Ontario N1G 2W1**

**E-mail: [dwey@uoguelph.ca](mailto:dwey@uoguelph.ca)**

## **ABSTRACT**

Producers are bombarded with advice on how to improve reproductive efficiency and move closer to the elusive target of 30 pigs per sow per year. As is true anywhere else, here in North America we have some longstanding traditions and beliefs as to the most efficient way to produce pigs. Over the past several years, the Danish pork industry has been held up as the success story. I will discuss current views on selected control points in reproductive management: entry of gilts into the breeding pool, estrus detection and AI, managing the lactation period, and the weaning to estrus interval. In what ways does the management of reproduction on the most productive Danish farms differ from that in Canada and in what ways are we on the same track? Are all their strategies applicable to the North American farrowing operation?

## **INTRODUCTION**

As producers, you are under pressure to increase reproductive efficiency, with the target of 30 pigs per sow per year dangled in front of you. You are then bombarded with advice, from the farm press, government agencies, consultants and your peers, on how to best manage your sows' lives so that you can reach this target. During my time as the head swine technician at the University of Guelph research facility, I've participated in the development of some of these strategies. But since then, I've had experiences in the 'trenches', working on several large corporate farms in Manitoba as well as on a boar stud and in a semen lab. In light of those experiences, I'd like to discuss some of the management ideas that are out there. During my presentation, I'll be referring to an article in the February 2005 issue of *Better Pork*, in which Henrik Jensen discusses strategies being used in Denmark to break through the '30-weaned-pig-per-year plateau' (Stoneman, 2005a). His approach was summarized in 11 points, relating to gilt management, breeding, gestation/farrowing and management of the lactating sow. As a group, I would like to discuss how some of Jensen's guidelines translate to the Canadian context.

## **AT WHAT AGE SHOULD GILTS BE BRED?**

As in all aspects of swine husbandry, the limits have been explored with induction of puberty at earliest possible age to reduce 'non-productive' days. The use of PG600 allows us to synchronize pre-pubertal gilts quite easily and there are herds where the animals' first estrus is always reached through human intervention. In my experience, breeding on an early

induced estrus has been counter-productive as these lean young animals were still in the rapid growth phase of their lives. Getting this animal through a pregnancy and lactation without compromising her own growth poses a major feeding challenge. Poor body condition after the first lactation and the resulting lengthening of the weaning to estrus interval (WEI) are particularly challenging in first-litter animals.

In the post-PG600 era, the pendulum is swinging the other way, as we are being advised to breed gilts bigger and older. Bill Close, a UK consultant speaking at this conference in 2003, suggested not breeding gilts until 130-140 kg and 220-230 days of age, after their second or third estrus (Close, 2003). In fact, the Danish model is to not to breed gilts until they reach 160 kg and nine months (~270 days) of age (Stoneman, 2005a). Chances are, this animal will come out of lactation in far better condition than her younger, artificially induced counterpart. However, the potential benefits need to be weighed against the delay in her entry to the breeding pool.

Could there be a limit as to how long we should wait for these gilts? Based on field studies indicating that gilts mated at an older age were more likely to be culled later for infertility, a group in Uppsala, Sweden looked for a relationship between age at first mating and WEI before the second litter. Their results suggested that gilts with delayed puberty (the oldest one-third of the 452 animals in their study, mean age 226 days) tended to express delayed estrus and ovulation after their first litter, and those with weak displays of estrus at puberty had a higher risk of showing a short/weak estrus after weaning (Sterning, et al., 1998). I should point out that in this study estrus checks did not begin until after 160 days of age.

The middle ground on this topic seems to be to allow the gilts to attain puberty naturally so that their reproductive tracts and the rest of their bodies are ready to embark on their reproductive careers, while striving for reproductive efficiency by selecting for gilts that show strong heats within a reasonable time frame.

## **HOW LONG SHOULD SOWS STAY IN THE HERD?**

Early removal of sows from the herd due to mortality, health problems, and low production is a major bottleneck in the swine industry. With sows reaching their peak production between parity 3 and 5, we obviously want first litter gilts to carry on in the herd. Mature sows are also an asset due to their acquired immunity to herd diseases. Yet 40 to 50% of sows are typically removed before three to four parities. Early culling of sows has an extra economic cost if you are buying in replacement gilts. In the Danish model, from second parity onwards sows are culled if they have less than 13 piglets, but gilts are never culled for litter size.

To attain a four litter per sow average while accounting for the normal attrition through structural and reproductive failures, we need some animals to stay in the herd up to 7 or 8 litters. If sow longevity is the goal as well as more pigs produced over her lifetime, then perhaps a later start down that road is a better way of achieving it. Our best defence against culling due to physical breakdown such as lameness or udder damage is through selection for

sound feet and legs and a good underline as well as careful monitoring of the sow during lactation (watching for mastitis, udder damage).

## **CAN OUR CONCEPTION RATES BE IMPROVED?**

Maximizing conception rates involves meticulous attention to detail at several steps: handling of semen, estrus detection, the insemination process itself and deciding when to breed.

I will assume that you are all using AI, with most or all of your semen provided by a commercial boar stud. Given that, I will first define which responsibilities lie with the boar stud and which fall under the control of your barn staff. The boar stud manager is responsible for selecting and training boars of high genetic merit, maintaining their health and nutrition at a high standard, and adhering to a collection schedule such that they are not overused. The lab manager at the stud is responsible for ensuring that the semen is divided into doses of 2.5 to 3 billion motile sperm in ~80 ml of extender. Using conventional AI rods and insemination methods (versus 'deep' or intra-uterine insemination) there is clear drop-off in pregnancy rates at lower doses. Given that these alternative insemination methods are yet not practical under farm conditions and semen is very affordable, there is little potential for improvement of this aspect of breeding. The final contribution of the boar stud is to deliver your semen order within a reasonable time, keeping the semen at or near 17°C. From this point on, it is in your hands.

Boar sperm are extremely sensitive to temperature changes, both warm and cold. A temperature-controlled storage cabinet is essential for high AI success rates. Ideally, this cabinet should be in a location accessible to the person delivering your semen. Take care to minimize temperature fluctuations right up until the semen is put in the sow. Bring the semen doses into the breeding room in a cooler containing gel packs from the 17°C storage cabinet. Only bring the number of doses you are going to use in that session.

Given that the timing of breeding is a critical determinant in litter size and whether a sow conceives at all, heat checking is often not given the attention it deserves. Heat checking at least twice per day is essential. Even better results have been shown with three times per day, but the gain is difficult to justify under North American labour conditions. Running a boar, often vasectomized, down the aisle ahead of the breeders is a common approach. Be aware that the sow will stand for 10-15 minutes, after which she won't stand for an hour or so. Control the boar's movement with a gate, board or chain and collar arrangement. If he gets too far ahead of the breeders, the 'refractory' sows will behave like they are not in heat. In the Danish model described by Jensen, the sows are actually brought to the boar, two at a time (Stoneman, 2005a).

The actual insemination process is not difficult, but by the tenth sow there is a strong temptation to squeeze that semen bottle and move onto other tasks. Careful attention to each sow is required. Avoid 'inseminator fatigue' by taking a short break after 7-8 sows. Bringing only that number of doses in the cooler would be one way of enforcing this rule: use up the doses and head back to the lab to restock the cooler with more semen and gel packs fresh out

of the 17°C cabinet. Given the income associated with each additional pig per sow, there is nothing more important you should be doing with that time. Jensen recommends a team breeding approach, inseminating all sows in a room within 15 minutes. In my experience in 3,000 sow units, up to 40 animals need to be bred in a session. Breeding this number of animals in such a short time would not be possible.

It is well established that sows display estrus for 1 to 4 days, they ovulate about two thirds of the way through this period regardless of the duration of their estrus, and the semen needs to be in the sow 0-24 hours before ovulation. Success rates plummet if sows are bred too early or too late. Unfortunately, there are no visible indicators of ovulation and this event is not related to the onset of standing heat. Can we predict whether an individual sow will have a long estrus or a short one? A study out of the Netherlands established that the duration of estrus was related to the WEI (Kemp & Soede, 1996). Sows with short weaning-to-estrus intervals have longer heats than those coming back 5-6 days post-weaning. The sows in their study coming back by day 3 were in heat 2.5 days, ovulating 41 hours after they were first detected standing, while those coming into heat by day 6 ovulated 27 hours after the onset of heat. With a policy of breeding on the day after the sow first stands, there would be a tendency to breed the early-returning sows too early and the late-returning sows too late. One solution is delayed breeding of the early-returning sows and diligent heat-checking and prompt breeding of the late-returning sows. Another strategy is to breed the early sows three times and space the breedings of the late sows over a shorter interval (twice within 12 rather than 24 hours). Of course, the best way to ensure that sows come into heat quickly is to have them come out of lactation with good body condition. Through the effect of body condition on the WEI, sow nutrition impacts on the success of AI.

