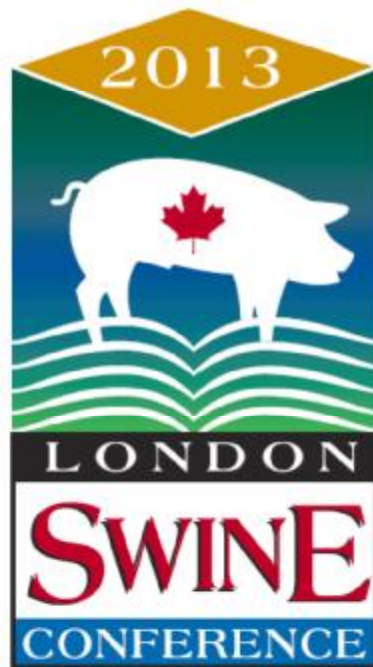


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Managing for Production

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LONDON SWINE CONFERENCE

MANAGING FOR PRODUCTION

Edited by
J.H. Smith

March 27th and 28th, 2013

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Proceedings of the London Swine Conference
Managing For Production

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Chair's Message

The London Swine Conference committee aims to provide a conference agenda that relates to what is happening in the industry and offers practical, real world experiences. This year we took that one step further and considered the issues that the pork industry will face in the coming year and beyond.

The theme, “Managing for Production”, echoes the program’s goal of addressing topics such as pain control, nutrition, barn design, performance indicators, antibiotics and influenza, to name a few. Each of these areas will most certainly challenge our perceptions and influence our decisions. Our line-up of speakers and sessions are intended to make you think, get engaged and discover new ways of doing business.

Each day of the conference has a focus on a specific type of hog operation and the guest speakers, whom are experts in their field, will provide the participants with global and local perspectives on certain issues and developments they have encountered or discovered. The focus of the first day is on sows, whereas day two switches gears and focuses on wean-to-finish operations.

Determining the future of our industry is not a precise science, but we can take our lead from other countries, market indicators, consumer behaviour and, in some instances, history itself. Decision makers, production managers and stockpersons can all benefit from this conference program and hopefully walk away with a greater understanding of what will make their businesses thrive, moving forward.

The London Swine Conference is a joint effort of staff from the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Ontario Pork, the University of Guelph, the Ontario Pork Industry Council and of course, the industry sponsorship that makes it possible.

This is a venue for attendees to network, dialogue and share ideas. Join us at the 2013 London Swine Conference and let us begin “Managing for Production” together.

Stewart Cressman

Chair, Steering Committee

2013 London Swine Conference

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Day 1: Sows

Paradox of Progress: Reality vs. Perception of Pork Safety in Modern Swine Production

**Peter Davies
College of Veterinary Medicine
University of Minnesota, USA**

THE PARADOX OF PROGRESS

Much of human endeavour and creativity is devoted to the goal of progress – that through advances in diverse arenas of science, technology, modernization, liberty, and democracy we can deliver a better quality of life for mankind. ‘The only constant is change’ is a fairly tired cliché, but history suggests that change is not constant, but is exponential. The futurist author Ray Kurzweil states that:

“analysis of the history of technology shows change is exponential, contrary to the common ‘intuitive linear’ view. So we won’t experience 100 years of progress in the 21st century – it will be more like 20,000 years of progress.”¹

The concept of the ‘paradox of progress’ has been traced to Adam Smith in the 18th century,² and has been the title of several books that have variously observed paradoxes such as:

- The more we know, the more we have to discover
- Higher economy and consumerism leads to more stress as people work more and society falls behind
- As society moves forward, more problems are created
- The better things become, the worse they are perceived.

The North American swine industry has been a case study of accelerating change, and I have heard ‘senior’ swine veterinarians speak of ‘100 years of change in 10 years’ when discussing their experiences in the industry. We can look at many facets of the industry and see evidence of substantial ‘progress’ in intensive swine production. Yet the US industry is perceived to be ‘worse’ than its preceding incarnations, and is accused almost daily of being responsible for, or contributing to, a range of societal problems. Platforms of opposition to intensive livestock production are multifaceted: sociological (e.g., loss of small farms and impact on rural communities; anti-corporate sentiment); ethical (e.g., questioning the acceptability of animal housing conditions, traditional farming practices such as castration, and carnivorousness itself); environmental (e.g., odour, pollution, carbon footprint) and sanitary (e.g., zoonotic and emerging disease; antimicrobial use and resistance; occupational health and food safety). Different issues resonate more or less with different people, and the deliberate amalgamation and blurring of disparate issues has been an effective tactic for galvanizing opposition to modern livestock production.³

All industries need criticism which serves to steer industry practices in the directions desired by the wider community. Career critics of the food system in general, and intensive animal production in particular, are primed to pounce on any event that can be portrayed as industry malfeasance. But to be constructive in a social context, criticism must be founded on accurate and comprehensive analysis that captures the inevitable trade-offs inherent in changes to, or constraints upon, industry operations. I will use the example of pork safety to discuss what changes in the US industry have meant for pork safety. Pork safety is perhaps the most

convincing illustration of the gap between a history showing measurable progress that is accompanied by paradoxically negative perceptions.

HOW DO WE GET OUR FOOD?

Food is an intimate element of the human experience and there are all manner of passionate opinions about what we should eat, and how it should be produced, procured and prepared. Engaging authors such as Michael Pollan and Eric Schlosser, and films like *Food Inc.*, have inspired a mass of neoromantic ‘locavores’ who disparage almost every facet of the mainstream commercial food industry, with intensive animal production a preferred target. The ability for average citizens, wisely or not, to indulge their dietary or non-dietary preferences is one hallmark of progressive societies. In developed countries, the transformation of food procurement from hunter-gathering and subsistence agriculture (i.e., the pinnacle of eating local) to one-stop supermarkets straddling complex global supply chains is virtually complete and the vast majority of citizens play no part in producing their food. As with electricity or running water, the facility with which those living at high latitudes can select from a panoply of fresh fruit and vegetables, among other foods, year round is largely taken for granted—yet would be sorely missed were their availability suddenly interrupted. It is hard to envision that, from the perspective of the average consumer, the evolution of the food industry over the last 100 years can be represented as anything other than progress, at least in terms of efficiency and convenience of accessing diversity of affordable dietary options, and in freeing time for pursuit of other activities for work and leisure.

The strong positive correlation between wealth and meat consumption, seen among and within countries, reflects the fact that animal proteins are preferred protein sources across the majority of cultures. The bulk of the socioeconomic spectrum of North Americans and Europeans has lived high on the metaphorical hog for several generations, with the affordability of the finer meat cuts leaving the once common consumption of offal and other lower value animal products largely to those of limited means or being channelled into export markets. On-going growth in developing economies such as China and India underpins bullish projections of future global demand for pork and other meats. However, contemporary discussions of projected world population growth, its implications for land use, and the environmental impact of food production raise complex questions about the future of meat consumption. Global population growth and wealth is revealing inevitable tensions between the desire to consume goods and services and our ability to sustainably provide them in a finite and increasingly crowded planet. These complex problems are beyond the scope of this discussion but can be distilled down to a simple question—if the world of the future is going to have a swine industry, what should it look like?

INDUSTRIALIZATION OF SWINE PRODUCTION AND PORK SAFETY

Media reporting and blogging about the safety of the food (and particularly meat) supply seems to be singularly fertile ground for misinformation. The parade of ‘worrying’ factoids and reports is endless, with a recent Consumer Reports study perhaps raising an already elevated bar of scaremongering founded on pseudoscience.⁴ In 2012, I reviewed evidence related to biological hazards in pork in relation to changes in the US swine industry structure, and concluded that the evidence indicates pork is safer than in any previous era.⁵ The following discussion presents some of the salient observations made in that publication (detailed references are provided in the original publication).

The foodborne parasites *Taenia solium*, *Trichinella spiralis* and *Toxoplasma gondii* have arguably been responsible for the majority of suffering from pork-borne illness throughout the history of mankind, and remain important problems in many developing countries. The Food and Agricultural Organization cites estimates that some 50 million people worldwide harbour the adult *T. solium* tapeworm, and up to 50,000 deaths per year are attributable to cysticercosis. *T. solium* is also largely responsible for the fourfold higher rates of epilepsy in developing versus developed countries. This parasite thrives where sanitation is poor and traditional, free-range/scavenging pig production is practiced. However, *T. solium* is off the radar screen of the US food safety dialogue and it has been suggested that elimination of *T. solium* from Europe and North America was largely a consequence of economic development that made small scale, subsistence pig rearing uneconomic. Methods of modern confinement swine production virtually eliminate any risks of pork-borne transmission of *T. solium*.

During the 1940s, about 400 clinical human trichinosis cases (and 10-15 deaths) were recorded annually in the USA. The incidence declined to about 60 cases per year by the 1980s, primarily through better control of trichina infections on pig farms. From 1997 to 2001, only 72 human trichinosis cases (and none fatal) were recorded by the CDC and consumption of wild animals had far surpassed pork as the most common source of infections. Once a major pork-borne pathogen, modern production systems have relegated *T. spiralis* to little more than an historical footnote for commercial pork industry. *Toxoplasma gondii* is one of three pathogens responsible for three-quarters of the fatalities attributed to foodborne infections in the US. Some 400 to 4,000 US children are born with congenital *T. gondii* infection each year, and the societal cost of congenital toxoplasmosis alone was estimated to be up to \$8.8 billion annually in 1990. Just 25 years ago *T. gondii* occurred in 40% of US sows and 20% of market hogs, and undercooked pork was considered an important source of human infection. Its prevalence has since been reduced by over 90% in today's commercial industry.⁵ The reduction of these agents to a state of relative inconsequence in modern pork production in developed countries is a notable public health accomplishment that has gone largely unheralded.

Relative to the parasitic hazards discussed above, the major bacterial foodborne pathogens of concern to the swine industry (*Salmonella*, *Campylobacter*, *Listeria*, *Yersinia*) have much more complex epidemiology, and progress with on-farm control has been minimal. These organisms have their primary ecological niche in the intestinal tracts of healthy birds and mammals. Their presence on meat stems from contamination events that can occur anytime during harvest and processing until meat is served. Contamination risk during harvest and processing is a function of both on-farm exposure and slaughter hygiene, and both preharvest and postharvest arenas are rational targets for interventions. *Salmonella* remains the preeminent bacterial hazard in most pork industries and (apart from the northern Nordic countries where uncommonly low *Salmonella* prevalence supports the possibility of excluding *Salmonella* from pig populations) most countries identify reduction rather than elimination of *Salmonella* to be a more attainable goal in pork production.

Knowledge and experience with preharvest control of *Salmonella* dwarfs those of other enteric bacterial pathogens yet there remains a dearth of validated, evidence-based interventions for preharvest *Salmonella* control. Despite the appealing logic for preharvest control of foodborne pathogens, the task has proven daunting and opinions remain divided on the feasibility and cost-effectiveness of preharvest control programs for *Salmonella* in pigs. Investment in preharvest surveillance and control has been widespread in western Europe, but much less in North America where substantial reduction of *Salmonella* contamination of hog carcasses has been achieved by

improvements in the post-harvest sector.⁶ The data generated by the Danish National *Salmonella* control program has provided much insight into the challenge of preharvest control, and indicate that benefits from preharvest control would most likely accrue in low prevalence regions and small processing plants. It was concluded that in medium to high prevalence scenarios, even drastic reductions at herd level may yield only limited benefits in reducing the prevalence of positive carcasses.⁷ While advances in process control and new interventions during slaughter and processing have yielded measurable improvements in meat hygiene, considerable investments in preharvest control of *Salmonella* appear to have yielded only modest benefits. Despite much noise claiming the contrary, there is negligible evidence that *Salmonella* are more prevalent in intensive swine operations than in feral pigs, historic swine operations in the pre-confinement era, or swine raised in less intensive systems in developing countries.⁵

The most vocal proponents of preharvest control of foodborne enteric bacteria have combined a degree of epidemiological naïveté with a belief (regardless of the vacuum of supporting data) that ‘the problem’ was attributable to modern farming methods and, specifically, confinement production. In my opinion, the least equivocal outcome from fifteen of so years of preharvest research is that elimination of organisms that are normal flora (*Campylobacter coli*), or common commensals (*Salmonella*, *Listeria*, *Yersinia*) of the swine intestinal tract will not be achieved by facile interventions in farm management. The complexity of the epidemiology of *Salmonella* and other enteric organisms is difficult to overstate, but is dominated by the fact that these organisms are commonly carried by, and shed in the feces of, healthy animals. Development of valid and reliable preharvest interventions to control bacterial foodborne pathogens remains the preeminent challenge for researchers in pork safety. In contrast post-harvest interventions, and most notably food irradiation, present proven, safe and relatively low cost options for risk reduction for multiple hazards which should be pursued for higher risk items such as ready-to-eat and comminuted meat products. However, implementation of food irradiation in the meat industry remains enmeshed in ideological opposition. Those who oppose irradiation of higher risk meat products on the grounds that producers must take more responsibility for food safety would appear to be more motivated to constrain the production sector than to protect consumers from foodborne illness. Regardless, measurable improvements in meat hygiene have been achieved by improved slaughter processes. A recent attribution study estimated pork to be responsible for <1% of human salmonellosis attributed to contamination of raw meat, poultry, and egg products in the USA,⁸ and available data indicate that commercial pork produced in the USA is currently safer than at any time in history.⁵

Looking forward, the international marketplace for pork will require incrementally more demanding standards for pork safety. In order to remain competitive in premium markets, exporters must achieve and assure very low risks for chemical, physical and microbial hazards, and any failures have the potential to incite crippling consequences for market access. Quality assurance programs implemented on farms should be adequate to manage the majority of physical and chemical hazards, as well as parasitic foodborne hazards. Unless major research breakthroughs occur in preharvest control of enteric bacteria, improved meat hygiene and slaughter processing will continue to be the mainstay for microbiological safety. An important challenge for the industry is to inform the general public of the real advances that have been made in pork safety and balance the misinformation of those who remained convinced that things have gotten worse regardless of the facts.

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A Genomic Future

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ABSTRACT

Animal breeding has had a large impact on the improvement of livestock production. With the sequencing of the genomes of the various species, the subsequent description of DNA markers and the cheap technology to map these markers, we are entering a new era of animal breeding. This technology enables animal breeders to select animals with a lot more precision at a younger age, i.e. it increases accuracy and decreases generation interval, key components in the rate of genetic gain that can be achieved. Besides accelerating the rate of genetic gain, this new technology also offers better solutions for traits that, up until today, have been proved difficult to measure, for example traits that are only measureable post-mortem e.g. meat quality.

INTRODUCTION

Mankind's association with domesticated animals goes back more than 10,000 years. During this period a variety of animal species has been adapted to suit our needs. The animals that best fitted our needs were used as parents for the next generation of animals. In the beginning the best animals were probably the animals that were most docile and easy to manage. This led to the formation of a number of different breeds and all these different breeds were adapted to the local circumstances. More recently, as farming became less for subsistence and increasingly a business/economic endeavour, the more specialized breeds were used for selective breeding with the focus being more on traits that maximized production (hence more income for the farmer). In the beginning this was done through phenotypic selection, i.e. the animals with the best performance were selected as parents for the next generation. Improvements were mainly made on traits that were easily observed and with a reasonable heritability. Later on statistical models (BLUP models) were developed that made it possible to include information from relatives (animal models). This made it plausible to also make significant improvements for traits that are less heritable, e.g. number born piglets, which hitherto had proved slow to improve.

GENOMIC SELECTION

On the whole the science and practice of animal breeding has been a major contributing factor to the improvement made in livestock production. For example, between the 1950s and 2005 the number of weaned piglets per sow per year increased by 50% and feed conversion was halved through breeding (Hume et al., 2011). As a rule of thumb improvements of 1-3% per annum are achieved for traits under selection. These results illustrate what can be achieved through traditional breeding methods. The efficiency of these methods reduces substantially when traits are either difficult to measure, cannot be measured on the animal itself, or when traits have a low heritability. There are traits that exhibit these problems that could be potentially very important, for example feed conversion efficiency, meat quality and disease resistance.

Rate of genetic progress is determined by four factors: 1) accuracy of the breeding values; 2) selection intensity—how big is the group of potential selection candidates and how many do I select?; 3) genetic variability of the trait; and 4) the generation interval—how long does it take before I can use the selected animals as parents. Genomic selection potentially impacts three of those, and certainly has an impact on accuracy (1) and generation interval (4).

Genomic selection, the principle

Today, animal breeders have a new tool in their toolkit, namely genomic selection. Genomic selection was first described by Meuwissen et al. (2001) and is based on the notion that breeding values can be estimated from the information generated by a large number of DNA (genetic) markers. With a large number of genetic markers spread across the entire genome there will always be a genetic marker close to the gene(s) of interest. Nowadays we have the full genome sequence of many species; more than 20 bird and mammalian species, including the human. The pig was added to this list in late 2009, and hundreds of thousands of SNPs (Single Nucleotide Polymorphisms) are now available. With genome sequencing—the laboratory process that determines the complete DNA sequence of an organism's genome—the whole library of base pairs of a pig is mapped. Pigs have billions of base pairs. A small part of these (still millions) can be classified as Single Nucleotide Polymorphisms (SNPs); a situation where the nucleic bases in a certain location of the genome are of different types in some of the individuals within a species. These SNPs can be used as easily identifiable markers for locations on the genome of the pig. There are several millions of SNPs discovered in the pig's genome. These SNPs are the basis of Genomic Selection. Through this technology a large number of SNPs are selected across the genome to serve as an information source for breeding value estimation.

The first, and key, step in genomic selection is the selection of a large group of animals with very precise (known) phenotypes. This is referred to as the reference population. This reference population is genotyped (defining the markers/SNPs each individual carries) and the genotypes are then associated with the accurate phenotypes to develop a statistical model that then provides estimates of the effect of each SNP for the trait of interest. Since from years past it has already been shown that most traits are influenced by a large number of genes each with a small effect, these SNP markers provide a more accurate and reliable measurement of the genetic merit of an individual. In order to make genomic selection work, a large number of breeding boars and sows with a known performance record have been gathered in combination with accurate phenotypes to estimate all the SNP marker effects. The marker effects are then used to predict the genetic merit of animals that do not have measured phenotypes but have only been genotyped for SNP markers, i.e. young animals without a performance record or for a trait that cannot be measured on the animal itself (Figure 1). The accuracy/reliability of the genomic breeding values depends on the size of the reference population, the heritability of the trait and the quality of the phenotypes used.

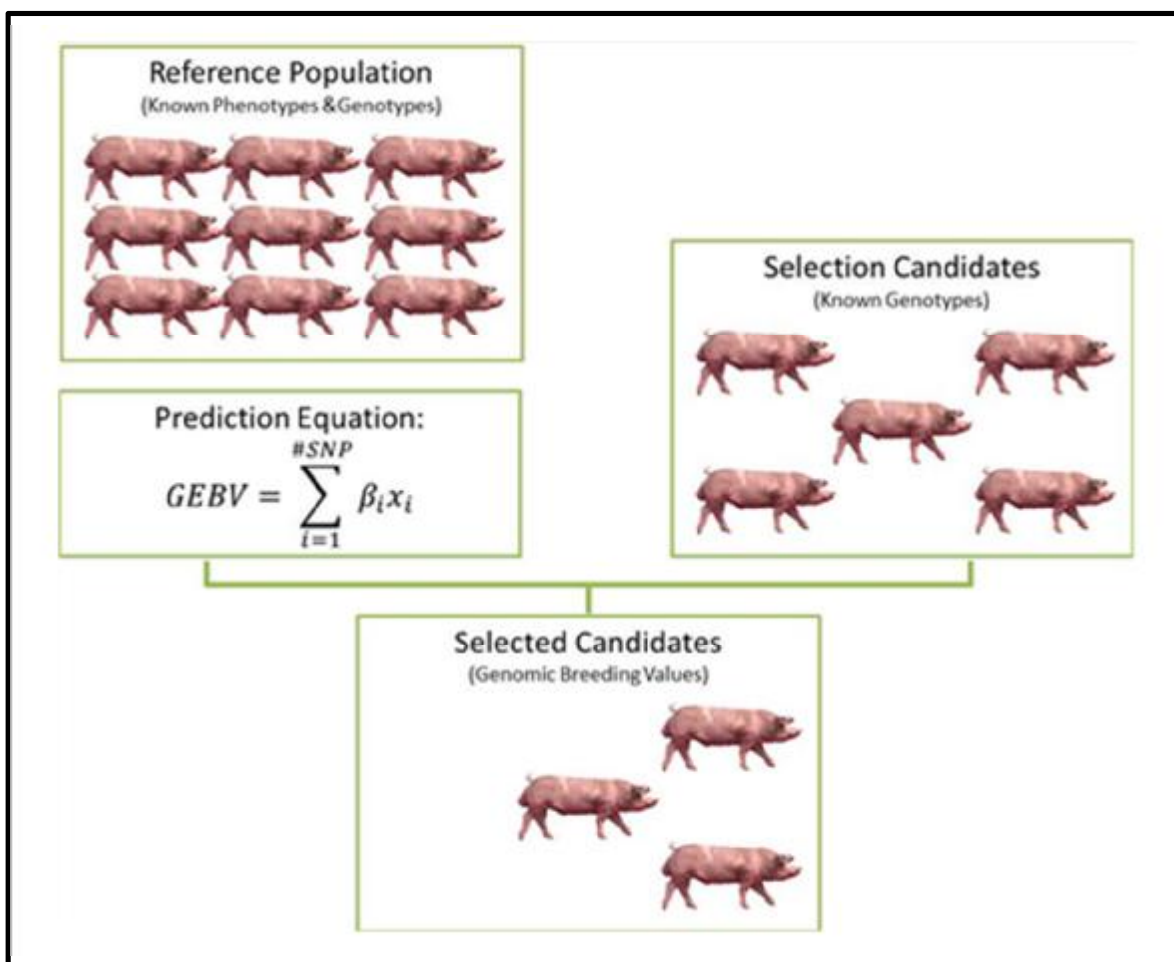


Figure 1. Principle of genomic selection.