## **HOW MUCH, OR HOW LITTLE, SHOULD WE INTERFERE WITH FARROWING?**

Attending farrowings can play a major role in reducing pre-weaning mortality, but how involved should we be in this process? A gilt and a fourth parity sow could be full sisters genetically but you aren't about to treat them the same way. As a first time mother, the gilt may require more supervision because parturition is a new experience for her and her distress could cause her to harm her piglets. At the other end of the spectrum, a seventh parity sow's uterus may have lost some of its tone leading to increased length of parturition and higher risk of stillbirths among the last of the litter. Both of these animals would benefit from attended farrowings but for different reasons.

The amount of monitoring that I have encountered in farrowing rooms in Ontario and Manitoba has been wide ranging. Some barns simply record the time and number of piglets with each farrowing sow when someone passes through the room while attending to other duties. The feed or farrowing card is used as a message board to give staff an indication of the time between piglets is 'too long'. Other barns dedicate a technician to monitoring the farrowing throughout the day. One company I dealt with went as far as to have farrowing attendants pull as many pigs as they could, regardless of birthing interval. In this instance stillbirths may have been reduced but I would be interested to know the longevity of their sows.

The amount of intervention in the form of administered hormones varies as well. Some farms use none while others synchronise all their farrowings with prostaglandins to allow for more efficient use of their farrowing room technicians. There are pros and cons to both approaches. The former will have litters born unattended, increasing the possibility of stillbirths. However the latter is not without its risks as well. Farrowing should never be induced more than two days before the due date. To avoid doing it too early, sows should never be induced without knowing the average gestation length of the herd. There is also the possibility that the contractions of an induced sow may not be as strong, necessitating further hormonal intervention with oxytocin. Once again, blanket statements and blanket treatments come with inherent risks. In all cases, a well-trained and skilled stockperson is invaluable.

### **HOW MUCH SHOULD WE FEED OUR LACTATING SOWS?**

A general rule of thumb is to continually increase feed intake throughout lactation. A sow reaches her maximum milk production during the third week and can produce 180 kg of milk over a four week lactation. We want the sow to consume as much as possible to promote ample milk production and maintain good body condition so that both she and her piglets come out of the crate in fine shape to face their next challenge, be it in the breeding wing or the weaner room. This is not simply a case of pounding feed to every animal. Over feeding is one of the quickest and surest ways of putting a sow off feed. “*Oh you can always cut her back!*” I’ve been told. Yes you can, but by how much and for how long until you get her back to where you had her before she shut down. The idea is to feed them to appetite so our task is to maintain and increase her desire to eat. Doing so is as much an art form as it is a science even with the aid of a hungry litter draining her reserves every hour. Room temperature, infection, injury or simply being a fussy eater all affect consumption and at this level it truly is an individual interaction between that animal and the stockperson. It takes keen powers of observation to determine if there is any physical reason for poor appetite. It involves more than a little physical effort, making certain every sow gets up when you feed. Also, sows eat more if fed three times a day. If you want to spread this over a twelve hour period you are looking at an evening shift, so some flexibility in staffing may be required. Teamwork and communication are essential.

### **IS WHAT SHE IS EATING DURING LACTATION REALLY HELPING HER NEXT LITTER?**

There is an indisputable connection between the sow’s feed intake during lactation, her milk production and the weight of her litter. But the connection between loss of body condition during lactation and subsequent reproduction is much less clear. Foxcroft and colleagues at the University of Alberta are using an experimental model in which first-litter gilts are restricted to 50% of normal intake during the last week of lactation. Although the expected effects on body condition, litter weight and WEI are observed, effects on the subsequent litter have been variable, ranging from reductions in both ovulation rate and embryo survival (Zak, et al., 1997) to no effects on reproductive performance beyond the extension of the WEI (Zak, et al., 1998, Mao, et al., 1999, Vinsky, et al., 2006).

Of more practical relevance is a study from the US based on PigCHAMP data from 30 commercial farms and more than 20,000 lactations (Koketsu, et al., 1996). Six patterns of feed intake were identified, three of which - low intake throughout lactation, low intake during the first week, and a major drop in intake lasting at least two days – were associated with decreased weights of the current litter and extended WEI. The same three feeding patterns were also associated with a higher rate of culling for post-weaning anestrus. However, there was no effect of intake pattern on litter size in the next parity. In fact, the effects of intake pattern on WEI were limited to first-litter gilts.

Despite decades of research into this question, the evidence for feeding the lactating sow to benefit the next litter is equivocal. But the sow coming out of lactation in poor condition will be slower to come into heat, which increases non-productive days. And as discussed previously, this sow will tend to have a shorter heat and is more likely to be bred late relative to ovulation. Reproductive issues in these sows, if any, can be addressed by more diligent heat checking to ensure proper timing of AI. But given the known effects on piglet growth rates, the better solution is to make sure sows, particularly first-litter gilts, come out of lactation in good body condition.

## **IS FOSTERING WORTH THE HASSLE?**

Consistency and routine play an important role in increasing efficiency, but hopefully that gives us the time to deal with tasks that require a certain amount of thought and careful consideration, such as fostering. We want as many piglets on each sow as she can carry but close monitoring is required to identify and deal with malnourished piglets and runts, and sows that are not milking well. Disadvantaged piglets need to be moved to an udder that can support them. Thirteen similarly sized runts have a better chance of survival on one sow than they would scattered throughout the farrowing room among larger and stronger competitors.

As litter sizes increase, through improvements in genetics or management, there will be sows with more piglets than they can handle. Nurse sows and intensive cross-fostering are key components of the Danish system (Stoneman, 2005a). According to Jensen, 13 five to seven day old piglets are fostered onto first or second parity sows in good body condition after their own piglets are weaned (Stoneman, 2005a). Surplus newborns are transferred onto the 5-7 day farrowed sow. The fostering of such large litters onto gilts may be one of the more difficult concepts to apply to Canadian systems (Stoneman, 2005b). Bear in mind that a key point of the Danish management system is to grow larger gilts that are able to cope with an extended lactation without compromising rebreeding.

Moving animals around the farrowing unit is time consuming, and holding back smaller piglets for an extra week can run counter to the practise of all-in all-out. Selecting the best milking sows from the week's weaning to look after a collection of the smaller animals while weaning the rest makes sense from the piglets' perspective but puts an extra demand on that sow. Fostering, split weaning and cascading also require additional space and equipment in the form of more weaning room or extra farrowing crates. In lieu of an over-flow nursery, farrowing room accessories such as Piggy Decks provide some wiggle room. They allow us



to shift larger stronger pigs away from their mothers earlier to free up space to shuffle and accommodate their smaller crate-mates. Of course all of this becomes a moot point if disease enters the equation.

Particularly in the farrowing room, we have to balance protocol with pragmatism. If we strictly follow an all-in all-out SOP there may be times that undersized pigs are weaned that do not survive. If we hold them back then we run certain risks to our sanitation efforts. Protocols ease decision-making but a certain amount of flexibility is required, since we are working with biological entities rather than cogs in a machine.

## **WHEN SHOULD WE WEAN?**

Like hemlines, length of lactation is something that has gone up and down over the years. With Segregated Early Weaning, an idea that arose to break the disease cycle, improve the health and survival of weaned piglets and reduce the interval between farrowings, we saw lactation lengths drop to as low as 11 or 12 days. This scheme requires that WEI, conception rate and subsequent litter size remain constant. In fact, composite figures representing 30 studies over nearly 50 years show that lactations of less than 18 days produce longer WEIs, reduced conception rates, fewer pigs in subsequent litters and reduced sow longevity (Belstra, 1999). And these figures do not tell the whole story, such as sows remaining anestrus and/or becoming cystic.

In the animals that do ovulate and conceive, why is there an effect on litter size? Are fewer eggs released or fertilized? No – ovulation and fertilization rates are fine and rarely limiting in pigs.

The issue seems to be with greater embryonic mortality by day 25-30 ... the uterus hasn't had sufficient time to prepare for a new litter of embryos to implant.

Some farms can wean early and still have respectable reproductive performance, or have WEI and conception rate issues but no problems with litter size. One explanation may be that they are handling first parity gilts differently. It is well established that first parity animals will have more difficulties with early weaning. In fact, gilts at any lactation length are more likely to have feed intake issues and to come out of lactation in poor condition. Although this may play havoc with an all-in all-out protocol, the negative effects of early weaning on reproductive efficiency can be offset to some extent by allowing the gilts to lactate a few days longer.

While there may be ways to make early weaning work, Denmark has clearly gone in the opposite direction. A lactation of at least 21 days is required by law, 28 days is more common, and cross-fostering schemes extend lactations to 30-35 days. Given the results coming out of Denmark over the last several years, it becomes increasingly difficult to support early weaning as the best way to run your farrowing room.

## **THE HUMAN FACTOR: HOW IMPORTANT IS STOCKMANSHIP?**

In the past thirty years we have achieved remarkable efficiencies in swine husbandry, to a point where there is a danger of looking at the sow as simply a production unit. In spite of dealing with herds whose size was unheard of in the 70s, those of us who work daily with the animals are still capable of seeing each one as an individual no matter how similar the genetics throughout the farrowing room.

There have been many examples throughout this paper of situations in which attending to the needs of an individual sow or gilt or their offspring by tweaking operating procedures can increase efficiency. Studies out of Australia have shown that pleasant versus unpleasant or even neutral contact with humans can also impact on productivity. Barnett and coworkers (1984) exposed gilts to five minute periods three times per week of pleasant (gentle stroking) versus unpleasant contact with humans (slapping, brief electric shock) from 11 weeks of age. A third group had little human contact other than normal husbandry. Expression of estrus was not affected by handling, but the pregnancy rates in the unpleasant, neutral and pleasant groups were 33%, 56% and 87%, respectively.

So a positive relationship between the stockperson and the pigs is ideal, but how can we ensure that this happens? Good stockpeople are hard to find and even harder to keep. Yet again, we can look to the Danes. It is perhaps in this respect that the Canadian and Danish situations are furthest apart. Barn staff in Denmark work 37.5-hour weeks and receive at least 5 weeks vacation annually. An 1,150-sow unit had four workers in the barn, which presumably represented a portion of the total staff required to run it on a 7-day per week basis (Stoneman, 2005a). There is a support agency with a network of highly trained people available for temporary work to cover holidays and illnesses. While it is difficult to imagine how such working conditions could ever be offered under the economic constraints in place here, small steps in that direction would be well received. Retaining skilled stockpeople is one of the biggest problems facing the industry today.

## **CONCLUSIONS**

A recurring theme of this paper seems to be that to increase reproductive efficiency and move closer to that 30 p/s/y target, we need to slow down and pay more attention to the details. The delay in getting older, larger gilts into the breeding pool may pay off in terms of litter size, good milk production and a quick return to estrus post-weaning. More time devoted to estrus detection and an awareness of the expected estrus duration of individual animals should result in better timed AI, higher conception rates and fewer not-in-pig females. Allowing a reasonable length lactation has advantages for both sow and piglets. We need to adapt our management priorities to the sow's biology rather than the other way around. Last but not least, stockmanship skills need to be valued and cultivated, and measures put in place to address problems of employee retention.

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# MANAGEMENT PRACTICES THAT OPTIMIZE PRODUCTIVITY IN THE NURSERY - CASE STUDIES ON WHAT WORKS!

Cameron Farrell<sup>1</sup> and Catherine Templeton<sup>2</sup>

<sup>1</sup>Elite Swine, 149 Brock Street, Thamesford, Ontario N0M 2M0

<sup>2</sup>515 Maitland Ave. S., Listowel, Ontario N4W 2M7

E-mail: cam@coldsp.com or templetonc@synergyservices.ca

A new group of weaned pigs is heading down the alleyway to begin their life in your nursery. What are the critical factors that determine if this group is a good one or one that you struggle with from start to finish? Whether you are a farrow to finish operator or a stand alone nursery, the issues that you face are the same.

Our jobs allow us to see a wide range of pigs and nursery operations. Part of our job is to look at current research in swine production and find ways to practically implement this on working farms. In this presentation we will share with you, through case studies, some of the factors that we believe, have made nurseries work.

## CRITICAL POINTS FOR ACHIEVING NURSERY PERFORMANCE

### Getting The Right Pigs – What Is Important?

Ask any nursery manager what they want in the pigs that they get and they will give you a pretty clear picture of what a good weaned pig looks like. But what about what you don't see?

The first and most critical factor to optimizing a nursery is to get the good pigs. Good pigs are more than ones that look nice. The key to nursery performance is getting predictable numbers of health stable pigs, on a regular basis. To achieve this requires lots of attention to detail in the sow herd. To produce the pigs, you want a sow herd operator that:

- Has a track record of good herd productivity.
- Has a sound genetic introduction program including an isolation and acclimatization program for gilts.
- Has a stable health status with no circulating PRRS virus or other major swine pathogens.
- Has a good biosecurity program.
- Has a good herd health program and an understanding of how factors in the sow herd can affect the performance of the weaned pig.
- Has open communication between the sow herd and the nursery.

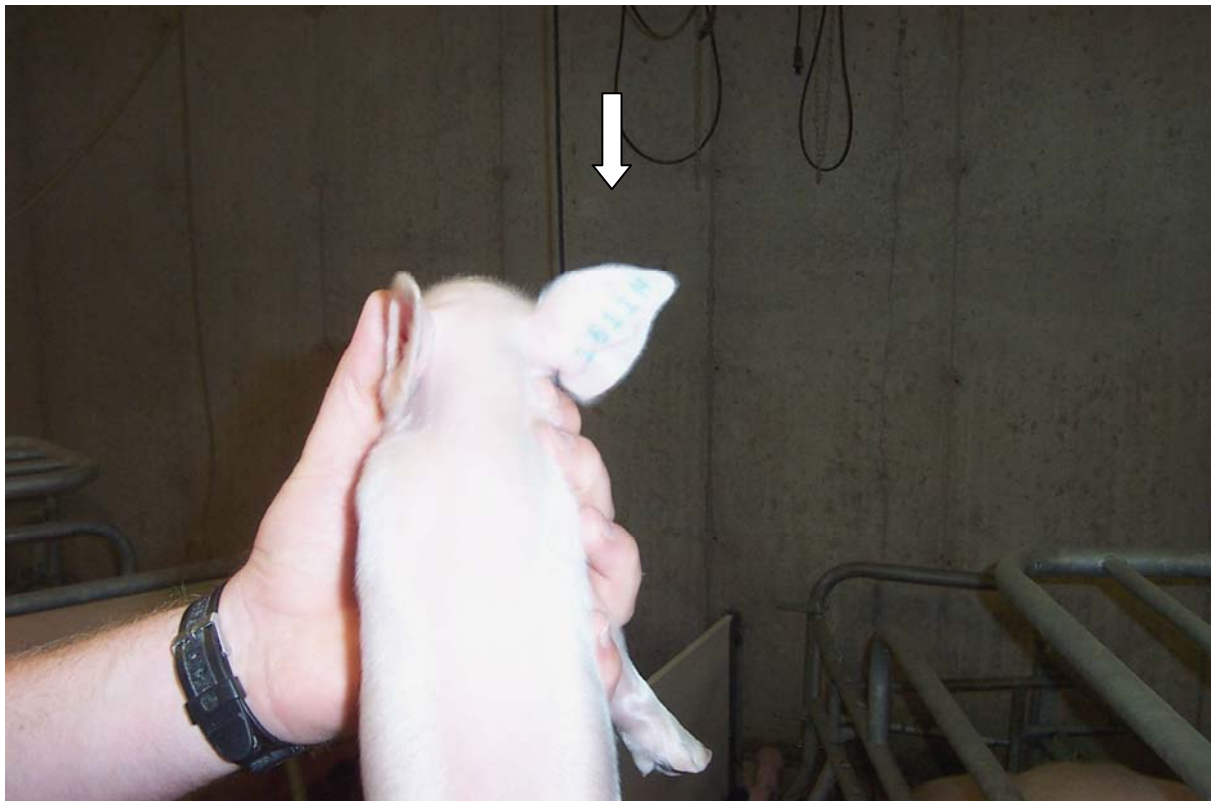
The right weaned pigs:

- Are reasonably uniform in size.
- Have age integrity. This means that pigs should be a known and designated age on

arrival at the nursery. There are multiple reasons why this is important:

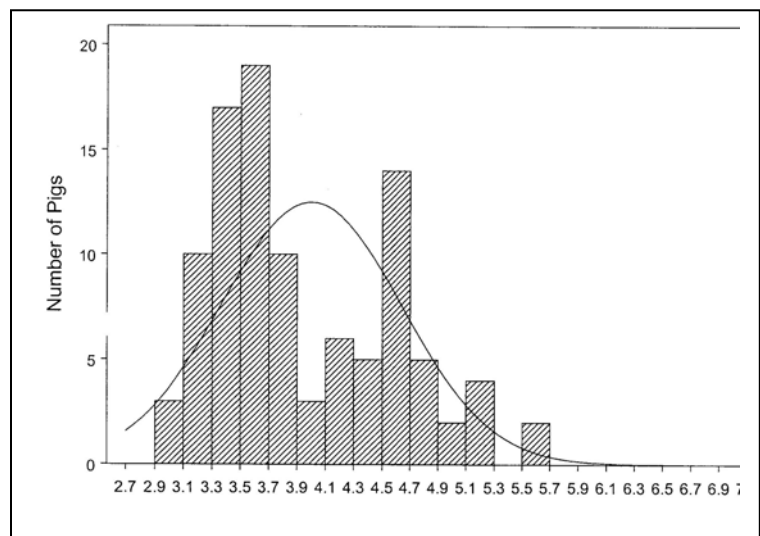
- Age is as important in determining the right feeding program for the pigs as weight. A very young pig who is large, may not have the physiologic maturity to cope with a less complex feed.
- Pigs who are small for their age, are most likely to bring diseases into the nursery (Allerson et al. 2007). It is a disadvantage to the nursery to hold back small piglets until they are large enough to meet the weight criteria, if they are still small for their age.
- Have uniform immune status.
  - Piglets from gilt litters frequently do not have the same degree of immunity that piglets from sow litters have. The use of parity segregated production has been one way to cope with this. Another way, that is more practical in smaller systems, is to keep the piglets from gilt litters together and apart from the rest of the pigs
  - It is important that there is no active disease circulating in the sow herd. Gilts are often sources of circulating disease, even though they may appear healthy. One way of minimizing this is to bring gilts into an isolation & acclimatization facility prior to entering them into the main herd. How long they need to be held there will depend on what diseases you are looking to acclimatize them to.

One way of keeping track of age is to tattoo the pigs at birth with the day of the year. All pigs born that day get the same tattoo number. If co-mingling pigs, a herd of origin letter can be added.



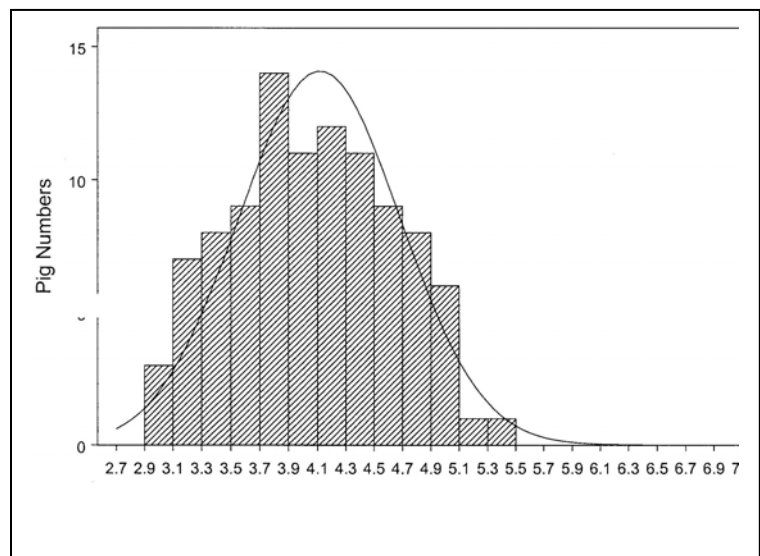
A look at weaning weights:

The following graphs depict the individual weights of 100 pigs per farm on the day that the pigs entered the nursery.