Genomic selection, the promise

Several research groups have investigated the potential impact of the use of genomic selection on the rate of genetic gain that can be achieved (Table 1). Estimated improvements vary between 20 and over 100%, where the lower numbers are for species already on a fast track breeding program (pigs, broilers, turkeys) and the higher numbers are for species that rely a lot on progeny testing (cattle, layer chicken).

Table 1. Potential impact of the use of genomic selection on yearly genetic progress.

Species	Additional genetic gain	Source
Dairy cattle	60 – 120%	Pryce, 2011
Sheep	20 - 40%	Van der Werf, 2009
Beef cattle	29 – 158%	Van Eenennaam, 2011
Swine	20 – 50%	Albers, 2010
Layers	40 – 100%	Dekkers, 2009; Wolc, 2011
Broilers	20%	Dekkers, 2009
Turkeys	15%	

Genomic selection, the application

Several breeding companies, in different species, have started with the implementation of this new technology in their routine breeding programs. The cattle breeders were the first to implement this new technology, followed by the layer breeders and later on the pig and broiler breeders. Genomic selection empowers breeding companies to exploit within litter genetic variation in reproductive traits in the selection process. In a departure from the results of BLUP methodology, littermates will no longer have the same expected breeding value at birth; but rather they will each have their own genomic breeding values, based on their own unique pattern of DNA-markers. The genomic breeding values predict, with high accuracy, what the pigs' genes are worth in the breeding program. Varying market demands require a specific focus on the characteristics and performance of herds on farms. Genomic selection can offer anywhere between 20-50% greater genetic progress in pig breeding programs. This allows producers to tailor existing practices—that are complementary to existing breeding programs on farms.

Genomic selection, the future

Typically, genomic selection has more added value when used for traits with a low heritability, traits that are sex-linked, or the ones that can only be measured at post mortem. In the coming decade many new traits will be added to the breeding goals. We are still at the start of the genomic era; new applications to make most use of this new technology are being developed. Technological developments are helping to rapidly reduce the cost of genotyping and sequencing. For example, 10 years ago the cost of sequencing one animal was millions of dollars, while today the same can be achieved for two to three thousand dollars. This massive reduction in cost of genotyping allows for more and broader applications in commercial breeding programs. Information from further down the chain, e.g. commercial crossbreds and/or slaughter house, can be linked to breeding animals through DNA information. This was not feasible on a large scale before.

The information captured in the genotypes can be used to hunt for specific genes or genomic regions with an (large) impact on traits of interest. An example of this is a study by Boddicker et al. (2012), where a number of pigs were infected with the PRRS virus (not something one would want to do with breeding animals). Then a whole genome analysis was done to identify genomic regions (read SNP markers) associated with the ability to cope with a PRRS infection. These SNP markers can then be used to select the most resilient animals in the breeding herd without having to infect them with the virus.

CONCLUSIONS

Genomic selection caused a revolution in the animal breeding world, it all started in dairy cattle but is also finding its way to the other livestock species. A lot more genetic progress can be expected due the implementation of genomic selection for traits that are measured late in life or are difficult to measure. Especially for the last group of traits, genomics can offer a lot more than the conventional animal breeding technologies.

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Top Profit Robbers In a Sow Farm

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1. SOW FEED – NOT GETTING IT RIGHT

Introduction

Sow feed is a critical part of operating a sow farm and one of the biggest costs. Getting it right can be a challenge. Feeding the target feed to the herd may be achieved but getting it delivered to the right sows is the biggest issue seen across farms. Agreeing on what body condition is ideal can be done but delivering an ideal condition sow to the farrowing rooms can be difficult. Creating charts to follow is an option but getting the staff to follow them is tough!

Gestation Sow Feed Targets

Getting the target set for feeding sows is pretty easy. Work with a nutritionist who will set the volumes or weights based on the energy of the ration, sow condition and weight. This can then be translated into a simple table (e.g. Figure 1). Weighing and/or probing each sow helps to fit her into the feed table. Then feed accordingly.

		Cond Score	2	3	4	5
		Feeding level from d of scanning to day			90	, Lb/day
	Flank to	Estimated	Backfat at breeding, mm			
Parity	Flank, cm	weight, kg	9 to 11	12 to 14	15 to 17	>18
0	< 90	115 to 150	5.0	4.0	3.5	3.0
1, 2	90.1 to 96.5	150 to 180	5.5	4.5	4.0	3.5
2, 3	96.6 to 104	180 to 215	6.0	5.0	4.5	4.0
3, 4	104.1 to 111.5	215 to 250	6.5	5.5	5.0	4.5
5+	> 111.6	250 to 300	7.0	6.0	5.5	5.0

Figure 1. Example of a simple feed table for gestation sows.

Delivering the Feed to Gestation Sows

While weighing each sow is probably not practical, it is possible to tape the sow to estimate the weight or simply slot her into a parity category. The goal is to place the animal in a weight category then condition score her to slot her into a back fat category. Use this to set the feeder at the desired amount.

This may seem quite simple but the challenging part is getting everyone to agree on body condition. This takes time, pictures and reiteration with everyone involved in doing it. One method is to take photos of sows at different body conditions. Put this on a laminated sheet for staff to carry. This helps keep everyone on track to keep things consistent.

Farrowing Feed

This is the time to feed the sow as much as she can eat. The goal is to maximize feed intake to get good milk production and litter growth. There are two systems for feeding lactating sows:

- Meal feeding according to need 2-3 times per day or
- Ad lib.

Ad lib.

Ad lib can be easier as the sow will regulate her own intake. More farms are moving to ad lib as it takes some of the guess work out of feeding. It saves on wasted feed from cleaning out feeders, and in general, lactation sow feed intake will be higher on this system. The main challenge is to identify sows not eating a set minimum amount per day. There should be a system in place to check at least once per day, who has and has not, eaten and how much. If sows are eating at least the minimum amount they should be okay.

Meal feeding

With this system, sows are fed two or three times per day according to the amount that they have eaten at the previous meal. This system is inherently limiting on intake. The challenge is to maximize feed intake without wastage. Feed cards with intake targets should be used with this system to be able to monitor intake and feed accordingly. Figure 2 shows an example of targets.

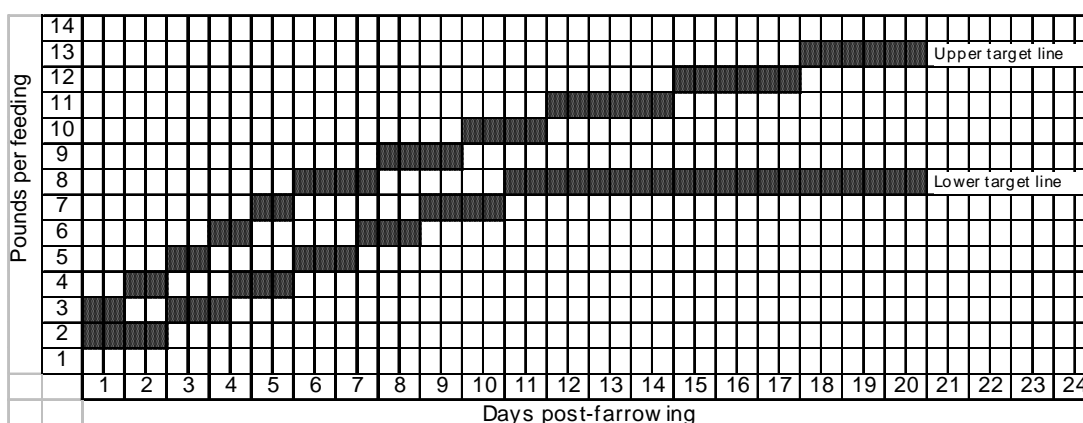


Figure 2. Example of feeding targets for sows post-farrowing.

Conclusions

The big question is “can sow feed be a profit robber?” The answer is yes! It can be a hidden one as you don’t see it every day. These are things to think about:

- Sow feed usage needs to be monitored on the farm on a weekly or monthly basis. A nutritionist can help to set reasonable targets based on ration density. This is essential to avoid over- or under-feeding.
- Sow condition needs to be looked at monthly by a “different” set of eyes. The correct amount of feed may be used by the farm but is it getting to the right sows? Variation can be an issue!
- Cleaning feeders out down the pit in farrowing can be very costly.

- If the herd is overfed, there will be sows that are too fat, resulting in farrowing difficulties, poor lactation intake, lower piglet weaning weights, and subsequent reproduction problems.
- If the correct amount of feed is used but it is going to the wrong animals there will be variation in condition within the herd (thin and fat sows) and this will have a negative impact on reproduction.

2. SEMEN MANAGEMENT

Introduction

To ensure that sows are bred to the best of the system ability it is critical to ensure that fresh semen is available for use each day however it is just as important not to overdo how much semen is available as it ends up being used as old semen or thrown away. This can become very expensive. It is a balance between having semen available and not running out!

Monitor usage

In order to manage it you need to be able to measure it! Each month, tally up the total number of matings. This would include single matings, multiple matings, and extra doses used due to leak back. Account for every dose used then look at the number of doses that were purchased. This comparison sometimes shows surprising wastage!

Put an opportunity cost beside it to show the cost of semen wastage. Figure 3 is an example of what can be used to monitor usage/wastage. There will be some carryover each month due to when the semen was delivered and what is in the fridge but tracking month over month and having a YTD opportunity cost shows the whole picture.

Mtn Vista	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12
One Mating	26	22	35	17	26	27
Two Matings	747	739	891	713	743	910
3+ Matings	128	135	193	150	89	189
Total Matings	1904	1905	2396	1893	1779	2414
Deleted Services	0	0	0	0	0	0
Double Dose Matings	0	18	23	26	28	18
<i>Target Double Dose Matings</i>	20	20	20	20	20	20
TOTAL INSEMINATIONS	1904	1923	2419	1919	1807	2432
SEMEN PURCHASED	1830	1921	2480	1924	1862	2691
DIFFERENCE	-74	-2	61	5	55	259
TARGET DIFFERENCE	0	0	0	0	0	0
Opportunity Cost - Month	-\$444.00	-\$12.00	\$366.00	\$30.00	\$330.00	\$1,554.00
Opportunity Cost - YTD	-\$444.00	-\$456.00	-\$90.00	-\$60.00	\$270.00	\$1,824.00

Figure 3. An example of monitoring semen usage.

This is a real farm example and back in 2002 the cost of throwing out semen was \$35,000!! This was what spearheaded the need to look at wastage. Measure the wastage and multiply by the cost per dose. This will give you your opportunity cost!

Conclusions

Can semen be a profit robber? Yes! If not managed correctly it can easily run away on you. Make sure you have a system in place to account for the use. Make sure staff are aware of the goal when ordering semen. Today with the long lasting extenders it is not such a big deal using older semen.

If you don't measure it you can't manage it!

3. GILT ATTRITION

Introduction

Every producer knows how crucial a regular supply of quality gilts is to their sow operation and most producers understand what their herd replacement rate is, but many do not track what their young sow attrition rate is. Why is this critical? Young sows have an up-front cost that includes:

- The actual cost of the gilt over the value of the cull sow
- The holding time from entry to breeding.
- The lower productivity of younger parity animal (litter size and sometimes litters/sow/year).
- The effect that young sows have on reducing herd immunity.

We need our young sows to stay in the herd and become old sows in order to maximize herd productivity!

Tables 1 and 2 are examples of two herds with very different gilt retention rate. In Herd A, **87.57 %** of the gilts that enter have 3 litters. In Herd B, that number is only **71.99%**. This is the major production parameter difference between these two herds and it drives a difference in 2 pigs per sow per year. This report is a standard report in the PigKNOWS sow data system and similar reports are available in other systems as well. Remember, to use this information, new gilts need to be added to the sow information database, *when they are eligible to be bred*.

To track this manually, record how many young animals are culled compared to the number of new gilts added. The target is for 93-95% of gilts entering a herd to have a first litter and 80% of these to have a third litter.

How do you get there?

- Have access to a good supply of health compatible gilts. If you are having trouble introducing gilts, talk to your veterinarian to get help planning a smooth introduction program.
- Breed sexually mature gilts at a designated minimum size. All gilts should be on second heat or greater at breeding.
- Feed and maintain the gilts in such a manner that they are in good condition after weaning their first litter and are ready to be rebred.

Table 1. Herd A: Pigs weaned /Sow/Yr. 25.2, Replacement Rate 30.2%.

Entry date	Gilts	1Parity	2Parity	3Parity
2010-04-01 - 2010-06-30	69	95.65	94.20	91.30
2010-07-01 - 2010-09-30	87	97.70	94.25	90.80
2010-10-01 - 2010-12-31	54	90.74	90.74	85.19
2011-01-01 - 2011-03-31	36	86.11	83.33	80.56
2011-04-01 - 2011-06-30	42	97.62	95.24	83.33
2011-07-01 - 2011-09-30	74	95.95	90.54	87.84
2010-04-01 - 2011-09-30	362	94.75	91.99	87.57

Table 2. Herd B: Pigs weaned/Sow/Yr. 23.2, Replacement Rate 41.2%.

Entry date	Gilts	1Parity	2Parity	3Parity
2010-04-01 - 2010-06-30	70	84.29	60.00	50.00
2010-07-01 - 2010-09-30	84	83.33	75.00	67.86
2010-10-01 - 2010-12-31	183	79.78	72.68	66.12
2011-01-01 - 2011-03-31	73	94.52	82.19	76.71
2011-04-01 - 2011-06-30	155	90.32	83.87	81.94
2011-07-01 - 2011-09-30	199	94.97	89.45	77.39
2010-04-01 - 2011-09-30	764	88.09	79.32	71.99

4. TARGETING PIGS WEANED/SOW/YR INSTEAD OF WEEKLY PIG FLOW

Introduction

The classical method for measuring sow herd productivity is pigs weaned per sow per year, but steady production of a consistent targeted number of pigs per week (or per group on a batch system) has tremendous value. This has two components.

Consistent weekly farrowing and pig numbers allows for the most efficient use of facilities and produces the most consistent product. Inconsistent weekly farrowing numbers translates into problems with:

- Variation in age and size at weaning
- Subsequent litter reproductive losses from sows weaned early
- Increased cost of raising those pigs
- Lost opportunities for use of fostering and nurse sows
- Lost opportunities for culling on productivity as substandard animals are kept to maintain breeding numbers.

A Farrowing Rate report is essential for tracking this information (Figure 4).

Herd C		Weeks bred				Farrowing Rate Report															
All Parities																					
Service wk	#Serv	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	%P&F	Farrow wk		
28-Oct-12	48	48	48	46	42	39	39	39	39	39	39	39	39	39	39	39	39	81.2	20-Feb-13		
4-Nov-12	44	44	44	43	38	38	38	36	35	35	35	35	35	35	34	34		77.3	27-Feb-13		
11-Nov-12	46	46	46	45	43	43	42	42	42	41	41	40	40	40	40			87.0	6-Mar-13		
18-Nov-12	44	44	44	44	41	41	41	40	38	38	38	38	37	37				84.1	13-Mar-13		
25-Nov-12	54	54	54	52	49	49	49	48	48	48	48	48	48					88.9	20-Mar-13	Number farrowing	
Parity 7+																					
Service wk	#Serv	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	%P&F	Farrow wk		
28-Oct-12	11	11	11	11	11	9	9	9	9	9	9	9	9	9	9	9	9	81.8	20-Feb-13		
4-Nov-12	15	15	15	15	13	13	13	12	11	11	11	11	11	11	11	11		73.3	27-Feb-13		
11-Nov-12	11	11	11	11	10	10	10	10	10	10	10	9	9	9	9			81.8	6-Mar-13		
18-Nov-12	13	13	13	13	11	11	11	11	11	11	11	11	11	11				84.6	13-Mar-13		
25-Nov-12	20	20	20	20	20	20	20	20	20	20	20	20	20					100.0	20-Mar-13	Number of 7+ sows farrowing	

Figure 4. Example of a farrowing rate report.

To achieve this consistency, the producer needs to use a *push system* to ensure that old animals are culled and replaced:

- Have a consistent supply of ready-to-breed replacement gilts.
- Have recorded heats on all gilts.
- Have an understanding of what replacements are needed on a weekly basis.
- Manipulate heats if necessary to achieve targeted replacements regular weekly breed.

Pigs per week (or batch) pay the bills. Modest sow herd inventory adjustment to maintain pig output while production issues are being sorted out more than pays for itself.

Example

A 1000 sow herd has a desire to achieve 26 pigs/sow/year. Targeted pig flow is 500 weaned pigs per week.

They are currently breeding 55 sows per week and farrowing 50 sows (90% farrowing rate) with 10 pigs weaned per sow. In September, the herd manager notices that his repeat rate is increasing and his projected farrowing rate is only 83%. To maintain pig flow, he needs to increase his breedings per week by 5 (assume 50 extra sows in the herd). The annual carrying cost of those 50 sows, in just feed and semen, is \$19,370 per year or \$372 per week (assume feed at \$325 per tonne). However, if the manager chooses to ignore the warning signs (repeats) and maintains his breeding target at 55, the weekly output of pigs drops to 456. This translates to a \$1540 a week drop in revenue.

The solution: Adjust the targets immediately to *maintain pig flow and cash flow*. Work at fixing the production problem to improve efficiency.

Income scenario 1: $500 \times \$35$ per weaned pig = \$17,500 per week.

Income scenario 2: $456 \times \$35$ per weaned pig = \$15,960 per week (-\$1540 per week).

Income scenario 3: $500 \times \$35$ per weaned pig = \$17,500 per week - \$372 feed and semen cost for extra animals = \$17,128 net.

Failure to maintain consistent pig out flow is a top profit robber in the sow herd!

CONCLUSIONS

Stopping the top profit robbers in sow herds depends on controlling costs and maintaining targeted herd output. To control costs focus on the major items:

1. Feed and feed management
2. Genetics – manage semen use and gilt replacements to minimize cost to the herd.

To maintain income, focus on maintaining targeted pig outflow through:

1. Striving for consistency in weekly (or batch) production
2. Maximizing gilt retention, via good gilt management.
3. Understand the age structure of each farrowing group and plan for replacement of older sows (a push system).

Top Profit Robbers in a Sow Farm: Energy

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ENERGY CONSUMPTION

Hydro costs continue to increase, therefore a periodic review of your barn's hydro usage is a good idea.

Is your lighting system efficient compared to current systems on the market? If you find you are replacing a lot of fixtures due to old age it may be time to consider a more efficient product. In fluorescent lighting the T12 should be replaced by at least a T8. If you are still using incandescent light bulbs there are lots of new style bulbs that use a lot less energy. You may want to review your use of lighting. Do you leave lights on all day? How often are lights left on overnight that should be off? Timers are a great way of ensuring that lights are on for the proper amount of time. If you use heat lamps for creep areas these are a major user of electricity. Proper management is essential. Again there may be more efficient products on the market than when you started farming. Ventilation fans that become excessively dusty are another large user of electricity especially in the hot summer months. These should be washed frequently to keep them as efficient as possible.

Propane or gas prices seem to fluctuate wildly over the years but the long term trend has been upward.

A properly set ventilation system especially in the winter can have an impact on the amount of heat you use. Most ventilation systems have the ability to monitor high and low room temperature as well as heater usage. This is a great tool to check frequently to see how your ventilation system is performing. The heater usage number over time will tell you if your minimum ventilation is set to high causing the heater to continually cycle on and off. Monitoring the high/low temperatures alone will not isolate this problem. A minimum ventilation rate set to low of course causes other problems, usually to the health of pigs and people, so there is a fine balance we need to obtain for maximum performance and efficiency.