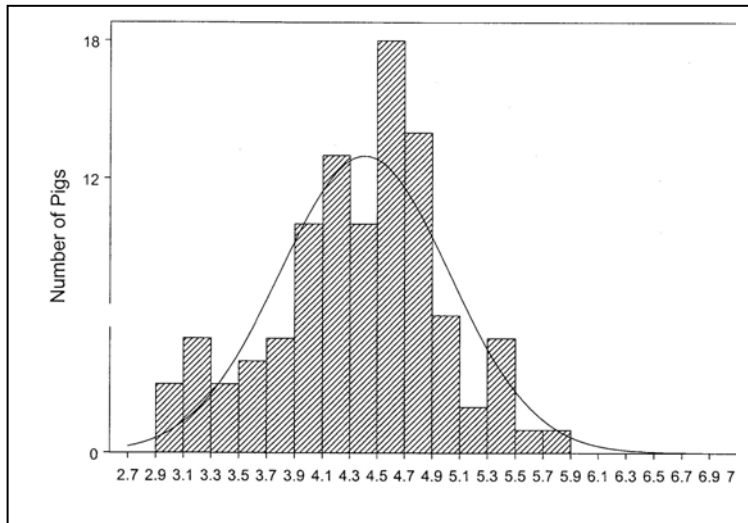
Farm 1 – Pig Weights into Nursery

Number	100
Mean	4.0010
SD	0.6383



Farm 2 – Pig Weights into Nursery

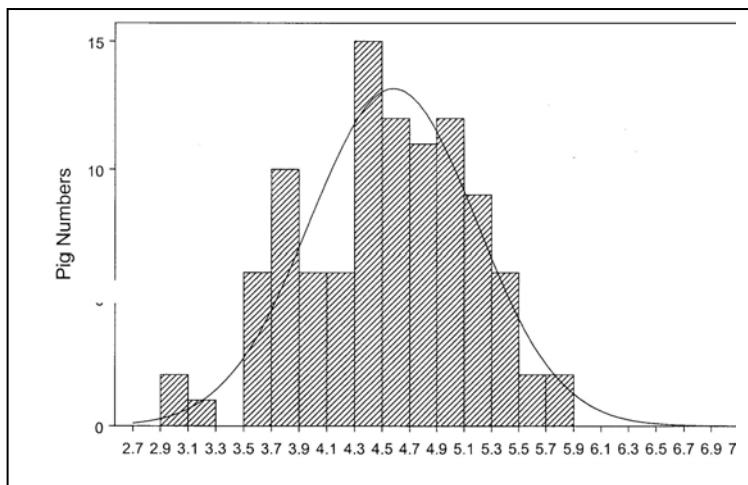
Number	100
Mean	4.1200
SD	0.5666



Farm 3 – Pig Weights into Nursery

Pig Age 15 Days

Number	100
Mean	4.4090
SD	0.6147

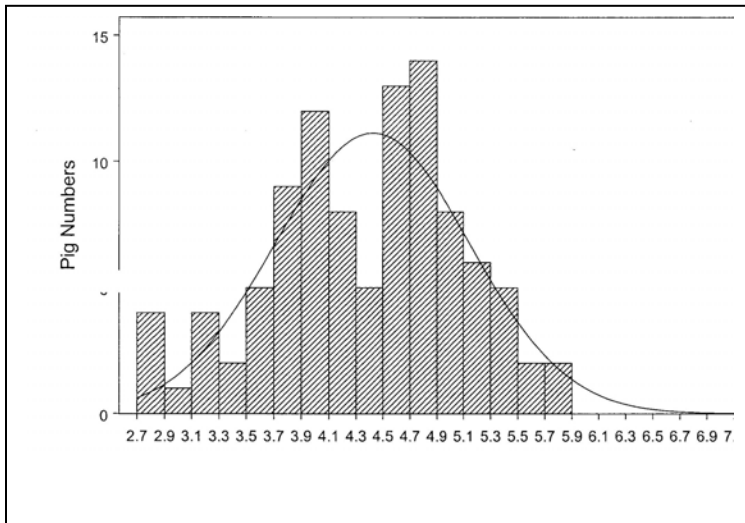


Farm 4 – Pig Weights into Nursery

Pig Age 15.3 Days

Number	100
Mean	4.5850
SD	0.6059

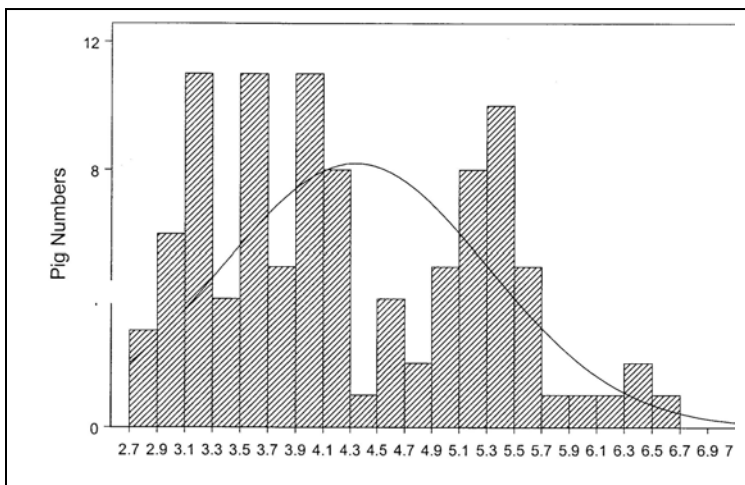




Farm 5 – Pig Weights into Nursery

Pig Age 15.6 Days

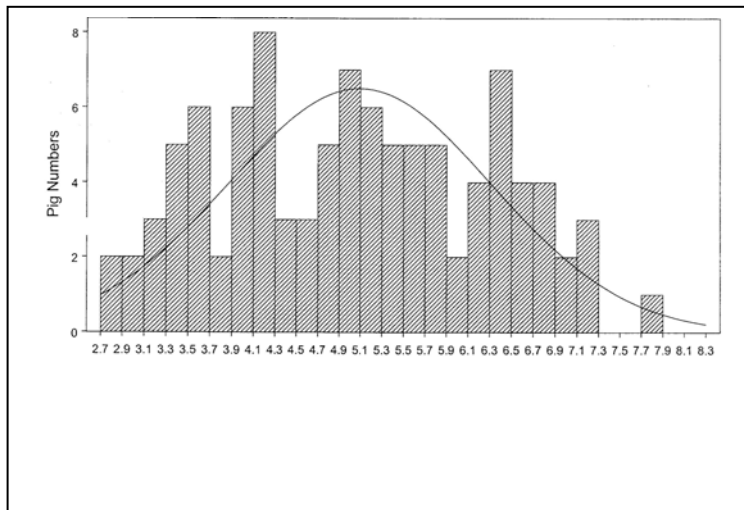
Number	100
Mean	4.4280
SD	0.7165



Farm 6 – Pig Weights into Nursery

Pig Age 16 Days

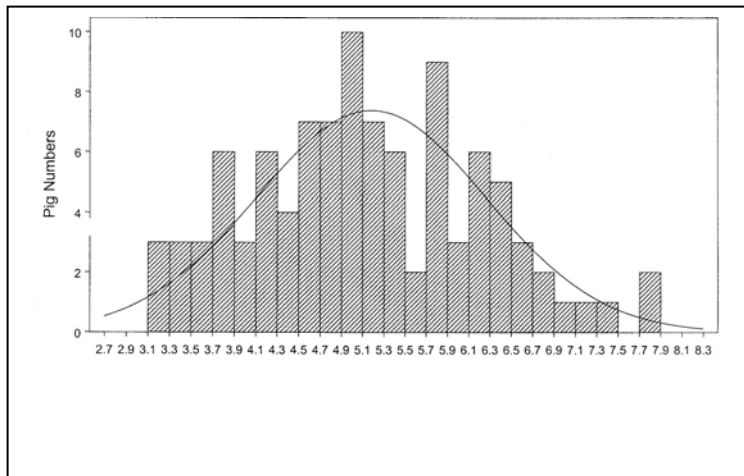
Number	100
Mean	4.3390
SD	0.9730



Farm 7 – Pig Weights into Nursery

Pig Age 16.1 Days

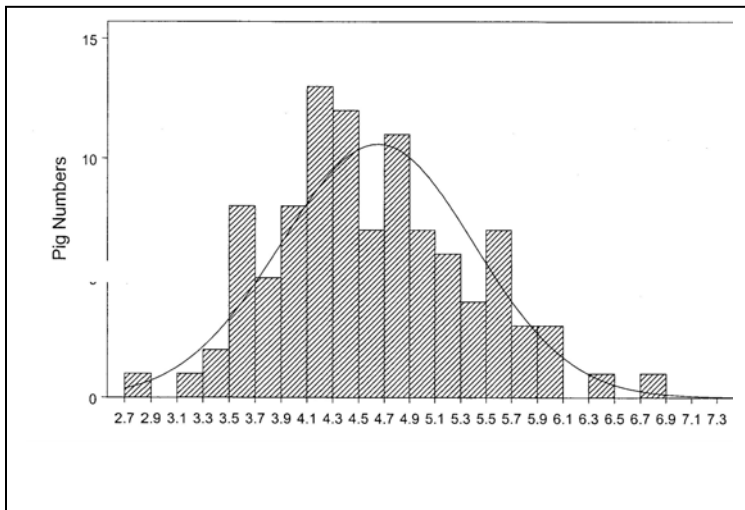
Number	100
Mean	5.0910
SD	1.2270



Farm 8 – Pig Weights into Nursery

Pig Age 16.1 Days

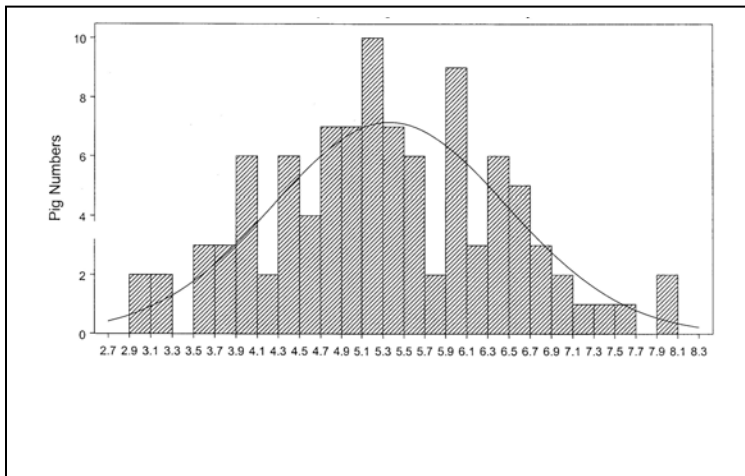
Number	100
Mean	5.1830
SD	1.0808



Farm 9 – Pig Weights into Nursery

Pig Age 16.4 Days

Number	100
Mean	4.6520
SD	0.7535



Farm 10 – Pig Weights into Nursery

Pig Age 17 Days

Number	100
Mean	5.3630
SD	1.1156

## Preparing the Nursery

Preparing the nursery has two components:

### I. Physical clean up:

- Start with a physical clean up of the area as soon as the animals are removed.
- Empty feeders and remove large amounts of feces.
- Presoak. The presoaking is most effective if the ventilation system for that area is shut off or reduced to a minimum during a 6 – 12 hour presoaking period. This aids in retaining moisture in the room or building and softening the residue left.
- Pull the manure plugs, allow the manure to drain and then replace the plugs. This is an important step for personal safety, as the levels of noxious gases will be lower (both during washing and afterwards) if the manure is removed and the wash water is allowed to accumulate in the pit.
- When you begin to power wash, restart the ventilation system.
- Once power washing is complete, disinfect using the proper amount and concentration of disinfectant.
- Allow the room to dry.

### II. Set up:

Having the nursery clean for new pigs arriving is important but it is equally important that the nursery should be set up and ready to receive pigs. The critical factors are:

- The nursery should be warm and dry. The nursery should have achieved the desired placement temperature before the pigs arrive. Temperature guidelines for nurseries are just that – guidelines. It is important to observe pigs at rest. Comfortable pigs lie on their sides, touching one another but not piling. Any temperature stress in the first few days in particular, can set pigs up for health issues like diarrhea.



- The height of waterers need to be reset for smaller pigs. The water source should be at shoulder height. The water source should be obvious to the pig. This may mean that nipples should be leaking slightly, or more ideally, a water bowl or cup is used.



- Feeders should be clean and empty.
- The ventilation system should be reset to start up levels or, if the controls are set on a production curve, reset to day 0.

A cleaning and set up check list is useful to be sure that no steps are missed in the procedure.

#### **Pig Arrival – the Action Plan:**

Research published in recent years has shown that extensive sorting of pigs by weight is not advantageous to overall pig performance (Gonyou et al. 2003). The result has been that

producers have ceased sorting pigs. In practice some middle ground is likely where the industry should be. These are some guidelines for weaned pig management at placement:

- Sort out the smallest pigs only. Leave the rest unsorted.
- Plan to feed the smallest pigs separately (see below)
- Leave 10 % empty space.



- Use this space to “pull” sick pigs into. In a batch nursery whole pens can be allotted. In a situation where just a few pigs are weaned each week, a smaller space can be made for sick pigs. The critical feature of a sick pen are:
  - The pen must be warm and dry.
  - There must be at least twice the normal amount of space per pig
  - Feed and water must be easily accessible and fresh.





### **The critical first 4 days:**

“Well begun is half done”. That quote applies to the pigs coming into your nursery but also to the success of the nursery batch overall. How you manage the first 100 hours that the pigs spend in the barn will determine, to a large degree, how well that batch of pigs does. The goal is to get the lightest 3 - 5 % of the pigs started on feed.

The first 36 – 72 hours are critical. That means the nursery operator will have to make allowance to spend a considerable period of time observing the pig, identifying those who aren't eating, and ensuring that they learn to eat at the critical 36 hour point. A pig that isn't eating looks like this.



By the time a pig looks like this, there is little that can be done to save this animal.



## Getting Started on Feed – A Cost Effective Approach

Nursery feeds are the most expensive feeds on the farm. Using the right feed program and the right amount of each feed is a critical step in optimizing nursery performance.

- Know what pigs you are getting (how old and how big). This involves good communication with the source sow herd.
- Do a nursery feed budget to figure out how much of each feed stage you will need.
- Track (record) feed disappearance and feed changes.

The Robin Hood Theory of Nursery Feed Management:

This is basically a “take from the rich (the big pigs) and give to the poor (the little pigs)”. Obviously, staying within the feed budget is important to cost control, but that is not sufficient to optimize performance. To get the most from your feed dollar, it is important that the feed is allocated to the pigs that can make the best use of it.

- Sort by size (within reason) on nursery placement.
- Decide how much of the expensive first feeds will go to small, medium and large pigs.
- Feed that amount of feed to each size group before switching to the next feed.
- In order to accomplish this you will need to track feed disappearance and feed changes by pen. Typically, this can be limited to the pens with the smallest pigs.

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# **RECRUITING AND TRAINING EMPLOYEES**

**Carole Gumprich M.A.  
C. B. Gumprich Ltd.  
425 Wilson Ave. Suite 401, Kitchener, Ontario N2C 2R8  
E-mail: cgumprich@cbgumprich.com**

## **ABSTRACT**

Swine producers are implementing recruiting and training programs in response to a changing labour market. Competing industries are increasingly tempting our workers with wages, incentives and air-conditioned work environments. Finding, hiring, and retaining the best employees on hog farms in Ontario is becoming a number one priority. A number of recruiting and training best practices can be applied to the hog industry.

## **RECRUITING**

### **Job Descriptions**

A comprehensive recruiting program requires a thorough understanding and description of the job that is to be filled. To begin, the producer writes down the skills and competencies that are required to be successful on the job. These skills and competencies are divided into beginner, intermediate and advanced levels. A written job description contains the duties, position requirements, wages, and working conditions. This helps the producer and the applicant to be very clear about their expectations.

### **Competing Industries**

The producer, in addition, must be aware of the competing industries in the local area that draw workers away from his company. An analysis of the competing industries, their skill requirements, wage scales, working conditions, and their opportunities for career advancement help the producer to position his place of employment in a favourable light.

### **Recruiting Program**

The actual recruiting program includes various options: advertisements, job fairs, and formal training programs. Advertising in media today takes many forms, such as, newspapers, online job banks, and trade publications. Secondary schools and colleges hold job fairs at which producers can explain their job opportunities and the rewards of working at their companies. Colleges with swine training programs produce a small cadre of workers, but these students come into the workforce with the expectation of making swine production their full-time careers. To date, swine apprenticeship programs in Ontario have not obtained sufficient enrolment to run. High schools with co-operative education programs do not traditionally

have an agricultural placement component, however, producers who have contact with active 4-H programs may find young people through this group.

Current swine recruiting programs have been introduced on an “as needed” basis. Recruitment strategies are pulled out when someone quits. The problem with this strategy is that it typically takes about 52 days for a new employee to become fully productive, and that is assuming that a qualified replacement worker is found quickly.

### **Human Resource Service Providers**

In today’s world, recruitment in every industry is a full-time occupation. With the baby-boomer generation approaching retirement, and Generation X having fewer numbers, all industries are facing a worker shortage. Until very recently, Ontario producers could apply to the Canadian government to sponsor qualified offshore workers for one to three years. However, in November 2006, the law was tightened, so importing long-term workers has become much more difficult. Producers are finding that the worker shortage requires them to put in long hours in the barn, and they are left with little daylight hours to work on recruitment. Hence, those producers, who focus their time on production, hire a human resource provider to recruit qualified workers and supply training for existing workers.

## **TRAINING**

### **Skills and Attitude Training**

There are two components to a strong training program: skills and attitude. A strong training program can build skills by guiding the worker through a series of exercises over time. Skills can generally be taught, but attitude is less of a training issue and more of a cultural fit issue. Helping a new worker fit into the culture of your company is part of the manager’s job. Most producers look for a person with a positive attitude and a teamwork approach and coach to develop the necessary skills for the job.

In a perfect world, we would have more workers who want to work in primary agriculture. It is rewarding to work with livestock and to be able to move freely around the workplace. We need to do a better job of promoting our industry. There are many people who are interested in working with livestock, but they lack training, and producers, who are already stretched from time constraints, are reluctant to invest the six to twelve months necessary to train them, only to have them leave for more money elsewhere. It’s a Catch-22. If we don’t train them, then we don’t have the workers. If we train them, they may leave for more money elsewhere. Most producers opt for training workers and identifying meaningful rewards.

### **Employee Training**

A successful training program takes the worker from his/her current skill level, and provides daily coaching to move him/her to the next level. Each task is broken down into small steps that must be practiced at least six separate times until it is fully mastered. Even skilled

workers may need to learn more than one way to complete a task based on the company's processes. Sometimes, it is more difficult to retrain an experienced worker from another swine company than to train a green worker who has never worked with hogs before. The important element here is attitude. Again, we note that people with a positive attitude can be trained quite easily, but people who are negative or resistant to change become a burden to the workplace.

## **EMPLOYEE RETENTION ISSUES**

There are numerous issues involved in employee turnover (low employee retention). McEwan's 2004 swine labour study found that pay (wages plus benefits) and weekends off were the main reasons for leaving. Human resource exit interviews also indicate that people leave for health reasons, the desire for career advancement (possibly in another industry), and poor management/supervision practices. Today, we will explore four issues: job satisfaction, wages and hours, and career paths.

### **Job Satisfaction**

Research into job satisfaction has found that most workers are highly concerned about how their managers/supervisors treat them. Workers want to be appreciated for their contribution, and they expect to be treated fairly. The farm is a workplace, and workers must be treated with respect, as they would be in any workplace. Managers and supervisors often move into these positions because of their technical skills, but may lack the formal training required to manage or supervise staff. They may not have acquired project and time management skills. They may be unfamiliar with training and coaching principles. These management skills are as essential to the workplace as production skills. The business of farming is more complex than ever, and producers, managers and their workers require training to keep their skills current.

### **Wages and Hours**

Workers expect to be paid fairly for their work. Young workers entering the labour market may be satisfied with entry-level wages for a short time, but workers with families want and need a sustainable wage. Knowing the competing industries in your local area helps the producer to set wages that are comparable based on skill-sets and experience.

Workers want some level of work-life balance, so they have quality time with their families and friends. Arranging the workday and the workweek according to effective time management practices helps to complete the jobs in a timely manner and allows the worker to have personal time as well. This includes arranging schedules for weekends and holidays off. Most producers have enough staff to rotate weekends and holidays off among them. Again, understanding the competing industries in your local area helps producers to review their options and set policies to retain good workers in the swine industry.

In Ken McEwan's 2004 swine labour study, low turnover farms (0% turnover in last 2 years) and high turnover farms (more than 70% turnover in last 2 years) were compared. Employees on low turnover farms worked fewer hours and received more time off (i.e. more weekends off, statutory holidays, vacation days) than employees on high turnover farms. Employees on low turnover farms also received higher wages.

## **Career Paths**

Finally, to increase worker retention for the long-term, producers need to develop potential career paths. Workers want to feel that they have a future with your company, otherwise after gaining experience at your company, they will move on. McEwan notes that employee turnover costs \$8409 per person, given the lost time between workers and the lost productivity of getting new workers up-to-speed. It is far more cost effective to invest in training and retaining good workers than to deal with employee turnover issues and lost production.