The heating component of the high pressure washer system is another area we should look at periodically. Set to low and washing time increases; set to high and a lot of energy is used that does not improve the time spent or cleanliness of the facility.

Monitoring both hydro and gas usage on a monthly basis is a good way to establish your requirements over time. This then can be used as a baseline. So, when you make a change in the barn that affects your energy usage you can then figure out the cost benefit of the endeavour.

CONCLUSIONS

Energy cost, while it is not one of the largest costs to producing piglets, still needs to be managed. Monitoring devices that use energy so that you can realize when they are not being used the most efficiently is an easy way to enhance the overall productivity of your barn.

Lactation in Motion
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ABSTRACT

Successful lactation in sows involves a complex, coordinated interplay between the behaviour and physiology of the sow and that of her pigs. The nature of this interplay is constantly changing and evolving from the birth of the first pig through to the removal of the litter at weaning. This overview of lactation in swine addresses this sow-litter interplay at two levels, including the shifting relationship between the sow and her litter, and the coordinated physiology that occurs between an individual pig and the mammary gland it suckles.

STAGES OF LACTATION

Getting going

At the time when the pregnant gilt or sow enters the farrowing barn several days prior to the expected farrowing date, her mammary gland is in the late stages of a rapid period of growth. The increase in mass of the mammary gland occurs most rapidly in the last third of pregnancy (Ji et al., 2006), and is regulated by several mammogenic hormones, especially estrogen from the placenta, progesterone and relaxin from the ovary, and prolactin and growth hormone from the pituitary. All of her mammary glands are stimulated to grow; however, typically the middle glands achieve the greatest mass prior to farrowing and the posterior glands are the smallest.

In the period immediately prior to farrowing the gland starts producing the antibody-rich colostrum. Attempts to remove colostrum from the glands usually are not successful until the time of farrowing when there is an increased release of oxytocin in association with the birthing process. As the milk ejection hormone, oxytocin plays an important role in the sow-pig interaction during lactation, as discussed below. After farrowing it again becomes difficult to manually “milk” a sow without exogenous oxytocin administration.

At the time of farrowing, the mammary gland undergoes the two-stage process of lactogenesis (initiation of lactation). The initial stage involves cellular development of the milk synthesis apparatus, expression of genes associated with synthesis of milk components (milk proteins, fat and lactose), and secretion of a limited amount of the milk components. In the sow, this initial stage of lactogenesis seems to only be occurring within a very few days prior to farrowing and coincides to some extent with the formation of colostrum (Kensinger et al., 1982). Copious milk secretion is the second stage of lactogenesis and involves a large-scale expression of all genes and cellular processes associated with milk synthesis and rapid secretion of large quantities of all milk components. In the sow, this second phase of lactogenesis is initiated shortly after farrowing.

The major hormone involved in regulating lactogenesis is prolactin from the pituitary. In the sow, the peripartum surge of prolactin secretion starts a couple of days prior to farrowing and continues for several days post-farrowing (Devillers et al., 2004), stimulating the gland to switch

from formation and accumulation of colostrum to synthesis and secretion of milk components. Anything that inhibits prolactin secretion around the time of farrowing can inhibit lactation.

Assembly of the partners

When the sow starts farrowing each of her mammary glands has developed structurally and functionally to the point of producing some colostrum. From that time forward, changes in the functioning of each gland will be determined by whether and how often it is suckled. Pigs can fairly quickly move around after birth, allowing them to act on their strong behavioural drive to suckle (Brooks and Burke, 1998). The synchrony of having mammary glands primed to lactate at the same time as the birth of pigs with a strong suckling drive is critical to getting the dynamic interplay of sow and pigs initiated.

For swine breeds most often used in the US swine industry, pigs establish a well-defined teat order or teat preference. Generally each pig will suckle from only one gland, although there are some pigs that are able to maintain some lactation function in two adjacent glands. Glands that are not suckled undergo regression. If a pig is removed from the litter, the gland that the pig suckled typically will not be adopted by another pig in the litter, but will undergo regression.

Synchrony of the motion

The process by which the pigs establish teat order continues for several hours post-farrowing. By approximately 11 to 12 hours post-farrowing the litter and sow have synchronized their respective behaviours and interact in a coordinated, repeatable manner. Teat order has been established so that the relationship among pigs is stabilized. The sow has started to let down her milk at fairly regular intervals, and the pigs have learned to pick up on the sow's cues when she is going to let down her milk. At this point, the suckling interplay between the sow and her litter occurs at intervals ranging from about 45 to over 60 minutes. In addition, the sow's mammary gland is refilling with milk between nursings, while the ingested milk in the pig's gastrointestinal tract is slowly digesting, making room for the next feeding.

It is also important to consider the dynamic interplay of the pig and the gland it suckles. Each gland responds to stimuli carried in the blood, such as the lactogenic hormone, prolactin. Prolactin secretion from the pituitary is stimulated by the pigs nuzzling the mammary glands and by their suckling action on the teats (Algers et al., 1991). In addition, each gland responds to local inhibitory factors that are produced within the gland (Knight et al., 1998). The mammary epithelial cells secrete an inhibitory factor, referred to as feedback inhibitor of lactation, as part of the normal cellular mechanism of milk secretion. As the feedback inhibitor accumulates in the alveolar lumen, it has an inhibitory effect on further milk secretion by the cells. When the pig removes the milk during suckling the negative effect of the feedback inhibitor is also removed, allowing milk synthesis and secretion to be stimulated again by the suckling-induced elevated prolactin concentrations. Therefore, maintenance of lactation in each gland is determined by the repeated removal of the milk produced by that gland. Each pig is different in its demand for milk from its preferred gland and each gland is independent from the other glands in its responsiveness to the pig's demands.

As a consequence of this synergy and coordination, the pig and the gland it suckles can be thought of as an interdependent, functionally linked unit. The more milk removed by the pig, the more the gland is stimulated to produce more milk and to grow, and the more the pig is stimulated to grow. The larger the pig, the more demanding it is for milk from the gland and perhaps the more effective it is at removing milk from the gland. This relationship results in a

positive and statistically significant correlation between growth rate of the pig and size of the mammary gland the pig is suckling. Pigs suckling heavier glands gain faster than pigs suckling lighter glands, although there is substantial variability among individual sows.

Ejecting the product

Milk ejection may be thought of as the climax of the sow-litter interplay. It is accompanied by an intricate and highly coordinated behavioural sequence involving activity of the sow and of the litter (Brooks and Burke, 1998). Typically the sow initiates a period of grunting that alerts the pigs. She lies on her side exposing the udder. While the sow continues her rhythmic grunting, the pigs assemble at the udder, nuzzling the glands and sucking on the teats. Release of oxytocin from the pituitary is stimulated by the extensive nuzzling of the udder by the pigs and occurs approximately at the point where the sow increases the rate of grunting. Milk ejection starts roughly 25-30 seconds later, however it only lasts for about 10-15 seconds. It is only during this short period of milk ejection that the pigs can remove milk from the gland. The end of milk ejection is evident when the pigs release the teat and start trying to suckle other teats. They will continue nuzzling the udder for several minutes after the nursing event. The nuzzling of the udder both before and after milk ejection also stimulates continued release of prolactin from the pituitary, which stimulates the refilling of the gland. Suckling during milk ejection not only removes the milk, but also removes the feedback inhibitory factor. After each suckling, synthesis of milk to refill the gland is nearly complete by about 35 minutes after emptying of the gland (Spinka et al., 1997).

Factors affecting the results

Total milk production by the sow and mammary growth during lactation are affected by many factors, including nutrition, environment, breed, stage of lactation, and parity (King, 2000; Hurley, 2001). Individual mammary glands also differ in their production ability according to teat location (Dyck et al., 1987). Suckling intensity is an important factor determining total milk production by the sow. Because of the strong teat order of the pigs, the larger the litter size, the more glands of the sow are maintained in a milk secreting state, and the more total milk will be produced by the sow (litter size is positively correlated with total milk production). This also means the larger the litter size the greater the total amount of mammary gland mass that develops on the sow during lactation. However, the increment of increase in total mammary mass or total milk production decreases with each additional pig in the litter. That is, the larger the litter size the lower the amount of milk received per pig.

Suckling intensity also is related to interval between sucklings, or how often the sow is suckled. Suckling intervals between 35 and 50 minutes, resulting in milk removal about 30 times per day, offers maximal daily production of milk. Sows that nurse every 45 minutes vs those that nurse every 60 minutes, will produce less milk per nursing, but more total milk in a day. Because the duration of milk ejection is very short and the process of milk ejection is negatively impacted by stress, some sucklings may be non-nutritive. The sow and litter go through the normal behavioural sequence of the nursing, but milk ejection does not occur.

When it is all done

When milk is not regularly removed from a gland the inhibitory factor gradually stops milk secretion in that gland. Lactation function is maintained only in those glands regularly suckled by the pigs. Those glands that are not suckled undergo involution. At the beginning of lactation, the milk secretion function of nonsuckled glands is irreversibly lost for that lactation cycle within

3 days of farrowing (Theil et al., 2005, 2006). At weaning, with the complete absence of suckling and milk removal, the mammary gland undergoes extensive regression and remodelling for about a week or more before reaching a regressed state that will be maintained until mammary development is initiated during the subsequent pregnancy (Ford et al., 2003).

SEVERAL IMPLICATIONS

Anything that disrupts the coordinated behaviours of the sow or litter will negatively impact the success of the pigs in receiving milk during the short milk ejection period. Pigs that are not able to participate in the suckling processes will miss a meal that may cause them to become weakened and unable to participate in further feedings. Stressors of any type in the farrowing barn may compromise the sow's ability to let down her milk.

The lactation history of a gland seems to impact the functionality of that gland in a subsequent lactation. Glands that are suckled in a gilt's first lactation will produce more milk and have a greater development in her second lactation than glands that were not suckled during the first lactation (Farmer et al., 2012). This indicates that there is a carry-over from the gland development that occurs in one lactation to the next.

Optimal success in cross-fostering a pig onto a non-suckled gland may be achieved on day 1 of lactation, with limited success on day 2, and no success by day 3. Even if a gland is not suckled during the first day after farrowing and subsequently a pig suckles that gland, the gland will not produce to the level it might have if regular suckling began sooner (Theil et al., 2005, 2006). If a pig dies during lactation, the gland it was suckling will undergo a regression similar to the involution process occurring at weaning. Efforts to successfully foster another pig onto that gland must be achieved rapidly before the regression process becomes established.

CONCLUSIONS

Successful lactation of a sow involves a highly coordinated interplay between the behaviour and physiology of the sow and her litter. This interplay occurs to a great extent at the point of physical interaction of the individual pigs and the mammary glands they suckle. The nature of this interplay is continually changing from the time of farrowing to weaning the litter. While there are many other factors that go into a successful lactation of a sow, ultimately it is the highly controlled milk ejection process of the sow, coordinated with the physical removal of milk from the gland by the pig, that determines whether and how much the pig grows, as well as how much the gland continues to produce milk. This coordinated interplay of the sow and her litter occurs many times daily in the farrowing barn. Careful observation of this sow-litter interplay may help us better understand those factors that would compromise their performance.

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Day 1: Workshop Sessions

Managing Pre-Weaning Mortality
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INTRODUCTION

Pre-weaning mortality is a critical part in the production system to deliver quality weaned pigs to the nursery. It is only part of it as managing the system to achieve good results relies on many areas. The teams in our system are very results orientated and we make sure we share all information so everyone involved has the tools to achieve the set goal. We rely on timely feedback and data to get this done. I will spend a bit of time referencing the nursery in this topic as they are the customer and play an important part in how well the sow unit is doing in meeting the goal. All of the following will require dedication by the unit Manager and his or her team. “Our Strength is in our People”.

OBJECTIVE

In our system our goal is to deliver the target: #1 weaned pigs to the nursery each week. This means “good quality” pigs. This is what drives our system. We start from the back end and then go back to the sow unit to be able to deliver this to the customer (the nursery). The Manager at the sow unit understands what the nursery wants and works with them getting feedback on each load on how the delivery was. Feedback is given on good and poor. Each step is worked back through to see what needs to be done at the beginning to set up to deliver these results.

With the above in mind the farrowing room staff understands what their goal is. If you just focus on PWM (Pre-Weaning Mortality) then you may not end up with the desired results. You may have low PWM but lots of poor quality pigs delivered to the nursery ready to eat expensive feed, never to make a market hog. At times this just moves the mortality from the sow unit to the nursery. Plus you have the transportation cost on pigs you will never get value from. In order for the nursery to work well they need a set number of good quality pigs weekly. This means even distribution of pigs in the correct age as well.

BREEDING

Now the sow unit knows what is expected of them. In order for them to achieve the desired results it is going to take consistent served sows weekly to hit sows farrowed and pigs weaned. We measure this weekly using “Production Graphs”. These graphs play an important role in how we manage the unit each week or day to achieve the results we are looking for. Figure 1 shows an example of service and projected to farrow graphs.

To achieve a narrow variation on farrowed sows you need a narrow variation in services. Fallout may vary week to week, but we can’t manage that very well so we focus on a tight serve tolerance and try to stick to it. This means spending time forecasting weaned sows and managing the gilt pool well with HNS (Skip heat records) so you know what you have coming in heat the following week. It’s extremely important to stick with the target and not let the variation in 4-6 week fallout drive your service decisions. Mind you if you are trending higher fallout you will have to compensate for it by increasing services; this should go up and flatten

out again. If you stick with this hard and fast rule you are on track to deliver consistent sows farrowed.

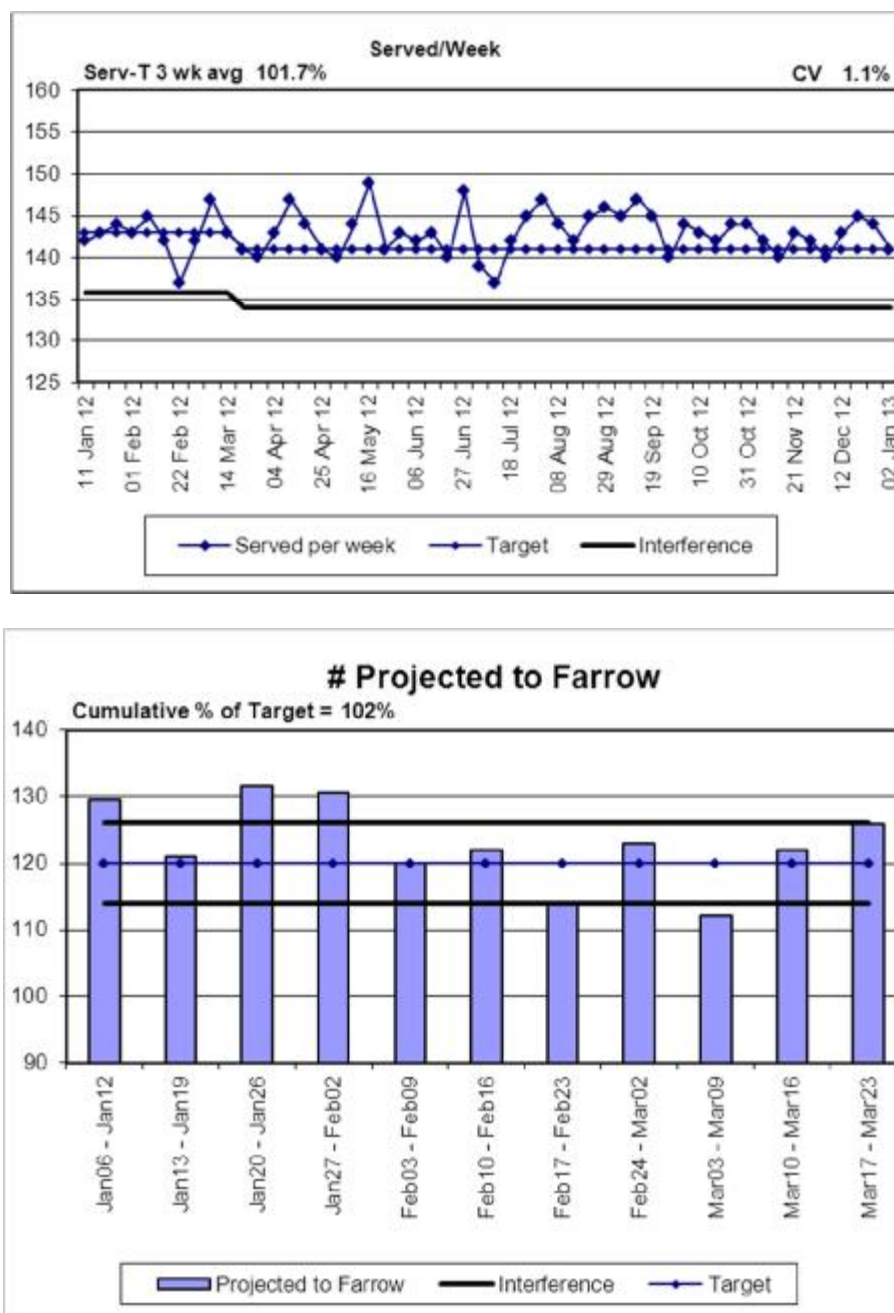


Figure 1. Examples of farrowing production graphs.

FARROWING

The farrowing and breeding teams need to work closely together as one in order for the unit to fire on all cylinders. The breeding team has now done its part in trying to achieve consistent sows farrowed. The importance of this is more pigs weaned in a tight wean group, i.e. more consistent wean age. By using the graphs weekly the farrowing team can see what they have

coming into farrow. This helps them manage the flow and use of induction to get sows farrowed in the correct wean group. We use wean groups to help manage variation. If we can target farrowings by weaned group, twice per week weaning, then it helps with fostering and then target wean age. We will use induction as a way of targeting when we want sows to farrow. We will not induce to farrow less than 114 days of gestation but we will let them go longer to target the wean group.

Room set-up

Rooms are washed and disinfected on an all in all out basis. Our goal is to dry before loading new sows but... well we seem to push the system and break this rule at times! Once sows are loaded the temperature is set at 23°C. Heat lamps are placed at the rear of the sow and the sow history cards are hung at the back. Heat pads are checked for temperature and adjusted if needed. Target temp is 95-100°F (35-37.8°C). A drying agent is sprinkled on the heat pads so when pigs get there it helps dry them off.

Ventilation

This is often an area overlooked by many, but is very important to ensure a good environment for the piglets. Training staff to identify ventilation issues can be a tough one. You can have the controller set to the desired settings and the temperature displayed can be correct but the “effective” temperature may not be right. You should be able to tell if a room is correct as soon as you walk in without looking at the controller.

When setting the room up it's a good idea to go through and “zero” the inlets. This is when you set the controller to 0 for inlet and make sure they are all snugged up shut. Then when the inlets need to open they will be even across the room. Also this will prevent drafting at minimum ventilation. If you have an inlet not shut when it should be you will get a stream of cold air falling into the crate where you don't want it. You need to make sure all set points are correct and that the minimum fan speed is where you need it. If you have a growth curve it's good to use that as it will adjust the temperature over time as the pigs grow. If not then you need to make sure you lower the set point each week. The room needs to be kept cool enough for the sow to have an appetite but not to chill the piglets. Remember, drafty inlets can cause scours and force piglets to lie in undesirable places, such as under the sow!

Farrowing process

Once farrowing begins staff monitor closely. They will reach sows that need it and ensure piglets get dried off quickly. The “midwifer” will carry a pail of drying agent to cover any new born pigs in to help them dry off. This is a critical part in achieving piglet survivability. The sooner a piglet is dry the less energy it has to spend drying and can use that to find the teat. The midwifer will also spend time ensuring the piglets get to the teat to suckle colostrum. On busy days there may be two or more staff helping with this. Large litters farrowing will get split suckled. This can be done by having a Rubbermaid bin with a drying agent in it. The bin is placed in the farrowing crate at the rear with the heat lamp over the top. As piglets are born they can be placed in the bin to dry off. Once dry they can be taken out so they can suckle. With the large litters, the big piglets are taken off the sow and put in the bin for 20 minutes at a time to allow the smaller piglets to suckle with less competition. Special attention needs to be paid at this time with your ears! Sows can be restless at farrowing so it is important to be listening for squealing piglets that may be in a tight spot, under mum! Spending time in the rooms at farrowing can really help save piglets.