## **CONCLUSIONS**

Hog producers are increasingly hiring non-family workers, which brings a new dimension to the business of farming. Human resources, the skills of recruiting, managing, and training employees, have moved to the forefront of operating a successful business. As in every business that has five or more employees, experience and training have to blend with teamwork and cooperation to meet competitive production goals. Developing and implementing a recruiting plan requires thought and planning. Not every applicant for your job will fit in well with existing workers. First, producers look for a positive work attitude, and second, train for skills. A strong training program is well planned and consistent. Managers and supervisors are trained in how to train and coach their employees. They are trained in how to communicate and supervise employees. Employees are expected to learn tasks within a skill structure. This structure categorizes skills by levels. Each new skill level builds upon previous successes, creating career paths for employees. Workers are shown potential career paths within the company and offered wages and incentives that encourage job retention.

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# **RECRUITING AND TRAINING EMPLOYEES**

**Aime Tamba  
Sunterra Farm,  
1929 Blezard Line, Indian River, Ontario K0L 2B0  
E-mail: Peterborough@sunterra.ca**

## **ABSTRACT**

The pig production industry is experiencing changes in employment trends. As operations expand, the need for employees grows as well. The objective of this presentation is to document some of the essential recruiting and initial training measures. These measures we have adopted at our farm, and now we are able to put together a better team that is meeting all production targets of the company.

## **INTRODUCTION**

Collins, 2001 described that *"those who build great companies understand that the ultimate throttle on growth for any company is not market or technology or competition or products. It is one thing above all others: The ability to get and keep enough of the right people."*

Human resource management in the swine industry has become a big issue. In large production systems, employees want the same things as employees in other industries - a good work environment, competitive wages, respect to feel valued, and fair rewards for work performance.

So, finding, recruiting and keeping the best employees on a hog farm is now the key for success.

## **RECRUITING**

In his analysis of the characteristics that differentiated a select group of top performing Fortune 500 companies from their contemporaries, Collins (2001) described that there were two steps relating to personnel management that were critical to their success:

1. Getting the right people on the bus and the wrong people off the bus.
2. Keeping the right people on the bus and on the right seat.

Before starting to recruit employees, employers have to follow and respect some rules in the process (Dial, 2001).

## **Setting the Company Goals**

Companies have to set their own business goals. A business goal can be to target all parameters of production needed to make a profit; for example, served/week, conception failure, 4 and 8 weeks failure rate, preweaning mortality, pigs weaned, and production costs. Also employees have to understand and believe the philosophy and culture of their employer.

Companies also have to set criteria for a new employee they are looking for.

New technician - Criteria to be hired :

- Has a positive attitude
- Is prepared to learn
- Is flexible with hours of work
- Is prepared to work with anyone
- Is prepared to put in the time it takes to ensure the animals are looked after
- Wants to work with pigs
- Be faster, stronger and smarter

## **How to Find People who are Looking for Work**

Before hiring good people you must target all the resources in your surroundings that are working with unemployed people. They work for you and for them without cost. Each municipality has an employment organization for immigrants (NCIC - New Canadian Immigrant Center), for unemployed people (PERC - Peterborough Employment Resource Centre) or a school of agriculture like Kemptville College or Alfred College. Human Resources and Social Development Canada (HRSDC) has a national network that also works with employers. Also, your own company network like cooperative shopping group, grain supplier and veterinarian might have advice about your needs. If you have some budget, many human resource consultants could help you find a good worker also.

## **SELECTION PROCESS**

This step is very important when you receive many resume and need to decide which one is the best. So it is important before you invite them for an interview to determine your criteria to hire the best person (Table 1). Criteria adopted by us on our farm looks for someone with a good attitude, quicker, stronger, and smarter.

During interviews you must ask questions about each criteria and assign points from 1 to 5 for each answer. The best way to do a good evaluation is to involve a senior employee on your farm who will make note of the answers and assigns a point score. Do not forget to ask questions about personal life such as about their family, children and social participation in the community. This will provide you with a fair idea if he or she will be a good team worker or if they have personal problems. Ask about other abilities as well - this could help you to



determine if they have other skills that will be useful in your operation, such as for maintenance help or truck driving for example.

**Table 1. Farm worker selection 2006-2007.**

Name	Hard worker	Loves animals	Jobs and references	Where Info **	Ability Test	Car Trans.	Open	Total
James	5	4	5	PERC	4	5	5	28
Lawrence	5	4	5	PERC	5	5	5	29
Jackie	3	4	4	Ken	3	2	5	21
Isaac *				Carole				0
Fred //				PERC				0
Barry %	5	4		NCCI	4	4	5	22
Hassan \$	3	4		NCCI	3	5	5	20
Helena	3	4		NCCI	3	3	5	18
and	3	4		NCCI	3	5	5	20
Jorge								
Gladys	3	4		NCCI	4	2	5	18
Keith \$	5	5	4	PERC	5	5	5	29
Kandel%	4	5	5	Carole	5	0	5	24
James %	4	5	5	HRSDC	4	5	4	27

\* Cancelled his appointment twice

// Resume not accepted

% Engaged after interview and farm visit

\$ Good interview, invited to visit farm and after visit refused to work with us

\*\* PERC (Peterborough Employment Resource Centre)

NCCI (New Canadian Centre Immigrant Services)

HRSDC (Human Resources and Social Development Canada)

After the interview, ask the applicant for a writing sample. Ask him to express his interest in working for you for example. In this way you can evaluate his writing skills and his real interest in the position. It is very important to ask for references and to call each of them.

Before making a decision, visit the farm and note any questions. If he or she is ready to work in this industry, you can validate the work they have done; otherwise, you can validate their interest. After visiting the farm do not immediately make a decision. Discuss with the senior employee involved in the process about their evaluation points and their feelings about the potential employee. Check the references given.

Local workers are often difficult to find and that is why many employers look outside the area and even the country. In our farm in Peterborough we hire many foreign workers. Now we have someone from India, Népal, El Salvador and Barbados and two pre-authorizations for other worker are in the process with Philipinos. This requires many forms to be filled out and

long delays before arrival but assistance is available through HRSDC with their foreign worker program.

## TRAINING

Now you have a good person in the bus. The next step after hiring is to discuss a clear job description or the expectations of the company about this position.

The first few days of employment set the perspective and the tempo that the new employee carries forward. Pay attention to their needs - failure to provide adequate supervision suggests to a new employee that the company does not care about them. Training costs a lot to the company and we have to build a good system to achieve success. During this time you have to explain to a new employee all benefit plans, probation time, bonus program and evaluation schedule.

Employers have to set all expectations or job descriptions for different level positions in the business. Level 1 basically will be for a new employee with no experience. Also you have to set a list of tasks a new employee is expected to handle and learn for the first 3 months probation period.

When you make this exercise you have to be fair and honest :

- Fair: Make the job expectations interesting and motivating (not only dirty tasks for a new arrival).
- Honest: You have to make sure that new arrivals can achieve all expectations before or at the end of the probation period.

New employees have to be informed of the different level positions you have on your farm. For the employer and the trainer, skills and attitudes are very important for a good training program.

### A Good Training Program Must Be:

**Practical and informative.** New employees have to understand the company goals and the importance of team work. They have to learn to do tasks by seeing HOW a senior employee does them. We have to explain WHY we use these protocols. In Sunwold Farm, we have a SOP (Standard Operating Procedures) manual to be clear. So we have to keep old and new employees on the same track for the same job. Before we start training we must be sure that old employees respect and follow SOP. So, in case you hire a new arrival with experience this one will have to learn and understand your protocols and your SOP.

**Theoretical.** It is time for building skills. We have to find time to explain to the new employee all aspects of animal function (nutrition, physiology, endocrine, reproductive). To make a profit with an animal we have to explain all the knowledge we have and use it in a better way. We have to be patient to explain WHY it is important.

The training program is for all your staff. Manage the top of your staff. It is not enough to hire the right people in the bus, you have to create the right kind of environment for them to be successful. This requires, in part, that people be put in the right seat on your bus.

## **EMPLOYEE RETENTION ISSUES**

### **Job Satisfaction**

As employers we have to:

- Treat all employees with respect
- Say thank you to the team or an employee for doing a good job (it is motivating)
- Plan some workout activities to strengthen the team
- On a regular basis have a production meeting with your staff to explain what is going on with production
- On a regular basis have a good meeting with your team to explain the pork industry situation
- Make sure that your employees understand the challenges and the opportunities are open for everyone

## **CONCLUSIONS**

Swine production is not the same as twenty years ago. We are very developed now and we have to keep in touch with animal research around the world by understanding all aspects of animals (building skills) to make a better profit. Having and keeping the best employees in your business is the key for this success. Create a good work environment for your employees and motivate them. Challenge the top and ask their inputs in the business goals. Schedule the workout activities for your team to strengthen the team spirit. Large production systems is no longer a local business but a world market.