Initial fostering

We will foster litters a couple times per day. When staff arrive in the morning they will write up all the litters that are farrowed and finished from yesterday and overnight. A team member will do a tally of piglets and also will have recorded the number of functional teats on each sow. This gives them an idea of how much space is available or not. The sows, especially gilts and P1s, will be filled to their maximum teats. If they have 14 functional teats they will get 14 piglets. We feel it is critical in the first litter to get all teats functioning to have the sow set up for lifetime productivity. Small piglets are all put together on a P2 or P3 sow with a nice udder. We do not use gilts as they will not have as good antibodies in their milk to provide the more challenged pig with immunity. We will generally put more piglets than teats on these sows as we will expect some not to make it. If we have teat space left over from fostering we will use this to put piglets on that are falling back at 2-3 days of age, within the same wean group. If the sows are not needed then we will leave the culls sow(s) empty and remove them. These crates can be used again to farrow another sow in. This helps maximize wean age. In the afternoon we will repeat this process with sows that farrow and are finished during the day. This way we get the piglets to their optimal teat as soon as possible. Large litters get reduced to help aid in reducing the chance of crushing.

Fostering day 4+

During the lactation period piglets need to be observed daily to ensure they are getting milk and growing as expected. Any piglets that are falling back need to be removed and put on a new mum. Generally piglets falling back between day 4 and 10 will be gathered up within their wean group. These piglets will then be put on a good milking sow together so they have equal competition. This can be done in a variety of ways:

- If there is an empty crate in the room a newly farrowed cull sow, which is not needed for the initial foster, can be brought in and used to put these piglets on.
- If there are no empty crates then piglets may get moved out of their wean group. The team member will look for a good litter at 12 days of age. This litter will be weaned to a piggy deck. Then a good litter at 7-10 days of age will be transferred to this sow. The sow these piglets came off will receive the fallbacks that have been gathered up. This way the fallbacks stay in their wean group to get the longest growth potential to be #1 weaned pigs.

It is critical to foster piglets when they need moving, not when you have time. This will ensure survivability at weaning. If you get to weaning and there are a number of poor pigs that did not get to the right sow they will end up being euthanized, as they will be poor quality pigs and you cannot afford to feed this type of pig, especially with today's high feed costs.

Feeding

Paying attention at feed time is also a critical part in reducing PWM. 70-80% of mortality occurs within the first 2-4 days. When the youngest rooms are fed the team member does not leave the room until the sows are laying down again. All sows farrowed and finished that day are got up to make sure they have a drink and something to eat if they want it. This gives the sow time to stretch her legs and switch sides if she wants. Staying in the room(s) to ensure the sows are down and not crushing piglets will help save a large number of them, as this is the time when

piglets are very active in suckling and have not quite figured out to stay away when mum is standing, and lay on the pad!

Monitoring results

Each week the team will sit down with the farm manager and go over the results from last week. Generally they know what they are, as data is record daily, so they tend to monitor each day how many piglet deaths there are. At the weekly meeting all the farrowing results will be looked at by the team but they will focus on the PWM and still-born graphs (Figure 2).

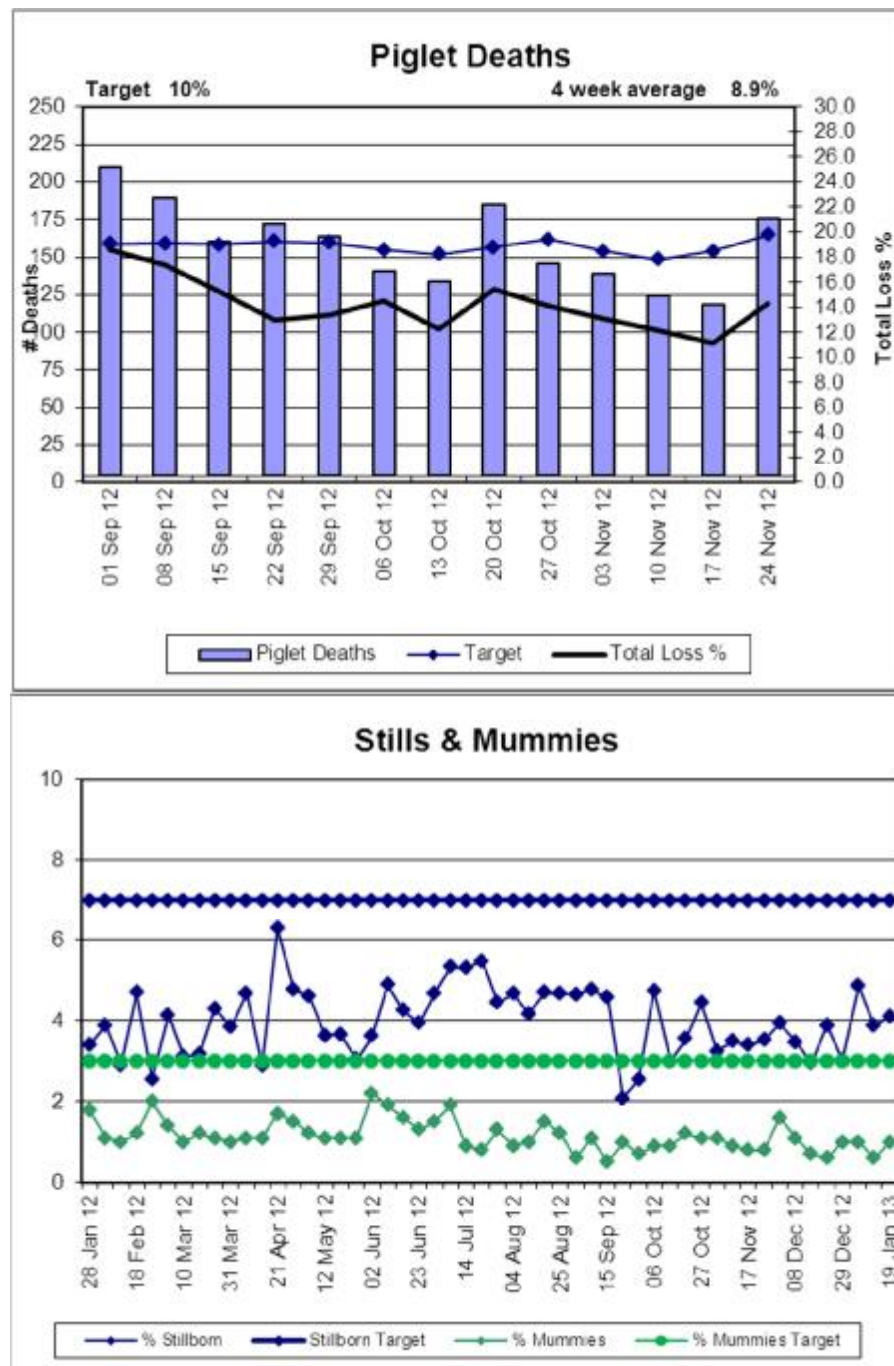


Figure 2. Examples of PWM and still-born production graphs.

We will look at “total loss” still-born and piglet deaths combined as these are all opportunity piglets regardless how they are categorized. All team members are encouraged to input into meetings and how to improve the results. If more data is required all our farm managers have access to the recording program to pull whatever in-depth data is needed, such as death reason, death day etc. Any actions are recorded and a plan is set with buy-in from everyone.

CONCLUSIONS

In order to achieve the lowest possible PWM it takes a team of dedicated staff and a good farm manager to lead the team and keep them motivated. Good results will not be achievable without buy-in from staff members. Our culture is to encourage input and ideas from everyone on how to better our results all the time. The goal needs to be a “shared goal”. Everyone has to buy into “the plan”. And probably the most important part, which is often forgotten, we need to “cheer the progress”. Most people thrive on improvements and good results, so that’s why it is critical to monitor the data weekly and get it put into a readable format in graphs so the teams know where they are and what needs to be done. I can’t emphasize enough the importance of people. We have set protocols that should deliver good results, but if they are not applied consistently by the staff you will not achieve the desired results. This is where keeping the team focused and creating an environment in which they are motivated is a critical part of success. I read a quote once: “The true measure of success is the benefits others have gained around you”. In this case it will be good results achieved by staff and piglets’ lives saved!

Managing Pre-Weaning Mortality: Practical tools and protocols to reduce PWM On-farm

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How much does a 1% increase in pre-weaning mortality (PWM) cost your operation? It is about \$33,750 lost opportunity for a 3,000 sow operation at \$45/isowean with 25PSY performance. If you own the barn, “Ouch! That hurts!” If you’re the manager, “Ouch and what can I do to correct this so I don’t lose my job?” If you’re the farrowing staff... it can either be “Okay... so what?” or “What can I do better to keep these pigs alive because I care?”

This is how the people working in the barn see the pre-weaning mortality value. There are varied emotions and mind-sets pertaining to PWM. And there are more people in the chain that see it differently like the nursery and grower-finisher personnel who receive the pigs from the sow barn either as good quality or sub-standard pigs. And there are also different feelings and emotions from those paying the bills (especially feed bills) and selling the hogs. Whatever role we play in the pig production chain, we should all focus on saving as many piglets as we can that would give us good profit for our operation. How about you, how do you feel about your PWM rate?

WHERE TO START?

We will start with the basics. These are the basic/fundamental things we have learned and heard before.

“Success is not doing 5000 things really well, it is doing half a dozen things really well 5000 times.”

- Darren Hardy, Compound Effect

The basics of pig production are providing food, water and a dry place to sleep/excellent environment to our pigs (I know you have heard this before...but it never changed since that time or for a long time...J).

Aside from food, water and excellent environment, there is another important component in pig production, all related to above mentioned activities, that we should not miss..... That is Care, also known as Great Stockmanship.

Being the most important factor in providing the pigs’ basic needs of food, water and good environment, the stockperson has a certain ingredient to add to the pig production mix to achieve optimum performance. That ingredient is CARE. Individual Pig Care. This is the fourth essential aspect of production.

REDUCING PWM

In the Farrowing Barn, these are the areas we should strive to be really great at:

- Sanitation
- Pre-Farrowing Facility and Sow Management

- Farrowing process
- Colostrum management
- Piglet care
- Lactation feeding
- Farrowing records.

Sanitation is something so basic it tends to be neglected most of the time. For room preparation: clean, disinfect and dry. It's that simple. Same with the processing equipment, crates, lunch area, everywhere—always be clean and think clean wherever you work in the barn especially in the farrowing barn. How much time does it take to scrape the back of crates? It pays to do it. This is the maternity area of the facility; do we want babies to be born beside a heap of manure?

Sow management before and after entry in the farrowing barns affects the output (quality pigs). Sow body condition and handling greatly influence the piglets being born. The people on the other side of the barn, the breeders, affect this. Let's work with them and make it a team effort.

The farrowing process is a critical time where we, as pig caregivers, can make a difference. The skill of assessing the sows' need for assistance is very important to save sows and litter. Drying new-born piglets is critical in chilling prevention. Using a drying agent, cloth/towel or disposable paper towels, can do this. ALL the piglets in the litter from their own sow must ingest colostrum. Do this by split suckling large litters giving opportunity to all deserving piglets. It means that the barn must have a standard birth weight to keep only those piglets that pass this standard (1kg for example). There is no use spending time and resources on piglets that will not provide the return we expect. With the activities cited above, it is important that we assign a person or persons to do these tasks. The only way we can save as many piglets as possible is to start them off right at farrowing day.

Fostering piglets off a sow with large litters should be done only when the piglets to be fostered off have ingested enough colostrum (+30mL). The critical part in this process is to know the number of functional teats a sow has and leaving her with the right number of piglets. Lactation management has proven to be the one of the critical component of reducing mortality in the farrowing crate. Previous lactation dictates subsequent lactation and success in the barn leaving litters intact for more than 70% of all farrowings is the goal to aim for.

Temperature management is important to reduce piglets being laid on by sows. The main goal is for piglets to go for the heat source—mats or lamps instead of under the sow. Reducing drafts by using cover boards or disposable cardboards work for this purpose.

Piglet care is another essential component of reducing PWM. Piglets that are starving should be picked up and given a functional, good milking teat. This is done by collecting the starve-outs and fostering them on to a weaned sow. Medication should be provided as needed dependent on your veterinarian's advice.

Sow care is another aspect that should be focused on. Happy sows = happy piglets. The sow is one of the most important components of piglet care. No matter how much we try, we cannot out-win the sow. She ultimately provides the essential nourishment and maternal care for her piglets, all day. It is our duty to help her with that role. That is why we must make sure that the sow is healthy, eating, milking, and has the best environment.

And the last is proper record keeping. It is essential to maintain accurate records of farrowing performance. It is the way to measure performance and make appropriate decisions. Many

different computerized record keeping systems are available—choose the one with accurate calculations and useful reports like PigCHAMP.

PIG CARE SPECIALIST PROGRAM

The **Pig Care Specialist Program** is an on-farm training tool provided by Swine Health Professionals Ltd and Zoetis Animal Health that aims to:

- ü promote Individual Pig Care
- ü optimize pig production
- ü improve swine operation performance.

There have been great improvements with the pig (Genetics) and production inputs (Health, Management (SOP), Feed, Environment/Facility), but the fundamentals of pig production are still at the core. Learn the technology but never forget the basics—food, water, excellent environment, and care. Work daily to master the basics, observe and choose to do the right thing for success.

RESOURCES

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Pain Control
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BACKGROUND

It is generally agreed that all mammals experience pain in a similar manner to humans. Some species such as pigs attempt to hide the effects of pain. Possibly in the wild this behaviour was protective, because a pig showing signs of pain might attract the attention of a predator. Therefore, one problem in minimizing pain in pork production has been the difficulty in detecting pain and assessing the severity of the pain. A second challenge has been the scarcity of products licensed for use in food-producing animals that are effective in treating pain. This area of medicine has expanded greatly over the past decade but the pharmacological options approved for use in swine are still very limited. There are other potential reasons that have limited the advancement of pain control in the pork industry including economics and labour requirements. On the other hand there are important reasons why we need to carefully examine this issue and determine where there are opportunities to improve pain control. In certain areas pain management might improve productivity, but more importantly an on-farm program to minimize pain will be considered part of responsible animal husbandry by the general public.

A report¹ from the French National Institute for Agricultural Research expert panel on pain in food-producing farm animals published in 2012 advocated using “the 3 S approach”. The 3 S’s refer to suppress, substitute and soothe. Under the “suppress” category they suggested that a first step would be to review a farming operation and eliminate any source of pain that brings no obvious advantage to the animals or the producers as well as sources of pain for which potential benefits are largely exceeded by the negative effects. Secondly, “substitute” refers to identifying a painful but necessary procedure and replacing it with a technique that is less-painful. And thirdly, “soothe” refers to administration of pain medication where appropriate. There are opportunities on every farm to improve animal welfare and possibly increase productivity by carefully considering the 3 S approach. Unfortunately the topic of pain associated with pig farming has been sensationalized by various groups who generate revenue through propaganda. This creates an environment of distrust and defensiveness that is counter-productive. In this presentation we hope to have an open and frank discussion to explore how as an industry we can implement improvements in pain control and how we might move forward with continuous assessment and change as techniques are developed to ease pain in livestock.

EXAMPLES OF THE 3S APPROACH

Suppress

On most farms at first glance there does not appear to be anything obvious that is done that creates pain that is not necessary or beneficial but maybe if everyone spent time carefully reviewing management procedures examples will be found. For example a large number of farms have discontinued clipping needle teeth. For the most part removing the sharp tips of needle teeth provides a benefit in reducing cuts and possibly minimizing the occurrence of greasy pig disease, but there are farms where the number of damaged gums and broken teeth outweighs the positive benefits. It is something that needs to be evaluated on each farm. Rather

than eliminating a procedure like needle teeth clipping a better solution might be to improve the technique or possibly replace the old side-cutters that are being used.

“The times, they are a changing!” All stakeholders need to face the fact that expectations are changing. Two decades ago it was common practice to castrate 90 kg-plus boars after they completed record of performance testing. This was done on most farms without any anesthetic or analgesic. Postsurgical infection was not uncommon and excessive areas of trim were a problem at the processing plant. Almost anyone would have agreed at the time that this did not seem right but the practice continued. The industry came together, in the absence of public pressure, and decided that this practice could no longer be justified based on animal welfare implications. The cost of marketing these animals as intact boars was absorbed as part of cost of production.

Substitute

Over the past few decades the swine industry recognized that castration appears to be more painful when performed on older animals and so has substituted castration of pigs under 10 days of age for the more painful traditional practice of castration of weaned pigs. Likewise on many farms there has been a lot of thought put into moving pigs. For example better design of loading areas has eliminated or reduced the use of prods and minimized pig injury.

Soothe

This is an area that hopefully will develop further over the next few years as new products become available to relieve pain. There are several categories of drugs that can be of use in reducing pain and stress. In general there are drugs that tend to block all pain sensation, the anesthetics (general and local), and there are drugs which suppress pain, often referred to as analgesics or pain killers. There are drugs which primarily reduce inflammation which is a major source of discomfort, for example corticosteroid drugs. In general the swine industry needs to consider incorporating the judicious use of anesthetics and analgesics into standard operating procedures as a way of improving welfare.

PAIN MANAGEMENT EXPECTATIONS

Pain is defined as an unpleasant sensory and emotional experience that is associated with actual or potential tissue damage.² Procedures that are potentially painful include tooth clipping, tusk removal, ear notching, tail docking, castration, scrotal hernia repair, abdominal hernia repair, Caesarian section, vasectomy and epididymectomy. The use of anesthetic or analgesic prior to routine procedures creates a logistical problem and increases labour costs. Pigs must be visited multiple times for one procedure.

Other conditions that are apparently painful include vaginal prolapse, rectal prolapse, fractures, arthritis, infections, bitten tails, bitten vulvas, shoulder sores, lacerations and contusions. Where these conditions are caused by deficiencies in the safety of the facilities or management problems every effort should be made to correct the problems as soon as possible so that pain can be prevented.

The Canadian Veterinary Medical Association (CVMA) holds that castration of piglets to prevent aggression and boar-taint in post-pubertal boars is a painful procedure at any age. The CVMA recommends that, “when castration of piglets is required, it should be performed between the ages of 3 to 7 days with the use of appropriate analgesia. Nonsurgical methods of

controlling boar taint should be considered as technology develops.” These technologies could include marketing of light weight intact males but this may cause a reduction in consumer demand. Immunocastration with Improvest® is another alternative.

A survey published in the Canadian Veterinary Journal in 2007 concluded that “veterinarians needed to give more consideration to pain management in livestock” and the authors further indicated that “the cost of pain relief in food animals should be incorporated into current food policy rather than remaining one of the many extrinsic costs of food provision.”³ Although it is relatively easy to make these pronouncements it is difficult for producers or processors to pass these additional costs along to the consumer and profit margins are already very tight.

PAIN RELIEF TOOLS

There are a wide variety of anesthetic and analgesic medications that are available for veterinary use. An ideal anesthetic or analgesic must be effective, safe and practical. Measurement of cortisol levels, vocalization, trembling, and suckling behaviour can be used to measure a reduction of pain. Off label use of approved products with a Drug Identification Number (DIN) and compounded products present meat residue questions. Anaesthetics may make the pig drowsy and susceptible to trauma or crushing by the sow. Intravenous medications are impractical for routine procedures due to the difficulty of performing intravenous injections. Intramuscular, subcutaneous and oral medications are much easier to work with.

The question of cost-effectiveness always arises. Arguments based on cost of pain control usually fall on deaf ears when it comes to explaining these constraints to consumers or society in general.

Anesthetics

Anesthetics–general–thiopental–e.g. Thiotal® (Label) (IV): An ultrashort acting barbiturate. Perivascular injections are painful. Causes some respiratory depression; a poor muscle relaxant and a poor analgesic. Pre-operative and post-operative analgesic is recommended. A narcotic and is therefore a controlled drug. There is no withdrawal period on the label indicated for thiopental. However, If thiopental was to undergo the approval process today the lack of depletion profiles, MRLs and human safety data would make it difficult to determine that the zero withdrawal is appropriate given that it is cleared from the system by depositing in fatty tissue.

Anesthetics–general–ketamine–e.g. Ketaset® (Off label) (IM/IV): A dissociative anesthetic that is not licensed for food animals in Canada. Not compliant with Canadian Quality Assurance guidelines. Useful for surgical procedures such as vasectomy, epididymectomy when boars will not be directed to the food chain. Some issues with respect to human abuse and therefore must be strictly controlled. No withdrawal information for food animals.

Anaesthetic–general–CO2 (Off label) (Inhaled): Carbon Dioxide is being used in some European Union countries. There is a measurable reduction in pain response. The product does however result in increased death loss associated with the procedure. No withdrawal.

Anesthetic–local–lidocaine–e.g. Lurocaine® (Label) (IM/SQ): Used for regional infiltration, epidurals, intra-testicular infiltration with diffusion into the spermatic cord.⁴ Often used in combination with a sedative in order to reduce stress and struggling during restraint. The withdrawal is 5 days.

Analgesics

NSAID–flunixin–e.g. Banamine® (Label) (IM): Label claim for flunixin in Canada for a reduction of fever in pigs with respiratory disease but like most Non-steroidal Anti-inflammatory Drugs (NSAIDS) flunixin does have good analgesic properties when used peri-operatively and for chronic musculoskeletal conditions. IM injection can cause some local tissue irritation. Flunixin has been shown to decrease plasma cortisol and pain induced behaviour when administered before castration in 4 to 6-day-old piglets.⁵ The withdrawal is 13 days.

NSAID–ketoprofen–e.g. Anafen® (Label) (IM): Label claim for reduction of fever and inflammation associated with respiratory infections. This product does an excellent job of reducing fever. Young piglets may have lower peak plasma concentrations than older piglets. Can be used as a peri-operative analgesic. The withdrawal period is 7 days.

NSAID–acetaminophen–e.g. Pracetam 20%® Tylenol® (Label) (Oral): Label claim is for relief of fever and associated clinical symptoms in acute respiratory disease. Acetaminophen has some analgesic properties but generally less than some other NSAIDs.⁶ Uptake through the digestive tract is greater than 90%. The withdrawal is 3 days.

NSAID–acetylsalicylic acid–e.g. ASA boluses®, Aspirin®) (Off label) (Oral): Approved for cattle. In other countries this product is recommended for the reduction of fever in pigs. ASA has weaker analgesic properties than some other NSAIDs and is less effective in reducing peri-operative pain. High doses (e.g. 100 mg/kg) reduce fever in pigs.⁶ No label withdrawal for cattle but because of the association with Reye's syndrome in children the Canadian global Food Animal Residue Avoidance Database (CgFARAD) policy recommends at least a 24 hour withdrawal.

NSAID–meloxicam–e.g. Metacam® (Off label) (IM): Approved in cattle but not in swine. Has a European Union label claim for anti-inflammatory and analgesia including non-infectious locomotor lameness. Pre-castration administration of meloxicam in 4-6 day-old piglets significantly reduce plasma cortisol levels and decreased pain associated behaviour for one to four hours when compared to negative control piglets.^{2,7}

Corticosteroids–isoflupredone–e.g. Predef 2X® (Label) (IM): Labelled for alleviation of pain and lameness associated with generalized and acute localized arthritis. The withdrawal is 5 days.

Corticosteroids–dexamethazone–e.g. Dexamethasone 5® (Off-label) (IM): Analgesia is associated with the anti-inflammatory effect. No label withdrawal available for swine.

Sedatives (they are not analgesic!)

Sedatives–azaperone–e.g. Stresnil® (Label) (IM): Fast onset within 10 minutes. Provides no analgesia and therefore not suitable for use by itself for surgical procedures. Can be used in combination with a local anesthetic and as a premedication for thiopental for surgical procedures. The withdrawal is 1 day.

Sedatives–acepromazine–e.g. Atravet® (Label) (IM): Variable onset and effectiveness. Provides no analgesia and therefore not suitable for use by itself for surgical procedures. Can be used in combination with a local anesthetic and as a premedication for thiopental for surgical procedures. The withdrawal is 7 days.

Sedatives–xylazine–e.g. Rompun® (Offlabel) (IM/IV): An alpha-2 agonist licensed for cattle. Provides good analgesic properties. Xylazine is commonly used in combination with ketamine

for minor surgeries and this produces a good combination of anesthesia and analgesia. No withdrawal information for swine available.

Euthanasia

Euthanasia provides pain relief that is absolute. As part of the Canadian Pork Council Animal Care Assessment all farms have specific, age appropriate, methods for humane euthanasia in place and these are clearly stated in the farm euthanasia plan. What is less clear on most farms is exactly how the decision is made with respect to timeliness of euthanasia. This option must be considered where prolonged pain control is impractical and animals should not be transported to market.

SUMMARY OF SOME OF THE RESEARCH INITIATIVES AT GUELPH

Three studies were carried out on a 600-sow commercial farm and involved 997 litters and 4379 piglets by Ryan Tenbergen (MSc student).

1. A study was conducted to determine the effect of minimizing post-farrowing pain by routine injection of an analgesic after farrowing was complete. Sows were either given an IM injection of meloxicam (Metacam[®], Boehringer-Ingelheim Ltd.) (0.4 mg/kg of bodyweight) (n=149) or a similar volume of a placebo (n=140) after farrowing. There were no significant treatment effects for piglet weight gain or mortality. Studies elsewhere have shown that treatment with pain killers to sows that had a difficult farrowing or were sick (MMA) results in improved productivity.
2. A study was performed to determine if the same pain killer (meloxicam) could be used to minimize the pain associated with processing piglets (castration and tail-docking). Both male and female piglets were alternately allocated to receive a single IM injection of 0.4 mg/kg of bodyweight of meloxicam (n=1427) or a placebo (n=1461) at least 30 minutes prior to processing. Mortality and growth rate were monitored and treatment was found to have no effect. Castrated piglets receiving meloxicam displayed significantly less tail-jamming behaviour and tended to exhibit less isolating behaviour compared to piglets receiving the placebo. These behaviour results suggest meloxicam did reduce pain. Likewise plasma cortisol, which rises when animals are stressed or suffer pain, was higher in the piglets receiving the placebo compared to the meloxicam treated piglets for the first few hours after castration.
3. A second piglet study was performed to evaluate a different pain killer, ketoprofen (Anafen[®], Merial Canada Inc.). This study involved 1491 male piglets, which were alternatively to receive either ketoprofen (3 mg/kg of bodyweight) (n=755) or similar volume of a placebo (n=736) at least 30 min prior to processing. Results were similar to the meloxicam study, with no difference in growth rate and mortality between pigs receiving a pain killer and those pigs receiving the placebo, but behaviour and cortisol levels suggested a positive reduction in pain during the first few hours after castration.

Another study was carried out by MSc student Michelle Lam. She evaluated the use of a local anesthetic (lidocaine) injected into the testicle to reduce the pain associated with castration. She also looked at the combination of freezing the testicle and spermatic cord with lidocaine, and using a pain killer, meloxicam. The local anesthetic helped block the acute pain caused by severing the spermatic cord and removing the testicle, and the combination lidocaine and meloxicam helped reduce behavioural changes up to 24 hours

after castration. The negative aspects of this approach were that the animals had to be handled twice because the freezing needed about 3 minutes to take effect and lasted for about an hour, and testicular injections did cause some discomfort.

CONCLUSIONS

Progress in animal welfare, including pain management, is being made. Implementation and improvement will require continuous reassessment of management and an awareness of new developments.

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Advances in Sow Nutrition-
The Use of Mathematical Modelling in Sow Nutrition
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ABSTRACT

Mathematical modelling can be used to describe and understand metabolic processes in sows which can lead to improvement in optimized performance and feeding. A model was developed to describe the milk yield and composition of sows during lactation where litter size and gain was used as inputs to the model. The model can also be used within a whole-animal model to describe the protein metabolism of the sow, particularly secretion in milk. In order to simulate a group of sows in a more realistic way, information about the variation between sows was included in the model. The model can be used to develop new feeding strategies or optimize production.

BACKGROUND

The modern high producing sow has undergone major changes in the last few decades. Sows have become leaner and larger because of selection for lean meat and litter size has also increased. These changes emphasize the need of studying the metabolism and nutrient requirements of the modern sow in order to optimize her performance (litter size and growth) and longevity. Measurements of body composition and milk production for instance can be very labour intensive and expensive to carry out, and is therefore not done very often. Mathematical models can be a very effective tool to describe and generalize metabolic processes. An important aspect to consider when developing models is that the data should be relevant to the current production system as genetics of sows are changing rapidly. Therefore it is important to generate appropriate data when new or improved animals are used in the field. It is also important to test the model for its suitability to a given simulated group. Significant differences in prediction will occur if used on different breeds or parities of sows.

LACTATION CURVE MODEL

During lactation the sow requires energy and nutrients for maintenance and milk production. At this stage, the majority of the requirement is for milk production. To maximize milk production and avoid excessive weight loss during lactation it is important to determine the sow's requirement at the different stages of lactation as accurately as possible. The major determinants of milk production are litter size (LS) and piglet growth (LG).

Hansen et al. (2012a) developed a mathematical model to generate lactation curves for sows. Litter size and average daily LG (kg/d) were used as inputs to the model. Figure 1 shows expected milk yield for three scenarios with varying LS and LG. As LS and LG change, so does the shape of the curve, indicating that milk production is not constant.

The model can also be used to estimate protein, lactose, fat and energy output in the milk. Figure 2a shows how the contents of fat, protein and lactose (%) change during lactation, and how this together with the milk yield (kg/d) curve can be used to estimate the daily output of

these nutrients in the milk (Figure 2b). Using this information the net energy output in the milk can also be calculated.

The model helps understand how LS and LG affect the milk yield of the sow, and also emphasizes that nutrient and energy requirements for milk productions changes throughout lactation. The mathematical model is described in detail by Hansen et al. (2012a).

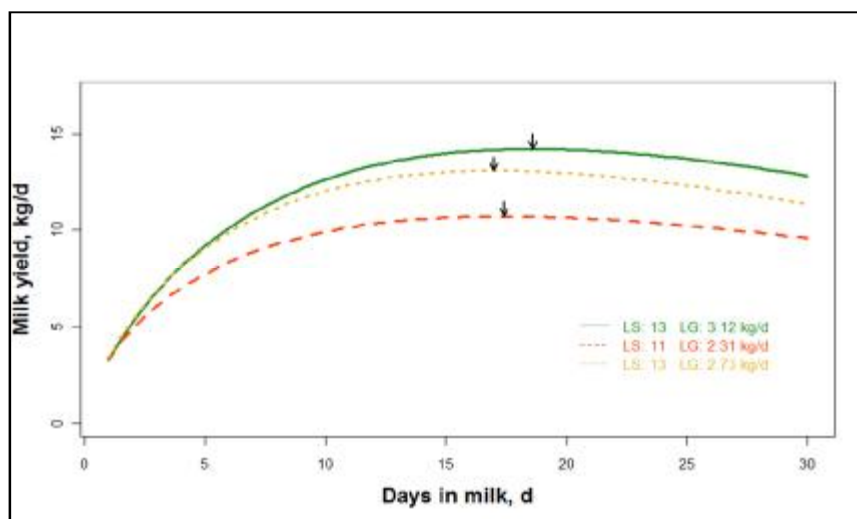


Figure 1. Plot of expected lactation curves for sows with litter size (LS) of 13, 11, and 13 and litter gain (LG) of 3.12, 2.31, and 2.73 kg/d, respectively. The arrows indicate time of maximum milk yield.

WHOLE ANIMAL MODELS

The lactation curve model is an example of how a mathematical model can describe a certain process within the sow and such equations have also been developed to describe e.g. changes in body fat and protein, fetal growth, and maintenance requirements. All these equations can be put together in a whole animal model describing nutrient metabolism of a lactating sow.

Using a whole animal model, a group or herd of similar sows can be simulated by giving the inputs. In this type of model all sows in the given group will generate the same outputs (e.g. milk production).

An improvement of the model is to incorporate information about between-sow variation, because in reality a group of sows with same inputs (e.g. feed intake, BW and body composition) will not give the same outputs.

Hansen et al. (2012b) developed a whole animal model for lactating sows including between-sow variability for estimation of protein and lysine requirements. The requirement was calculated using a factorial approach. Information about between-sow variation on milk yield and composition, feed intake, composition of mobilized body fat and protein, energy and amino acids for maintenance and efficiencies of energy and amino acids for milk production and growth was included in the model. When simulating the protein requirement of 1000 similar sows the output is 1000 different curves (Figure 3), because of the inclusion of the between-sow variation.

From these curves the cumulative distribution function for protein requirement could be calculated for the entire lactation or for different stages.

In Figure 4 the cumulative distribution function for the protein requirement of each of the simulated sows is plotted and it shows the variation between sows. For example, if the sows are fed approximately 760 g of protein per day 50% of the sows will have their protein requirement met. In a production setting this means that any proportion of sows that will have their requirement met can be used and this could depend on for instance feed prices or other production factors. For example, if feed prices are high compared to the profit for a higher piglet growth, then a lower proportion of sows that meet the requirement could be chosen.

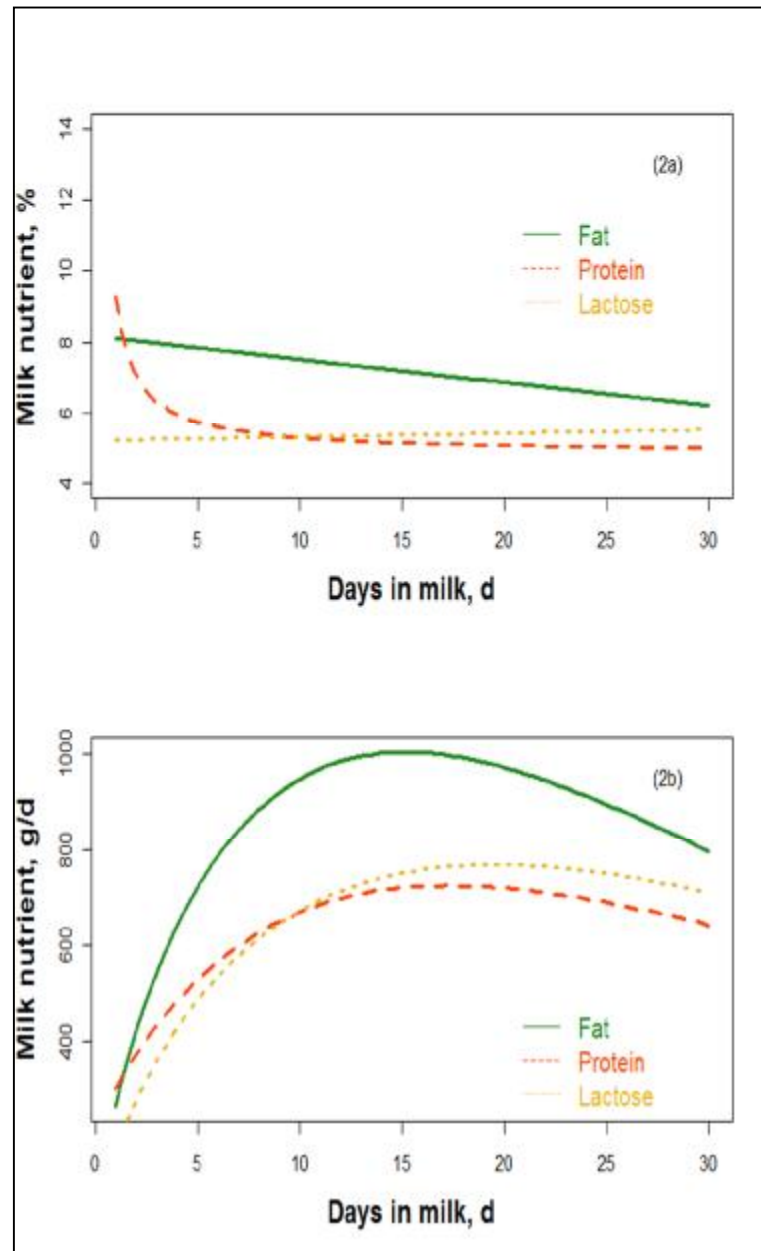


Figure 2. Plot of a) milk composition (%) , and b) nutrient output (g/d), LS = 13, LG = 3.12.

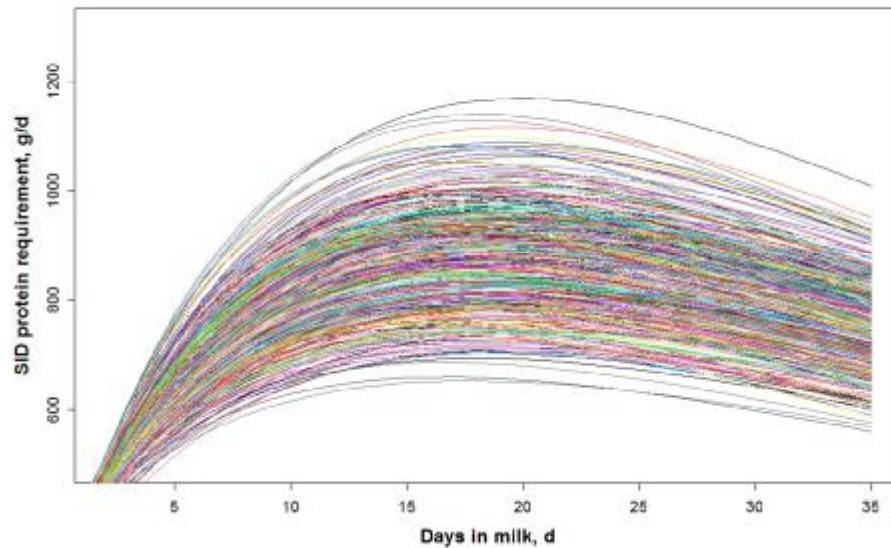


Figure 3. Simulated protein requirement of 1000 sows during lactation.

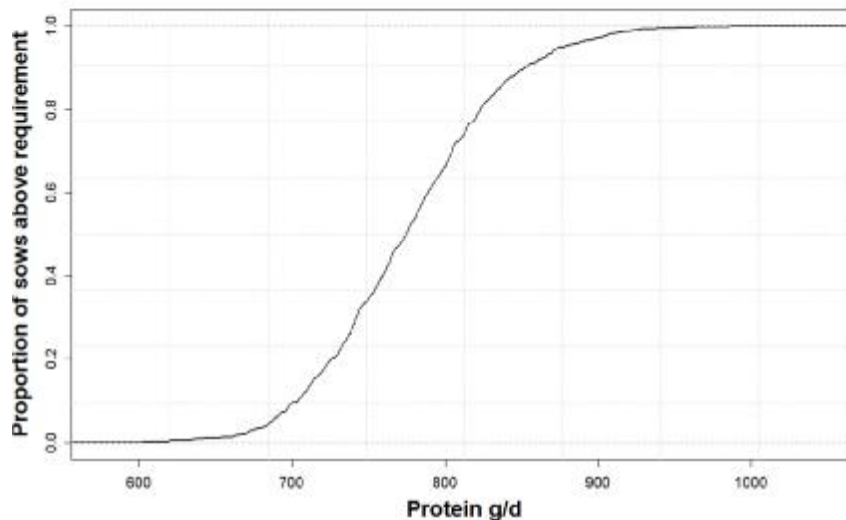


Figure 4. Cumulative distribution function for the protein requirements for 1000 simulated sows.

There are several other models that can also simulate sow metabolism (e.g. Pettigrew et al., 1992, Dourmad et al., 2008), but these models do not take into account the between-sow variation, which is valuable information in the development of strategies to optimize feeding and performance of sows.

CONCLUSIONS

Mathematical models can help describe and get a better understanding of the metabolism of sows and by including the between-sow variation a group of sows is simulated in a more realistic way. The models can be used to determine nutrient requirements of different groups of sows, development of new feeding strategies and economic optimization of the production.

ACKNOWLEDGEMENTS

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Nutrition of Pregnant Sows
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INTRODUCTION

In the last few years, the recommendations for feeding pregnant sows have been revised in that greater protein (amino acid) and energy intake have been proposed for late gestation (LG) compared to early gestation (EG). These revised recommendations have been based on growth models, e.g. GfE (2008), Kim et al. (2009) and NRC (2012). In addition, there have been empirical results (Moehn et al., 2011) that support the conclusions drawn in the growth models. In the current paper, we will show agreements and differences between models and empirical data, and will discuss the implications and relevance for commercial pig production.

CONCEPTS IN GESTATION FEEDING

Nutrient and energy requirements during gestation were previously considered to be constant (NRC 1998); practical experience with feeding prolific sows showed that it was necessary to increase feed and nutrient intake during late gestation to maintain performance.

Feeding a constant level of amino acid and energy during gestation is incorrect because it assumes an equal distribution of nutrient demand throughout gestation. However, the metabolic focus of the sow changes from the recovery of sow body tissue following weaning to the synthesis of fetal tissue in late gestation. Fetal weight, fetal protein content and mammary protein content increase 5-, 18- and 27-fold, respectively, in the last 45 d of gestation (McPherson et al., 2004; Ji et al., 2006). These dramatic increases in fetal weight and protein gain indicate that the requirement for amino acids must be greater in late gestation compared to early gestation. Similarly, the sows' maternal growth rate decreases with age becoming virtually zero in adult animals so that mature sows have lower requirements than gilts that are still growing vigorously. Ignoring these dynamics by applying a single phase feeding program will lead to overfeeding during early gestation and underfeeding during late gestation. Overfeeding in early gestation results in a waste of feed and money, while underfeeding in late gestation leads to sows entering lactation in a severe catabolic state.