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# **ON-FARM FEED INSPECTIONS**

**John Secord**  
**Canadian Food Inspection Agency**  
**174 Stone Road West, Guelph, Ontario N1G 4S9**  
**E-mail: secordj@inspection.gc.ca**

## **ABSTRACT**

The Canadian Food Inspection Agency verifies livestock feeds manufactured and sold in Canada or imported are safe, effective and are labelled appropriately. Effective feeds contribute to the production and maintenance of healthy livestock. This paper lists some of the requirements for on-farm feed producers to follow in order to be compliant with CFIA's regulations.

## **CURRENT REGULATIONS**

The Feeds Act and Regulations regulate the manufacture, import and sale of feed. They ensure that feed is safe, effective and labelled correctly. Revisions to the Feed Regulations come into force on July 12, 2007 and coincide with changes to the Health of Animals Regulations as they relate to Specified Risk Material (SRM). SRM are tissues that, in BSE infected cattle, contain the agent that may transmit the disease.

The Mammalian to Ruminant Feeding Ban proclaimed under the Health of Animals Act in August, 1997 prohibits the feeding of prohibited material to ruminants. Prohibited material means anything that is, or contains any, protein that originated from a mammal, other than a porcine or equine. It does not include milk, blood, gelatin, rendered animal fat or their products. The focus of these regulations includes labelling, record keeping and following written procedures to prevent cross contamination. The Enhanced Feed Ban comes into effect on July 12, 2007, removing SRM from rendered ruminant material.

CFIA inspectors confirm that feeds a) contain only approved ingredients and are labelled as prescribed, b) contain only approved medications at the correct levels, c) do not contain harmful levels of biological or chemical contaminants and d) feeds for ruminants do not contain prohibited material.

## **PROPOSED REGULATIONS**

The proposed medicated feed regulations are expected to include mixer performance testing, scale and metering device performance testing and the provision for licensing of all manufacturers of medicated feed. These regulations will be under the Health of Animals Act. The Gazette 1 version of these regulations are expected later this year. Gazette 1 is the stage

where comments are requested from the public for a period of 75 days, and it will be available on the CFIA web site.

## **MEDICATION LEVELS**

The Medicating Ingredient Brochures (MIBs) list the approved levels for each medication. There is one MIB for each medication approved for feed and CFIA issues these based on Health Canada's advice. The Compendium of Medicating Ingredient Brochures (CMIB) is the publication which contains all of the MIBs.

A veterinary prescription is required for medications used at levels or for species not approved in the MIBs, and for liquid feed. Veterinary prescription feeds must meet the requirements of Feed Regulation 5 (2) (g) to be exempt from registration.

Correct medication levels are important as over-medicated feeds may pose a threat to animal health or result in residues in food products. Under-medicated feeds may be ineffective or contribute to the development of antimicrobial resistance. In Ontario, CFIA follows up on 30 to 40 cases of feed-related medication residues in food each year.

CFIA samples feed manufactured on-farm and tests to verify that the medication level meets the MIB or the veterinary prescription. Samples are also tested for medication residue in feeds that are not intended to contain medications and for biological or chemical contaminants.

## **RECORDS ARE REQUIRED**

On-farm feed manufacturers must keep records of mixing formulae and mixing sheets. Depending on the types of feed made, they may also need to keep written equipment cleanout procedures and documentation to show that the procedures were followed. The mixing formula must contain the name of the feed, the name and weight of each ingredient, including medications used in the manufacture of the feed. Mixing sheets must include the same information as the mixing formula, the manufacturing date of the feed, list only approved ingredients and list medications at MIB levels. Records must be kept for both mixing formulae and mixing sheets for a period of at least two years from the last date of manufacture of that feed.

## **WRITTEN CLEANOUT PROCEDURES**

Written cleanout, flushing or sequencing procedures are required for manufacturers using the same equipment for a) medicated feeds containing different medications, b) medicated and non-medicated feeds or c) feeds containing prohibited material and ruminant feeds. A non-medicated feed made immediately after a medicated feed with no cleanout will result in a medication residue in the non-medicated feed. Sequencing is one way to deal with the residue.

## **MORE INFORMATION ON FEED**

Visit the CFIA web site: [www.inspection.gc.ca](http://www.inspection.gc.ca)

Click on “Animals”, then “Feeds”

Scroll down the “Livestock Feeds” page for:

- Feeds Act and Regulations
- Health of Animals Act and Regulations
- Canada’s Enhanced Feed Ban
- Approved Feed Ingredients
- Compendium of Medicating Ingredient Brochures (CMIB)
- Trade Memoranda
- Livestock Producers and the Feed Ban
- Forms - Application Form For Feed Registration
- Policy Documents / Industry Notices

Or contact:

John Secord, Guelph - [secordj@inspection.gc.ca](mailto:secordj@inspection.gc.ca) or 519-826-2910

Darrell Mueller, London - [muellerd@inspection.gc.ca](mailto:muellerd@inspection.gc.ca) or 519-691-1300, ext 199





# **ON-FARM FEED MEDICATION USE – CHALLENGES AND OPPORTUNITIES**

**John Rheume  
Great Lakes Nutrition Inc.  
Monkton, Ontario N0K 1P0  
E-mail: jrheume@glninc.ca**

## **ABSTRACT**

Approximately 20 medications are approved for in-feed use in Canada and they are typically used for growth promotion or therapeutically for disease treatment. At the current time the in-feed medication regulatory environment in Canada is not very well harmonized. The Canadian Food Inspection Agency is the federal department with the mandate to ensure that livestock feeds manufactured and sold in Canada are safe, effective and labelled correctly. The Canadian Pork Council has their quality assurance program, commonly referred to as CQA, while the commercial feed industry has a feed safety program, known as FeedAssure. Both of the latter programs are voluntary, HACCP based and were introduced to their respective sectors in the late 1990s.

## **MEDICATION USE ON-FARM**

Medications make their way to the farm, and ultimately the feed trough, by a variety of means. Approximately half of the pigs in Ontario are fed complete feeds that have been prepared in commercial feed mills. The vast majority of this feed is being manufactured in mills that have been accredited under the FeedAssure program. For pork producers using medicated feeds from these sources the task of maintaining records is fairly straight forward. The onus is on the feed supplier to provide the necessary documentation with respect to medication rate, directions for use, withdrawal times, etc. However, one of the challenges faced by the producer is when the class of feed and/or type of medication needs to be changed in a given feed bin. Producers should be aware that proper sequencing and/or perhaps emptying of bins may be necessary to abide by regulations governing the carryover of medications between different classes of swine.

For pork producers purchasing supplements or premixes, maintaining accurate records becomes a little more challenging. In many cases, more than one type of medication is being used and/or there are several classes of swine being fed medicated feeds. There is the need to convert medication concentrations in the premixes to levels in complete feeds and often the same medicated premix is being used to manufacture a series of feeds. If concentrated medications of various strengths, and potentially multiple feeding rates, are being used on-farm the situation becomes increasingly complex. Detailed mixing instructions, sequencing or flushing protocols and mixing records are required.

## **PROPOSED REGULATIONS**

The proposed Regulations Regarding the Manufacture of Medicated Feeds (RRMMF) is a federal document meant to govern the manufacture of medicated feed in both commercial feed mills and on-farm. The last version of this document included provisions for mixer performance testing, scale and metering device verification, and equipment cleanout procedure verification. Dropped was the requirement for daily reconciliation of medication inventory.

Appropriate cleanout, flushing and/or sequencing procedures are required for all feed manufacturers that use the same mixing equipment for medicated feeds containing different medications and/or medicated and non-medicated feeds. This is perhaps the single most significant requirement where there is disagreement among the various quality assurance programs. Sequencing of feeds is the method preferred by the feed industry to deal with medication residues.

## **CONCLUSIONS**

Over the past decade the Canadian Food Inspection Agency (CFIA) and various stakeholder groups have engaged in a series of failed attempts to harmonize the regulation of medications in livestock feeds. In the absence of a collaborative framework, the feed industry through its FeedAssure program, producer groups through on-farm CQA programs and CFIA through its feed inspection system have worked in isolation to ensure the safe use of medications.

A new round of consultations among the various stakeholder groups is underway. It is anticipated that an updated set of regulations will be introduced later this year. These new regulations must be aimed at protecting human and animal health, but must not introduce unnecessary costs to feed purchasers.