MODELS FOR AMINO ACID REQUIREMENTS IN PREGNANCY.

The NRC (2012) model is based on the growth of sow body protein pools, their amino acid content and the efficiency of amino acid use. The requirements for each body protein pool are added up, and complemented by maternal energy-dependent and time-dependent protein deposition. Results are calculated on a day-by-day basis and presented as an average for the chosen time period in pregnancy.

The protein pools cover conceptus, i.e. uterus, placenta and fluids, mammary and fetus, and maternal protein. The conceptus, fetal and mammary protein pools increase sharply in the second half of pregnancy, and contribute most to the increase in amino acid requirements in late gestation. In comparison, uterus protein growth contributes little to the total requirements, while placenta and fluids show a peak in protein growth in mid pregnancy. Combined, the conceptus protein growth changes little until mid pregnancy, but accelerates rapidly after day 70.

Maternal protein growth is, firstly, dependent on energy intake. Because NRC (2012) treats energy (feed) intake as a user input, and suggests an increase of feed allowance of 400 g/d after day 84 of pregnancy, maternal protein deposition increases after that time-point. The second component of maternal protein deposition is the time dependent protein gain. This was defined as the protein deposition determined experimentally in gilts that could not be explained by the other components of maternal and conceptus protein deposition. The need to include a factor to account for the unexplained changes in protein deposition indicates that there are important changes in protein metabolism of the sow that we still do not understand; these must be investigated if we are to improve the accuracy and application of the NRC (2012) model.

The age of sows is accounted for by assuming that energy dependent maternal protein deposition decreases from parity 1 to 4, becoming zero in parity 5 when sows have reached their adult age and have effectively stopped growing. The time-dependent protein deposition, however, remains at the same magnitude for all parities. There is no provision for regaining maternal tissue lost in a preceding lactation. It needs to be determined if the time-dependent protein deposition, derived from studies in gilts, is suitable to describe regaining lost body mass.

The Excel-based NRC (2012) model is versatile in its application. User defined performance inputs are sow body weight at breeding, parity, expected litter size, piglet birth weight and gestation length. In addition, the user can define 4 feeding phases in pregnancy. Both the day in pregnancy when each phase starts as well as the feed amounts and feed energy and fiber content within each phase can be varied. The entered feed energy and fiber content, however, remain the same for all phases, unless a feeding program is entered for evaluation. Thus, the model can be used to predict nutrient requirements for most situations encountered in commercial pig production, or can be used to compare actual to predicted sow body weight and back fat gain to predicted values, if this option is chosen.

The recommendations of GfE (2008) for amino acid intake in pregnant sows are based on the same principles as the NRC (2012) model. Based on lysine, the daily amino acid retention is the sum of maintenance requirement, and lysine retention in products of conception (fetuses, fluids, placenta), uterus, mammary gland and maternal protein gain. Similar to NRC (2012), the sum of lysine retention is subjected to an efficiency factor to yield daily lysine requirements. The requirements for other amino acids are estimated by applying specific amino acid ratios, relative to lysine, to each of the components of requirement. Because the method of requirement calculation by GfE (2008) and NRC (2012) are analogous, recommendations are similar, too, but may differ in their absolute values. This occurs because the assumed amino acid patterns and efficiencies sometimes differ between GfE (2008) and NRC (2012). Both sets of recommendations, however, agree in principle: amino acid requirements are greater in late pregnancy and decrease as sows approach maturity.

Contrary to NRC (2012), GfE (2008) does not treat energy requirements as an user input but calculates energy requirements using a factorial approach. The factors used in calculation of energy requirements are the same as used for amino acid requirements. This results in similar trends, i.e. both amino acid and energy requirements increase rapidly in the last quarter of pregnancy. The GfE (2008) recommendations also show that energy requirements increase from 1st to 3rd parity due to the combined effect of increasing sow weight and decreasing growth rate as sows age. The decrease in energy requirement from 3rd to 4th parity is caused by the assumed cessation of maternal growth so that energy requirements of mature sows are only driven by the requirements for maintenance and pregnancy.

EXPERIMENTALLY DETERMINED REQUIREMENTS OF PREGNANT SOWS

Very few amino acid requirement studies of pregnant sows have been performed in the last 10 years. Srichana (2006) used the nitrogen balance technique to determine the lysine requirement of gilts in early, mid and late pregnancy. Zhong et al. (2009) reported the true ileal digestible lysine requirement in gilts up to day 84 of pregnancy as 0.69% in a diet containing 12.5 MJ ME. In contrast, Dourmad and Etienne (2002) did not report differences in lysine and threonine requirements in four consecutive nitrogen balance periods in pregnant sows.

The experimental data from our research group include the requirements in early and late gestation for lysine (Samuel et al., 2013), threonine (Levesque et al., 2011), isoleucine and tryptophan (Moehn et al., 2012 a,b). In these experiments, each sow received each of six test diets in both early and late gestation. Feed allowance was kept constant throughout gestation. Amino acid requirements were determined using the indicator amino acid oxidation technique simultaneously with indirect calorimetry to measure energy expenditure. Key results of these experiments are compiled in Table 1.

Table 1. Sow performance during amino acid requirement studies in early (EG) and late gestation (LG) over 3 parities.

Parity	AA studied		BW, kg	Maternal gain, kg	ME intake, MJ/d	Protein retention, g/d	Energy retention, MJ/d	Litter size	Litter weight, kg
2	Lys	EG	177		34.2	32	3.0		
2	Thr Trp	LG	215	44	34.5	126	-0.7	13.8	19.5
3	Lys	EG	205		36.1	38	1.2		
3	Thr	LG	244	40	36.0	119	-0.9	13.6	20.1
4	Thr	EG	240		35.6	4	1.5		
4	Ile	LG	266	25	35.5	64	-1.3	15.8	22.1

Srichana (2006) found no difference in the lysine requirement of 15.0 g/d between early and mid gestation, but reported an increased requirement of 18.0 g/d in late gestation (Table 2). Samuel et al. (2013) showed that the total lysine requirement of 2nd parity sows was 13.1 g/d and 18.7 g/d in early and late gestation, respectively. For 3rd parity sows, the dietary total lysine requirement was 8.2 g/d and 13.0 g/d for early and late gestation, respectively (Samuel et al., 2010). Levesque et al. (2011) found that 2nd parity sows required 7.2 g/d total threonine in early gestation (day 35 to 53) and 13.6 g/d threonine in late gestation (day 92 to 110), based on indicator amino acid oxidation. In multiparous sows (Levesque et al., 2011), the total threonine requirement was more than doubled from 5.0 g/d in early gestation to 12.3 g/d in the last third of gestation. The tryptophan requirement of 2nd parity sows increased from 1.7 g/d to 2.6 g/d from early to late gestation. The isoleucine requirement of 4th parity sows increased from 3.6 g/d to 9.6 g/d from early to late gestation.

Table 2. Total lysine¹, threonine², tryptophan³ and isoleucine⁴ requirements of gestating sows.

		1 st parity	2 nd parity	3 rd , 4 th parity
Lysine	Early gestation	15.0	13.1	8.1
	Late gestation	18.0	18.4	13.0
Threonine	Early gestation	n/a ⁵	7.0	5.0
	Late gestation	n/a	13.6	12.3
Tryptophan	Early gestation	n/a	1.7	n/a
	Late gestation	n/a	2.6	n/a
Isoleucine	Early gestation	n/a	n/a	3.6
	Late gestation	n/a	n/a	9.7

¹Srichana (2006) for 1st parity, Samuel et al. (2010) for 2nd and 3rd parity, ²Levesque et al. (2011), ³Moehn et al. (2012a), ⁴Moehn et al. (2012b), ⁵not available

These requirement values need to be considered with respect to sow performance as affected by stage of gestation and age of sows. The body weight of sows increased from early to late gestation (Table 1), regardless of parity, and increased from parity 2 to 4. Litter size and weight increased marginally over 3 parities. Protein deposition was greater in late than early gestation, across all parities, which is in accord with the fetal growth that occurs predominantly in late gestation. Thus, fetal growth drives amino acid requirements in late gestation, whereas maintenance and maternal growth are the principal factors affecting amino acid requirements in early gestation. Because maternal growth markedly decreases in the 4th compared to 2nd and 3rd parity, older (adult) sows will require amino acids in early gestation predominantly for maintenance. In fact, the isoleucine requirement for maintenance in early gestation (2.2 g/d based on 35 mg/kg^{0.75} body weight, Moehn et al. 2012c) was only slightly less than the measured early gestation requirement of 3.6 g/d (Table 2). The largely similar fetal growth over three parities coupled with reduced maternal growth can explain the greater difference between early and late gestation requirements in younger versus older sows.

COMPARISON OF REQUIREMENT VALUES

The requirement values determined by our research group were correlated to the values calculated using the NRC (2012) program with $r = 0.85$ (17 observations, $P = 0.001$) and to the GfE (2008) with $r = 0.82$, while NRC (2012) and GfE (2008) values were correlated with $r = 0.94$. Thus, there is a large degree of agreement between empirically determined and modelled amino acid requirement values.

Another common feature among the determined and modelled amino acid requirements was that the requirements for late gestation were always significantly greater ($P < 0.001$) than for early gestation. However, the degree of requirement increase differed among sets of recommendations. The greatest differences in amino acid requirements were found in the empirical data by Moehn et al. (2011; 77% increase in late pregnancy over early pregnancy values), followed by the data modelled by GfE (2008, 61% increase), while the NRC (2012) recommendations showed the least difference at 22% increase. A possible reason for the

differences in requirement increase is the time-dependent protein deposition that was included in the early gestation requirement in the NRC (2012) model; this component in protein deposition is not a feature of our empirical data or the GfE (2008) model, which may explain the larger differences between early and late pregnancy. In our experiments, we did not observe the time dependent protein deposition of approximately 20 g/d between day 0 and 50 predicted by NRC (2012) and, thus, the amino acid requirements determined in our experiments were lower than predicted by NRC (2012). However, our experiments were not designed to study protein retention shortly after breeding so that the existence and extent of the time-dependent protein deposition cannot be verified. Because of its large impact on amino acid requirements, this needs to be studied in gilts as well as in sows directly after weaning.

In early pregnancy, empirical requirement values were lower ($P = 0.04$) than those proposed by NRC (2012), while those modelled by GfE (2008) were intermediate. In late pregnancy, our empirical values were similar to those modelled by GfE (2008), and both these sets of recommendations were greater ($P < 0.1$) than the proposed values by NRC (2012). This is despite NRC (2012) and GfE (2008) suggesting increased energy intake in late pregnancy, while our experiments were conducted with a constant feed allowance. It is possible that increased energy allowance for sows will increase daily amino acid requirements as in growing pigs. However, the lack of data means that the relation between energy intake and amino acids needs to be determined in sows.

To elicit reasons for the differences, we need to look at amino acids individually. This shows that the requirement values for lysine were similar for all three sets of recommendations in both early and late gestation. For threonine, the late gestation values were similar for all three recommendations, while in early gestation, our empirical values and the recommendations of GfE (2008) were lower ($P < 0.1$) than the recommendations by NRC (2012). For tryptophan, the range of requirements was quite close at 1.6 to 2.0 g/d in early, and 2.3 to 2.8 g/d in late gestation. Large differences were found in the isoleucine requirement of adult sows, ranging from 1.8 to 5.0 g/d in early and from 4.4 to 9.1 g/d in late gestation. This indicates that the agreement of requirement values is close for more frequently studied amino acids or when sow growth is a large component of requirements. For little studied amino acids in adult sows, however, large discrepancies between requirement values can be expected.

There is good agreement between the NRC (2012) and GfE (2008) recommendations and our empirical data for the necessary increase in feed (energy) allowance in late gestation. NRC (2012) suggests that the feed allowance be increased by 400 g/d after day 90, while our data suggest increases between 600 g/d for gilts to 400 g/d for older sows. The suggested increase in energy intake by GfE (2008) are equivalent of 570 g/d and 430 g/d of a corn-soybean meal diet for gilts and 4th parity sows, respectively.

In conclusion, there is general agreement between modelled and empirically determined energy and amino acid requirements of sows, however, there are important questions that need further investigation. Despite this, the current recommendations represent requirement values that reflect the changing physiology of pregnant sows. To meet these requirements, parity-segregated phase feeding is the ideal nutritional regimen for pregnant sows.

WHAT IS MORE IMPORTANT: AMINO ACID OR ENERGY INTAKE?

These new data on changing amino acid requirements during gestation have important consequences for feeding sows. Because amino acid requirements increase to a much greater

degree in late gestation than energy requirements, it is nearly impossible to satisfy the requirements by simply feeding more of the same diet in late gestation. If the feed allowance of the same diet is increased sufficiently to cover amino acid intake, the sows will consume excessive amounts of energy. This is wasteful, and may lead to increased fatness of sows at farrowing. In addition, Shelton et al. (2009) have shown that increasing the feed allowance of pregnant sows by 0.9 kg/d in the last 3 weeks of pregnancy did not improve sow or litter performance, except for improved conception rate after the 1st litter. To increase piglet birth weight, Soto et al. (2011) observed increased piglet and litter weights when gilts were given an extra 1.82 kg/d during the last 2 weeks of pregnancy. This increase in feed intake was sufficient to cover the increased protein requirement of gilts in late pregnancy. Kleisiary (2007) showed increased piglet birth weight when the dietary protein content was increased from 11 to 13% for the last 30 d of pregnancy. In addition, Kusina et al. (1999) showed that increasing dietary protein during gestation increased sow lactation feed intake and milk yield and piglet weight gain. This indicates that meeting the protein (amino acid) requirement is more important than meeting the energy needs. Parity segregated phase feeding is the ideal tool to meet the both the amino acid and energy requirements of pregnant sows of all ages.

FEEDING RECOMMENDATIONS FOR SOWS

The preferred strategy is to formulate just 2 diets—one corresponding to the highest, the other to the lowest amino acid needs—can be mixed in appropriate ratios to meet the entire range of requirements, from late gestating gilt to early gestating adult sows. This approach minimizes nutrient deficiency or excess, and allows sows to perform to their potential while eliminating expensive oversupply of nutrients. Therefore, this approach maximizes the benefits of a parity-segregated phase feeding system. Although from a nutrition and feed cost point of view, this option with ‘high’ and ‘low’ diets is the best; its implementation incurs some costs to upgrade existing feeding equipment.

Feed intake of pregnant sows is severely restricted to control body condition and prevent excess weight gain. Therefore, energy intake is the limiting factor for gestating sows and, thus, the feed allowance to provide the necessary energy needs to be considered first when devising a sow feeding regimen.

Sows given a constant feed allowance in gestation can achieve good body condition at farrowing. However, the excess nutrients allow sows to deposit body protein and fat in early and mid gestation that is mobilized to offset the inadequate nutrient intake in late gestation. This is metabolically and energetically wasteful because both fat deposition and fat mobilization are less than 100% energy efficient. Therefore, the total feed eaten by a sow during gestation can be reduced slightly by introducing phase feeding and still provide optimal nutrition for sow and conceptus.

In phase feeding, less feed is offered in early and mid gestation (days 0 to 85) and a higher intake in late gestation (days 86 to 114); this will result in less total feed eaten by a sow during pregnancy compared to feeding a single diet. We recommend an increased feed allowance for 1st, 2nd and 3rd parity and older of 0.6 kg/d, 0.5 kg/d and 0.4 kg/d, respectively, during the last 4 weeks of gestation. An increase in late gestation feed allowance does not impair lactation feed intake and may improve litter weight (Miller et al. 2000). These considerations lead to the feed amounts shown in Table 3 for corn-soybean meal diets. These feed amounts apply to sows of

average body weight and condition; they should be modified for sows that are too lean or too fat, heavier or lighter than average, and more or less efficient in their nutrient utilization.

The feed allowances in Table 3 were chosen to cover the energy requirement of sows; Table 4 shows the necessary amino acid contents. In addition, an example is given for the amino acid contents that can be found in a single diet for pregnant sows. It becomes clear that a single diet is not adequate to provide sufficient amino acids in late pregnancy for young sows. Conversely, a single diet provides excess amino acids throughout pregnancy for older sows. The consequence is that the single diet may impair performance of young sows and will waste money because it is over-formulated for older sows.

Table 3. Daily feed allowance (kg/d) of a corn-soybean meal based diet for average sows in good condition in early and late gestation.

	1 st parity	2 nd parity	3 rd parity and older
Early gestation (day 1 to 84)	1.8	2.2	2.4
Late gestation (day 85 to 112)	2.4	2.7	2.8
<u>Average daily feed:</u>			
Phase feeding	1.95	2.32	2.50
Constant allowance	2.00	2.40	2.50

Table 4. Total dietary amino acid contents (g/kg) in parity-segregated phase feeding compared to feeding a single diet for all sows.

		Phase feeding		Single diet
		2 nd parity	3 rd parity	
Early gestation	Lysine	0.60	0.34	0.60 ?
	Threonine	0.32	0.21	0.45 ?
Late gestation	Lysine	0.68	0.46	0.60 ?
	Threonine	0.50	0.44	0.45 ?

The immediate benefits of parity-segregated phase feeding lie in reduced feed usage for younger sows and lower formulated diets for older sows, thus reducing feed costs throughout a sows' life. Further benefits of phase feeding may extend to increased sow productive life and possibly improved piglet quality. However, such benefits cannot be confirmed at present and need to be quantified.

CONCLUSIONS

Completely different methods—mathematical modelling and experimental animal research—agree that amino acid and energy requirements of sows increase in late pregnancy. Despite this, amino acid requirements right after breeding, requirements for first litter gilts, and the relationship between energy intake and amino acid requirements in late pregnancy need further study. To supply nutrients and energy at the right amounts and at the right time for sows of all ages, parity-

segregated phase feeding is the most appropriate approach. Such a feeding regimen will minimize feed costs for pregnant sows and may result in improved sow and piglet performance.

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Preparing the Barn: Stockmanship

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If a man is called to be a street sweeper, he should sweep streets as Michelangelo painted or Beethoven composed music, or Shakespeare poetry. He should sweep streets so well that all the hosts of heaven and earth will pause to say, "Here lived a great street sweeper who did his job well."

-Dr. Martin Luther King Jr.

What a great way to show leadership! Can we show this kind of world-class attitude and leadership in the barn? Of course! All we need is the right mind-set or attitude towards preparing the barn or the room for the next batch of animals.

The basics of pig production are providing food, water and a dry place to sleep/excellent environment to our pigs. These are the non-negotiables, the essentials that must be delivered outstandingly everyday if we want to be successful in our swine operation. This paper will focus on the "dry place to sleep or excellent environment" aspect of these basic requirements. And let us not forget the 4th component and the most important input in pig production, the Stockperson. Success will not come even with the other inputs like genetics, facilities, feed, management/techniques, and health if we don't have the applied care of outstanding personnel.

WHY PREPARE THE BARN?

One quick answer is to prevent disease. When we finish a cycle or batch of animals, we clean and disinfect the emptied space to reduce or eliminate the challenge for the new in-coming batch. This is a most fundamental activity in the barn that it is sometimes not given attention or even neglected and we only focus on it once we get hit with problems. Most of the time, costly disease problems! What's worse are production problems we don't see right away that deplete our profitability all because we neglect this basic need to clean, wash and disinfect effectively.

Let us focus on the stockperson who care enough to prepare the barn/room accordingly to provide the best environment for his/her pigs.

THE THREE QUALITIES OF A GREAT STOCKPERSON

1) Leadership

The industry we are in now needs us to be leaders in whatever position or role we play – whether we are a barn washer or the owner of the barn. "Leadership without a title" (Robin Sharma) is extremely necessary now more than ever. We need to be world class in everything we do.

2) Great Attitude

How a person feels about something affects the way he/she deals with that thing. How do you feel about yourself? You must understand how important you are to the whole swine industry in

Canada and the World. You are a food provider to the world. **YOU ARE VALUABLE!** The things you do affect the products of the barn you work for. The pig that you saved yesterday may be the pork chop on the plate of the Japanese emperor in a couple of months!

How do you feel about others? Nobody can succeed by themselves. Each of us, need all of us. One person cannot make a family or a company or a church or a country. Each of us is valuable and can bring special gifts to others but we must also appreciate gifts and value of others.

Having a positive attitude and seeing value in raising quality hog is a must for all of us.

Happiness is a choice.

When we are happy, fulfilled and satisfied there is a corresponding positive effect in what we do. We work better, exert extra effort and produce extraordinary results in the barn or in the office. Simple but important tasks such as washing and preparing the rooms, breeding sows, attending farrowing sows, giving special care and attention to all animals, and providing individual pig care, all seems easy and logical. Planning and implementation of production protocols for the swine business will be more relevant and applicable when done in a positive mood. The pig in turn will be happier, healthier and provide us with more meat and profit. So let us be happy and make money!

3) High Standards

What we have at this time of our life are reflections of our standards, our daily habits done as dictated by our standards. Our physical, mental, emotional, financial, spiritual and career conditions are results of the principles we have set for our selves. How we do our work, talk to our colleagues/friends or relate to our family members are all reflections of the standards we have set. This is true for our life as well as our work in the barn and our situation, whatever that situation is. My advise to all of us, let us Raise our standards!

CLEANING, WASHING, DISINFECTING, BIOFILM REMOVAL

Preparing a room is a four-step process that must be done in an orderly manner to have the best result. This is like cooking your favourite dish; you have to put in the ingredients in the right order so that each food item is cooked correctly – no over cooking or under cooking!

The first Step is pre-cleaning or removal of organic materials, dirt, manure etc. by washing with water. Allow the room to dry or drip off before proceeding to the next step. The second is application of degreaser or detergent to the surface being washed. This will help in the removal of Biofilm (a protective layer around bacteria and viruses) which can either be greasy or mineral film-like. Use alternating alkaline or acidic degreaser or soaps for better removal of these Biofilms. This will later aid in better penetration and kill more bacteria during disinfection. Then thorough cleaning and pressure washing to remove loosened Biofilm and dirt etc. This stage allows for preparing for the next important step of disinfection. Let the room dry before proceeding. Disinfectants need to be applied at their working concentration. Read the label and make sure the final product is at the right concentration. Allow the room to dry before animals enter; also be aware that some disinfectants are more toxic than others and feeding/sleeping areas may need to be rinsed before use, even if it is all dried.

Preparing the barn is an activity that let us also prepare ourselves mentally. If we set ourselves right and have the right attitude then we can apply the qualities of a great stockperson and make every room preparation/washing episode a delightful event!

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Preparing the Barn
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CLEANING, WASHING, DISINFECTING, BIOFILM REMOVAL

Removal of biofilms is essential to obtain the best results from the cleaning and disinfection process. Detergents have the components to remove these biofilms. Acidic detergents remove mineral deposits and alkaline detergents remove greasy organic biofilms. Mineral biofilms can be visible and organic biofilms are most likely invisible. The choice is crucial depending what is on the surfaces. Rotation of detergent is to be considered. For disinfection the final choice of a product must take in consideration the pathogen that must be controlled, cost and return on investment, environmental and health issues.

There are four steps in the process of cleaning and disinfection. First is the removal of organics. Presence of organics will reduce the efficacy of detergents. Second is the use of detergents for removal of biofilms. Allow the room to dry before applying disinfectant to prevent over dilution on the surfaces. Third is disinfection. Reading labels allows using the product correctly. Use protective gear to ensure health and safety. Apply disinfectant on surfaces just enough to wet surfaces and prevent from dripping. Fourth step is drying. This ensures the prevention of the development of bacteria. In a humid environment bacteria will reproduce every twenty minutes. Using ventilation and heat will dry rooms more rapidly. In some cases insufficient time is provided for drying and animals can come in contact with disinfectants. Some products can be harmful to livestock and can be corrosive. Rinsing surfaces will prevent any issues.

It is important to understand how application equipment works to apply the right amount of detergent or disinfectant for better efficacy and to prevent the waste of over-using. Injector systems on power washer and foaming guns works at a ratio of dilution and this ratio must be calculated to prepare the stock solution. This workshop will allow understanding and calculating properly.

Cleaning and disinfection is an investment in animal health. It can lower costs of medication and allow obtaining better growing results. If these steps are done correctly, the benefits will overcome the work needed to prepare the barn.

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What Are The Key Performance Indicators of the Future?

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INTRODUCTION

Swine Management Services, LLC (SMS) over the last few years has developed a Farm Benchmarking data base which has grown to 800+ farms with 1.41+ million sows. Farms range in size from 200 to 10,000+ sows with most being independent pork producers. We get data from 24+ different record programs and 16+ different Genetic companies represented. Tables 1 and 2 are summaries of data ending 2012. It is very interesting to us to see the variation in production levels from farms with range of <15 to 30+ pigs weaned per mated female per year with 16 farms at 30+ pigs the last 52 weeks. We have been tracking production numbers since 2005 with the pigs weaned per mated female per year average going from 21.28 to 24.31 pigs for a +3.03 pigs, and with the Top 10% going from 24.72 to 28.60 pigs. Pigs weaned per female weaned from 9.17 to 10.55 pigs with Top 10% weaning 11.77 pigs.

Table 1. SMS performance data 52 weeks average-2012 summary.

	Top 10%	Top 25%	All Farms	Bottom 25%
Number of farms	78	196	788	197
Pigs weaned / mf / yr	29.6	28.2	24.8	21.2
Litters / mated female / yr	2.50	2.47	2.37	2.23
Wean to 1st service interval	5.52	5.85	6.73	7.60
Percent served by day 7, %	91.3	91.0	88.6	85.9
Percent repeat services, %	3.90	5.00	7.90	11.00
Farrowing rate, %	91.1	88.8	85.0	79.8
Female Death Loss, %	5.40	6.30	7.50	8.30
Replacement Rate, %	52.1	51.7	54.5	63.7

What are some of the Key Indicators that Drive Increase Pigs Weaned per Mated Female per Year?

The dash board from the SMS Farm Benchmarking data base (Figure 1) shows the Key Indicators we look at to improve Pigs Weaned per Mated Female per Year: Litters / Mated Females / Year, Wean to 1st Service Interval, Pigs Weaned / Female Farrowed, Female Death Loss, Farrowing Rate, Total Born / Female Farrowed, and Piglet Survival. I would like to make some comments on some of these indicators.

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Table 2. SMS performance data 52 weeks average-2012 summary.

	Top 10%	Top 25%	All Farms	Bottom 25%
Total pigs born / female farrow	14.46	14.26	13.42	12.66
Pigs born live / female farrow	13.24	12.98	12.13	11.28
Pigs weaned / female farrow	11.77	11.38	10.55	9.67
Piglet survival, %	82.5	81.4	79.8	77.6
Stillborn, %	6.30	6.50	7.00	7.80
Pre-weaning Mortality, %	11.2	12.1	13.8	14.5
Average gestation length	115.7	115.8	115.8	115.7
Average age at weaning	19.14	19.24	20.12	20.48
Average parity	2.61	2.70	2.67	2.60
Average Parity of Cull Female	4.37	4.33	4.22	3.75

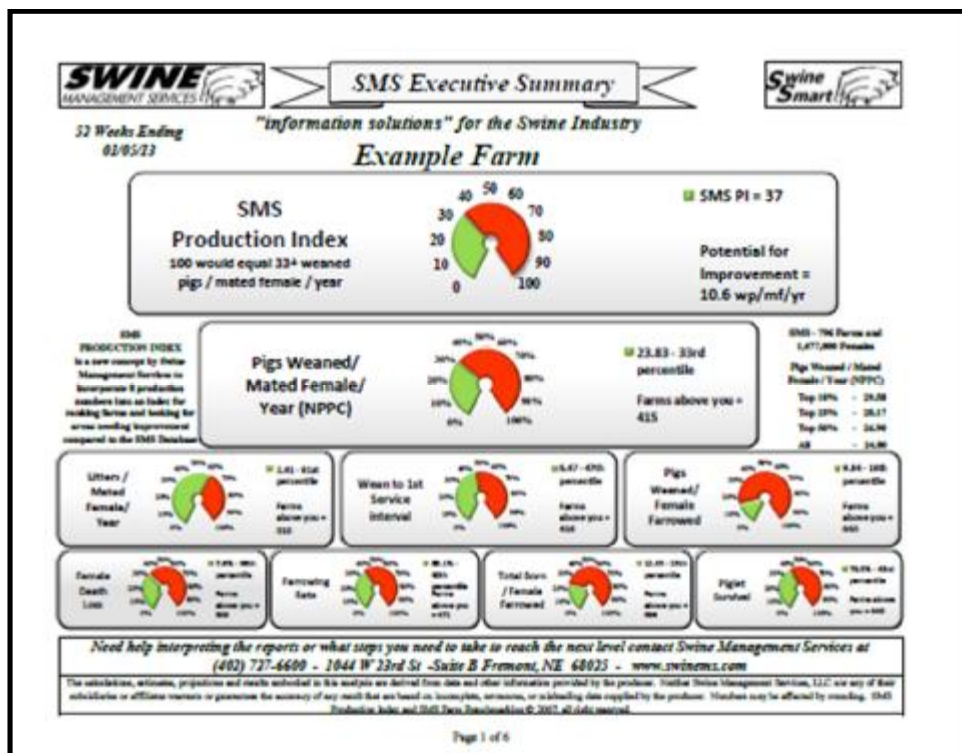


Figure 1. SMS Farm Benchmarking database dash board.

Litters per Mated Female per Year

Litters / mated female / year have a biological top of 2.60 litters. Assume farrowing rate at 100%, 116 days of gestation, + 19 days of lactation + 5 days wean to 1st service = 140 days divided into 365 days = 2.60 litters. This means there are no repeats and cull sows are removed from records at weaning day. In Table 1 the average is at 2.37 litters with Top 10% at 2.50 and

Bottom 25% at 2.23 litters. The key numbers that affect this number are farrowing rate, weaning age, wean to 1st service interval, and farrowing interval.

Suggestions on how to improve litters / mated female / year:

- review breeding procedures to improve farrowing rate
- start heat checking 14 days after breeding
- improve heat and pregnancy checking to find 60+% of returns by day 25 of gestation
- consider a visual pregnancy check day 70-80 of gestation to find more the late returns sooner

Wean to 1st Service Interval

In Table 3 is data from 602 farms that wean over 20 pigs per mated female. The farms are sorted by **wean to 1st service interval**. As you see in the Table, the lower wean to 1st service interval influenced pigs weaned per mated female, percent bred by day 7, percent repeats, farrowing rate and total pigs born. The trend line for the SMS data base has been a drop in average days for weaned sows to cycle starting in early 2011. We feel this is probably due to more farms increasing feed intake in lactation with more farms going to automated feed drop systems or feeding females more times per day.

Table 3. 602 Farms over 20 pigs weaned / mated female / Year – ranked by wean to 1st Service interval

	Top 10%	Top 25%	Top 50%	Total Farms	Bottom 50%	Bottom 25%	Bottom 10%
Wean to 1st Service Interval	5.2	5.5	5.9	6.9	7.9	8.8	10.1
Pigs Weaned/ Mated Female/ Year	25.9	25.5	25.2	24.5	23.8	23.7	23.5
Bred by 7 Days, %	93.6	92.5	90.3	85.9	81.8	78.7	75.0
Repeat Services, %	6.8	6.6	7.4	8.0	8.5	8.6	9.5
Farrowing Rate, %	85.7	86.1	85.4	85.1	84.8	85.3	84.6
Total Born	13.5	13.3	13.2	13.1	12.97	13	12.95
Piglet Survival, %	79.9	80.1	80.2	79.8	79.5	79.0	79.4
Weaning Age	19.8	19.9	19.7	19.8	19.9	19.9	19.8

Suggestions for lowering wean to 1st service interval:

- feed sows more aggressive in farrowing starting day one of farrowing
- feed sows as individual with feed hopper or reservoir in farrowing
- feed weaned sows extra feed from weaning until bred (flushing)
- start daily boar exposure the day sows are weaned
- start heat checking sows the day after weaning and breed sows in heat, do not skip

Farrowing Rate %

Farrowing rate is a three part variable **Female X Semen X Breeder (AI Technician)**. If each variable is at 90% the farrowing rate will be about 73%. If you improve farrowing rate by 4% production will improve by about 1.35 pigs per sow per year. In Table 4 a set of 603 farms that were sorted by farrowing rate to see if farrowing rate is a key indicator. You see farms with farrowing rate at 90+% weaned 26.10 pigs per mated female per year versus <75% at 20.40 pigs. The trend lines for improvement in farrowing rate for all farms was 5.4% starting in 2005 at 79.7% and going to 85.1% in 2012. The Top 10% farms had farrowing rate in 2012 at 90.4%.

Table 4: Farms sorted by farrowing rate (%).

	>90	85-90	80-85	75-80	<75
Mated Female Non-productive Days	29.3	36.4	44.1	55.6	64.3
Average Farrowing Rate, %	91.60	87.20	82.50	77.80	73.00
Repeat Services, %	3.50	6.30	9.40	12.80	17.30
Pigs Weaned / Mated Female / Year	26.1	24.96	23.14	21.06	20.4
Litter / Mated Female / Year	2.48	2.42	2.35	2.26	2.19
Litter / Crate / Year	14.8	14.4	14.3	13.8	12.9
Pigs Weaned / Crate / Year	155.4	147.0	140.9	128.3	120.4

Suggestions on what should be done to improve performance of Breeder (AI Technician):

- provide training and oversight/supervision
- take planned breaks to prevent fatigue
- record all mating information by AI technician including time of day (01-24 military time), and semen batch number
- fine tune breeding procedures for each farm based on records broken down by number of services and matings, wean to 1st service interval, parity, day of week and hour breeding and semen batch number

Suggestions on what needs to be done to influence semen quality:

- at semen delivery record batch information for evaluation later
- using temperature gun to check temperature of semen bags on outside and inside of bag for differences in temperature
- record daily Hi/Low temperatures of semen cooler for monitoring fluctuation in temperature which should be less than 2-3 degrees in 24 hours
- temperature setting for semen storage cooler temperature based on extender being used by semen provider
- rotate semen at least once per day
- arrange storage of semen by delivery date so older semen is used up first
- place semen storage unit in an air conditioned room at about 70 degrees F in hot weather and keep warm in winter

Total Born per Female Farrowed

Trend lines for the last 8 years for total pigs born for an average farm was from 11.70 to 13.37 pigs with a gain of 1.67 pigs with Top 10% farms went from 12.41 to 14.47 pigs for 2.06 more pigs. A most influential number is total born for first litter gilts. The first litter total born for gilts sets the potential for life time production. So to get P1 female off to a good start replacement gilts need to have at least 1 recorded skip heat before breeding and if possible spent at least 14+ days in gestation crate pre-breeding. In farms we work with we see gilts with at least 1 skip heat having 0.20 to 1.0+ more pigs on their first litter.

Suggestions on how to increase total pigs born:

- genetics: using F1 females
- gilts development: skip heats, crate exposure, 300+ pounds
- increase feed intake in lactation
- increase feed intake from weaning till breeding (+2.0 lb. per day)
- lower wean to 1st service interval
- more stimulation at breeding of female by Breeders (AI technicians)

Piglet Survival

At SMS we created a new formula a few years ago to more accurately measure piglet survival in farrowing. Instead of looking at stillborns % and pre-weaning death loss % separate, we combined them with a formula of $100\% - (\text{stillborn \%} + \text{pre-weaning death loss \%}) = \text{Piglet survival}$. We look at stillborn and pigs that die as potential live born pigs. There are farms for a 52 weeks period at <67% with a few farms now at 90+%. In **Table 5** you see the farms at 30+ pigs figured out the extra pigs are in the farrowing area they just needed to figure out how to save them with stillborns at 4.50% and pre-weaning mortality at 7.30% putting them at 88.2%. For the last 8 years the SMS data base showed piglet survival percent peaked in 2007 at ALL at 80.2% and Top 10% at 84.5%. Since then as total born has improved piglet survival has declined some and has been flat the last few years with average in 2012 at 79.9% and Top 10% at 82.0%.

Suggestions on what you can do to improve piglet survival:

- extend farrowing hours to address stillborns (having someone attending sows farrowing for 18 hours per day (5am to 10pm) will allow them to attend 87.9% of the farrowings
- reduce chilling of pigs by towel drying or coating with drying agents at birth. Normal rectal temperature of pigs at 102+ F at birth, pigs that are not dried within 5-10 minutes loose 4+ degrees of body heat and will take 90+ minutes to get up to normal body temperature.
- define the JOB responsibility for day 1 person
- split suckle pigs first day of life
- plan for managing fall back pigs days 2-8
- euthanizing small pigs <1.50 pounds
- CO2 chamber for euthanizing pigs in farrowing
- promoting "People Save Pigs".

Female Death Loss

In the SMS data base 2012 sow death loss at an average of 7.5% with Top 10% farms at 5.4% and the Bottom 25% farms at 8.3%. We sometimes do not see the effect of female

death loss on production numbers. A change of 1% in female death loss can influence pigs per sow per year by 0.25 pigs. So lowering female death loss by 4% equals 1.0 more pigs per sow per year. We like to suggest you look at female death loss by parity to see where the deaths are coming from. You may be surprised to see a very high percent are your younger parity females.

Table 5: SMS performance data 52 weeks from 493 farms-2012 summary of farms with minimum of 20 pigs weaned per mated female.

		>=28 to <30	>=26 to <28	>=24 to <26	>=22 to <24	>=20 to <22	Total / Ave.
No. Farm	13	61	104	164	117	34	493
Pigs weaned/ mated female/ year	31.26	28.68	26.79	24.96	23.13	21.32	25.4
Total Born/ Mated Female	36.26	35.22	33.88	31.79	29.20	27.22	25.40
Piglet Survival %	88.2	82.7	80.8	80.2	80.8	79.9	81.0
Stillborn, %	4.50	6.30	6.90	6.80	7.20	7.30	7.00
Pre-weaning Mortality %	7.30	11.00	12.30	13.00	12.00	12.80	12.00

Suggestions on what you can do to lower female death loss:

- improve training of crew on how to spot sick or lame females
- have written SOPs for how to handle and treat sick and lame females
- have your farm veterinary provide a list of what antibiotics to treat sick females with and stated withdraw times
- record detailed information on each treated female and keep for 12 months (PQA Plus)
- have someone accountable for treatment records and doing the euthanizing of problem females

CONCLUSIONS

In conclusion, how well is your farm doing compared to the SMS database? What key indicators do you need to work on? Can you and your staff make some changes that may be out of your comfort zone? If you improve pigs weaned/mated female/year by 1 pig per sow you can lower your cost to raise a weaned pig by \$1.60 per pig.

Pioneering New Performance Indicators
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Over the last decade, significant advances have been made in sow productivity around the world. We are also starting to learn and realise differences in Sireline fertility.

Academic papers, commercial benchmarks, genetic trends and other industry statistics point to the same fact – our breeding herds are becoming more prolific, productive and in many cases more efficient. And although there are many ways to measure sow productivity, my experience has been that most farm production service visits will be focused on five key performance indicators (KPIs) when benchmarking and measuring improvement over time:

1. Farrowing rate
2. Total born and born alive
3. Pigs weaned per sow
4. Piglet survivability
5. Pigs weaned per mated female per year (PWMFY).

Listed below is a combination of most common and “new” KPIs for your review. I sincerely would like to ask that you put aside your scepticism and open your mind to take some time to review and compare what some of your neighbours are looking at and the performance their herds are achieving.

- Total Born (TB) = 14+
- Born Alive=13+
- Weaning over 11.5+ pigs per litter
- Farrowing rate over 90+%
- Wean to Service Interval – 5.5 days
- % sows bred by 7 days 95%
- % litters less than 7 TB = 3-5%
- 50% of young sows P1,P2,P3 weaning 12,13
- % of all sows weaning more than 12 pigs = 35+%
- Pigs weaned sow lifetime = 55+
- Total pigs weaned before P4=33-36

Over the last few years I have been very fortunate to work with some of the best producers and pork production systems in the industry. Being the best is usually the result of challenging the status quo and doing things differently, so working with the best has provided me with a great opportunity to learn, take me out of my own comfort zone and develop new ways of thinking.

Some questions that have come out of meetings with these top producers include:

1. Why is there so much litter size variability from my most productive sows?
2. Why are some of my sows weaning 12, 13, 14 piglets and others are not? Review Table 3 for an explanation.
3. Is our breeding timing off?
4. Are we missing heats?
5. What is the impact of Boar Fertility on litter size and litter size variability?
6. Are sows coming to heat after weaning sooner than “normal”?
7. Where can we focus, cost-wise, to produce pig more efficiently?

Before wrapping our minds around answering these questions and developing action plans in pursuit of new goals, it is essential that we are able to track the results of any changes we implement and for this some new KPIs can be very useful tools. In this short summary I would like to zoom in to two KPIs that I see as “NEW, different and unique”. Most pig production software programs on the market today will report:

- % Litters less than 7 Total Born
- % Sows weaning more than 12 pigs.

What does Chart 1 demonstrate?

Chart 1 represents a 2500 sow unit’s last 24 month-by-month averages, total born and % of litters with less than 7 total born. Months 23 and 24 are showing particularly interesting trends.

Percentage of litters with less than 7 total born – several farms are reporting observations that there are certain Sirelines that are capable of producing more piglets than others. Research at the University of Alberta (J. Patterson et al.) have demonstrated in recent North American trials that there are significant differences in boar fertility.

Could you imagine how happy farrowing people would be if every sow would farrow with minimal variability of piglets born (some of the best producers are reporting less than 7 total born at 2-3% per 100 litters farrowed).

What does this mean?. From practical point of view it means:

- Less fostering
- Less disease cross-contamination
- Less litter growth disruption
- Less labour (hours per sow farrowed) to get litters started.
- More healthier and heavier piglets at weaning

What does Chart 2 demonstrate?

Chart 2 demonstrates the sows’ ability to wean piglets based on their udder capacity.

As we continue to challenge sows to wean more piglets the goal should be to pay close attention at selection time to ensure we have only the best gilt delivered to the gilt development unit.

Farmer et al. (2012) clearly demonstrated that teats that were suckled in first lactation produce more milk and have a greater development in the second lactation than non-suckled teats. In other words, better mammary stimulation and development on the first and second lactations mean the better will be sows ability to wean large uniform litters.

Chart 1. Month by month averages for total born and % of litters < 7 total born (TB), for a 2500 sow unit.

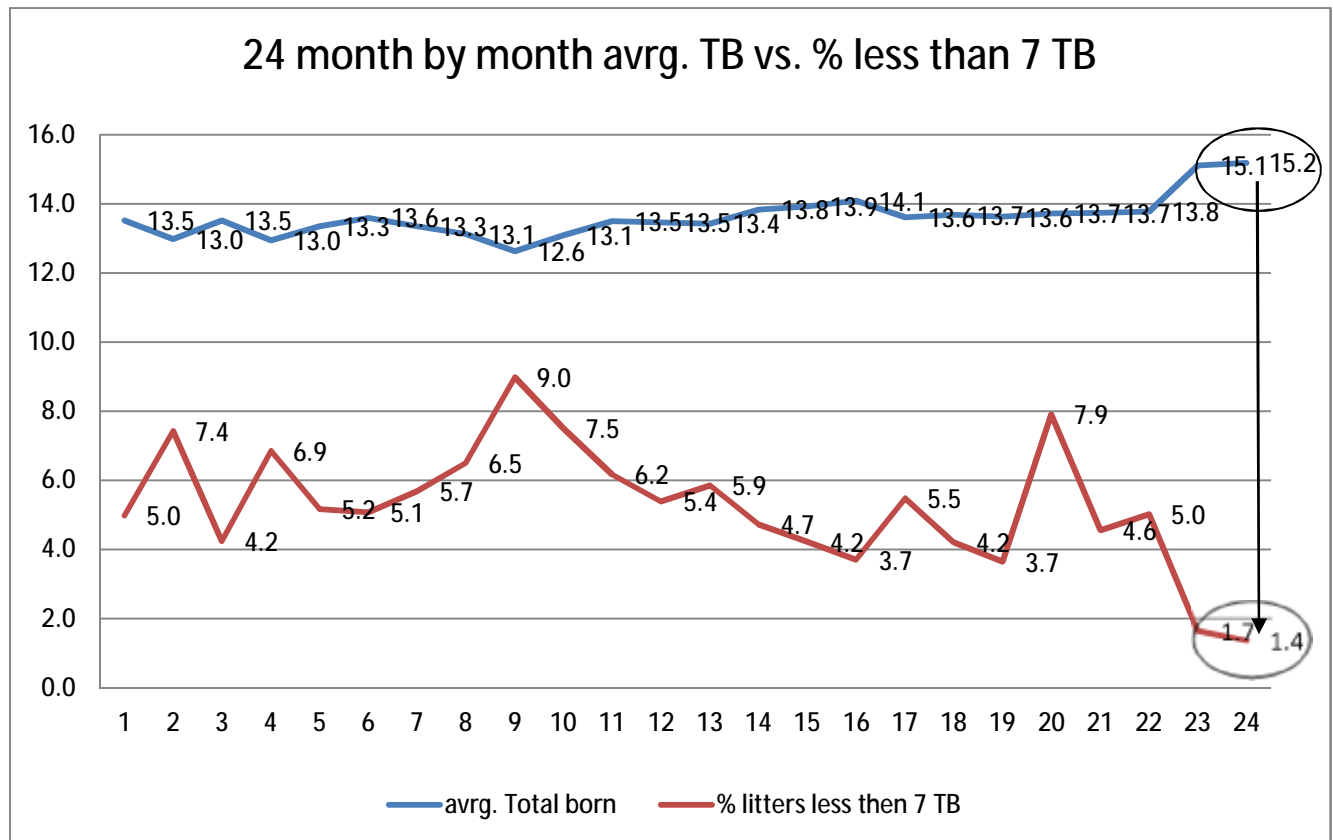
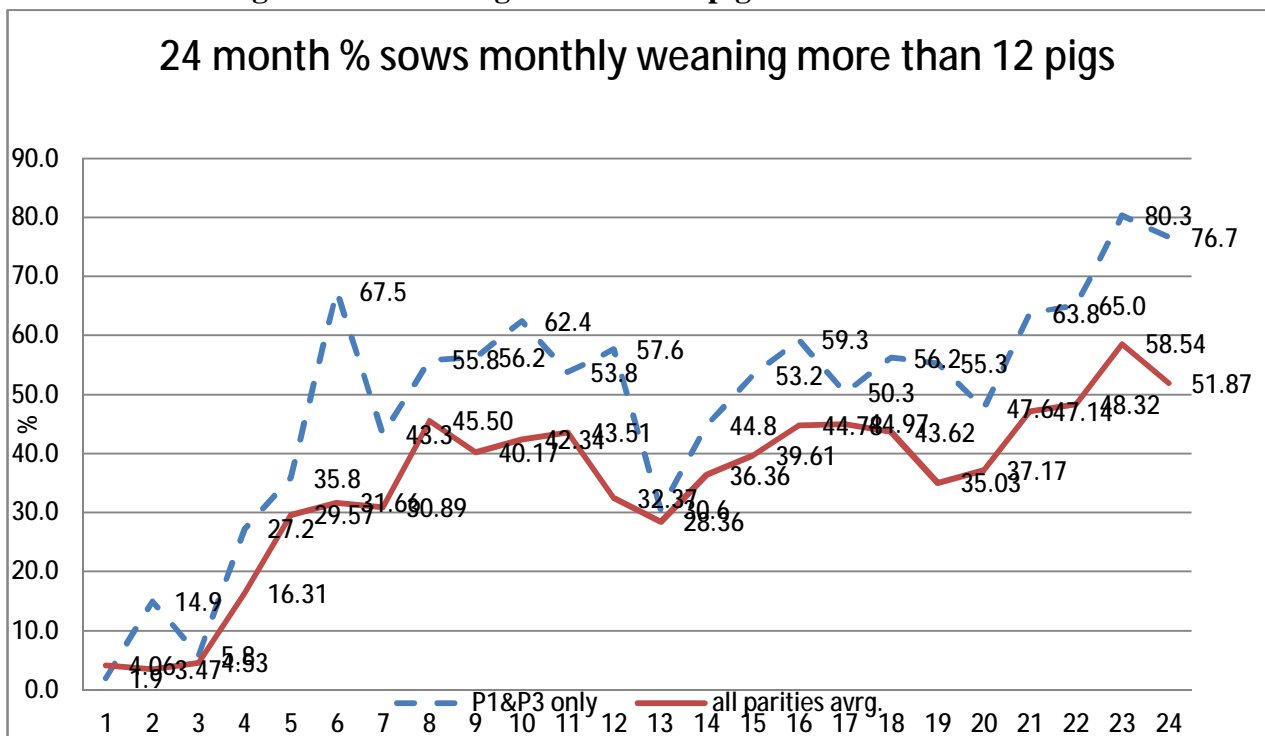


Chart 2. Percentage of sows weaning more than 12 pigs.



What does Chart 3 demonstrate?

Chart 3 demonstrates the feed cost per piglet weaned. What is clear is that feed cost decreases if sows are capable of weaning more piglets.

Assuming \$0.40 per kg lactation feed cost and 6.7 kg daily consumption X 21 lactation days=\$56.

The difference in this example is \$1.56 per piglet weaned (Table 1).

Chart 3. Feed cost per piglet weaned.

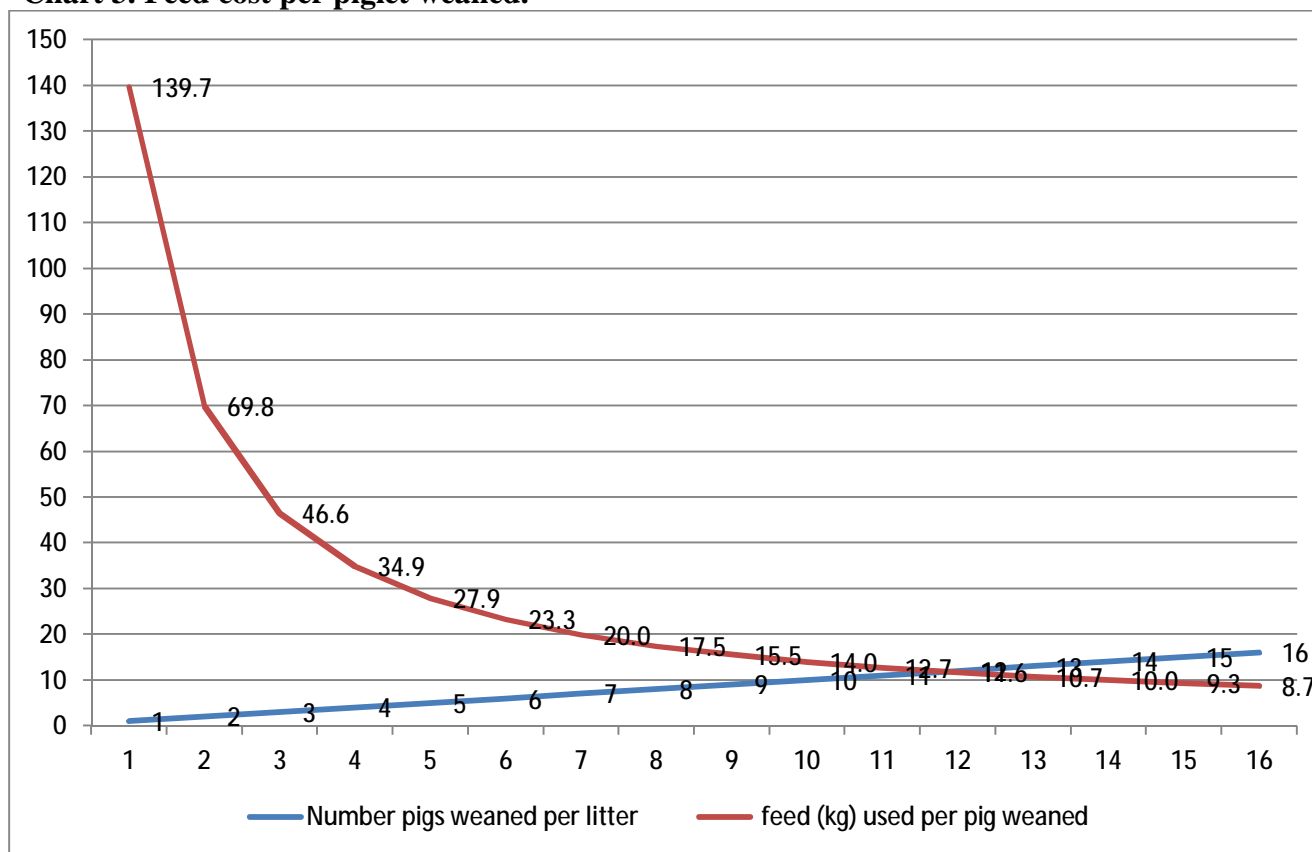


Table 1. Feed cost per pig weaned at different litter sizes.

Pigs weaned	Feed used	Cost per pig weaned
9	15.5	\$6.20
12	11.6	\$4.64

CONCLUSIONS

As the industry continues to operate under the pressure of higher input costs, the challenge upon on everyone is to do more with less. We are all aware of feed cost trends and one way to offset increased (isoweane piglet) cost of production is to wean more quality pigs with fewer sows. We can see that these difficult market conditions are making us think differently (cost vs. production interaction serves as a base for discussions) and it is motivating to be part of brainstorming

sessions at the kitchen table of some of the very best industry minds, where new business and management ideas are discovered.

I would like to take opportunity to thank all producers that I had the opportunity to work with in discussing and learning about NEW KPIs, implementing them, and extracting performance evaluations once management practices surrounding those KPIs were executed. I also know that those that work on those new management techniques are satisfied with their accomplishments.

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“At some point in life the world surrounding us breaks everyone, and afterward, some are stronger at the broken places.”
-Ernest Hemingway

Repeatability of Litter Size in the Sow Population

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INTRODUCTION

In livestock species lifetime productivity and health may be limited by key events occurring during fetal development and the early postnatal period. Prenatal programming, an important area of animal research, is a biological process in which an adverse event such as maternal stress, malnutrition, uterine overcrowding or placental inefficiency occurs at a critical period of fetal development and results in fetal growth retardation and potential lifelong changes in the performance and health of the offspring. It is common to all mammalian species, and in humans implicates the fetal origin of adult-onset diseases (Harding et al., 2011).

A phenotypic trait is controlled by the genetic make-up of the organism and arises from environmental pressure and the complex interactions of component traits (Knol et al., 2010). Average litter birth weight in sows is a phenotypic trait and arises from interactions between ovulation rate, the dynamics of embryonic and fetal survival (factors that determine litter size) and placental function and uterine capacity (factors that affect prenatal development) (Figure 1).

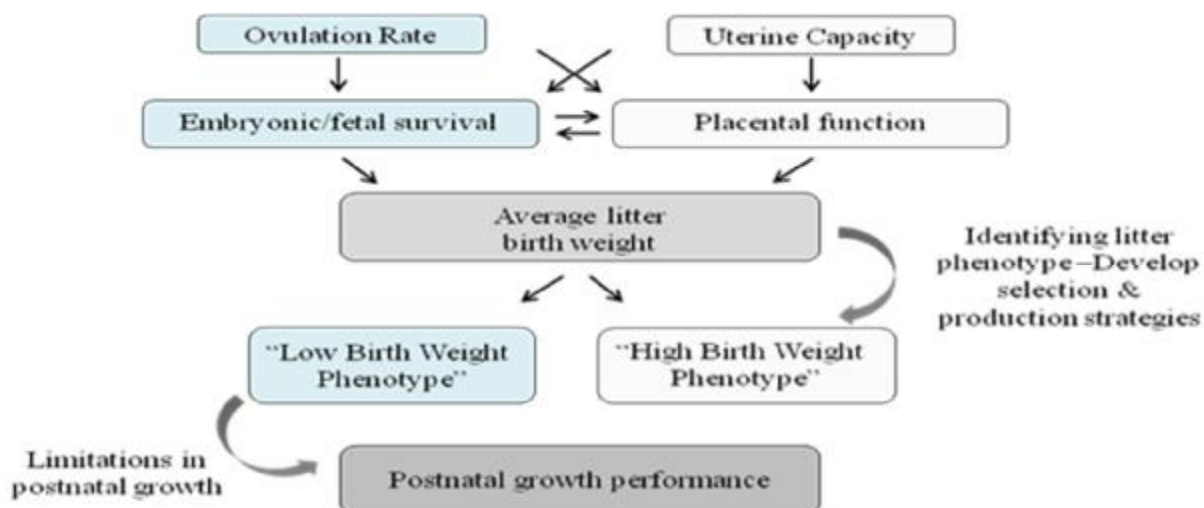


Figure 1. A schematic diagram that illustrates the effect of complex interactions between components traits on average litter birth weight (ALBW) and subsequently postnatal growth performance.

Knol et al. (2010) reported that the “low birth weight phenotype” is most often seen in dam-lines that have been aggressively elected to increase litter size born. The consequences of the “low birth weight phenotype” have adverse effects on post-natal development, increased pre-weaning morality, reduced survivability, reduced growth rates and feed efficiency, increased variation in market weight pigs (Smit, 2007) (Figure 1). Sows with low litter weights and high litter size at birth are often most susceptible to exhibit the “low” phenotype (Foxcroft, 2012).

Recent studies confirm that an overall negative relationship exists between litter size and average litter birth weight (ALBW) (Figure 2a). Within litter size, even greater variation exists in ALBW between litters, allowing for sows to be classified as exhibiting the “high” or “low” BW phenotype. Furthermore, in different sow populations, litter birth weight phenotype has been shown to be repeatability over successive parities (Knol *et al.*, 2010; Smit 2007). Sows can be identified that consistently over several parities, exhibit the “high” or “low” phenotype repeatedly. Foxcroft (2012) suggests the concept that exaggerated ovulation rates, particularly in higher parity sows (Figure 2b and c), drive crowding of embryos *in utero* in early gestation and thus set up the programming of a low birth weight litter phenotype. The “low” birth weight litters have been shown to produce significantly fewer pigs born alive, more pigs born dead, fewer pigs surviving to weaning, compared to ‘high’ average birth weight litters (Foxcroft *et al.*, 2013).

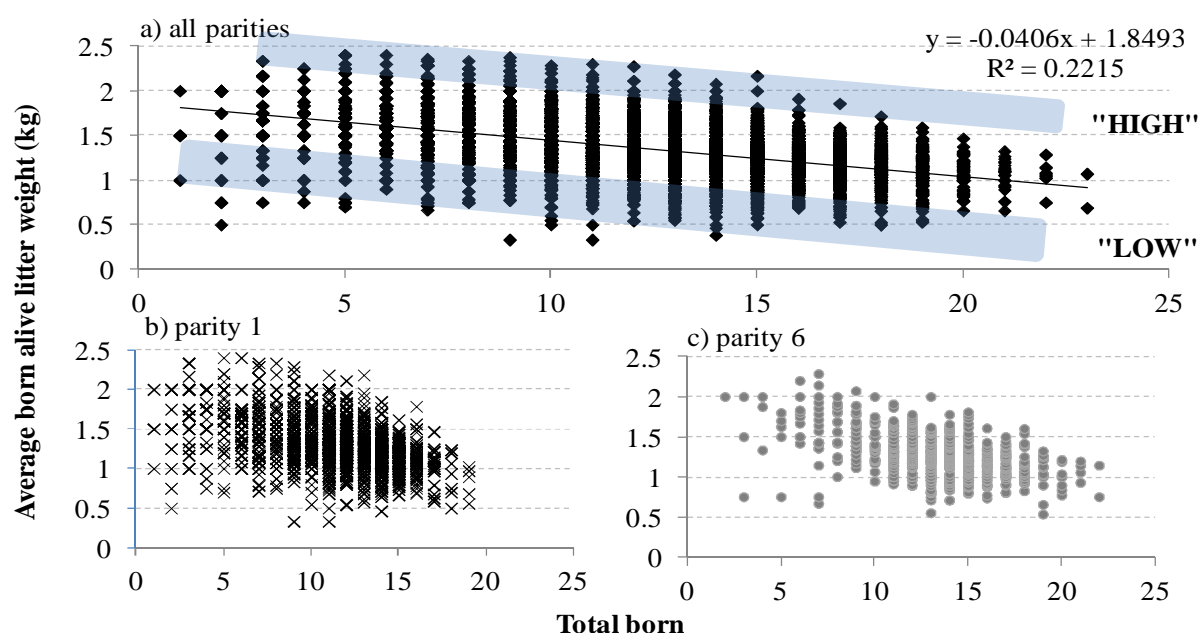


Figure 2. Relationship between total born and average born alive weight for a) all parities (highlighted bars indicated the extreme high and low birth weight phenotypes), b) parity 1 and c) parity 6 females.

The economic impact these low birth weight litters is a major concern for the pork industry. As reviewed by Foxcroft *et al.* (2013), potential management strategies may include 1) segregating mature sows into farrowing rooms based on expected birth weight phenotype, 2) segregating different birth-weight litters into different nursery/grow-finish flows, 3) adjusting nutrient requirements to reflect expected lean growth potential, 4) targeted nutritional intervention of sows with the low-repeating phenotype, and/or 5) where possible, earlier culling of sows delivering repeated low birth weight litters. The ability to most effectively apply these management strategies relies on the concept that litter birth weight phenotype is repeatable.

This paper examines the feasibility of identifying sows that repeatedly exhibit the “low” birth weight phenotype in a large sow population. Identification of these sows would allow for implementation of previously mentioned segregated management strategies to help offset these negative traits and help fine tune culling strategies on farm.

IDENTIFICATION OF PHENOTYPE

A dataset containing 8012 individual parity records, from 1960 multiparous sows (parity ≤ 10) over 6 years (2006-2011) was obtained from a 1,200 sow production nucleus/multiplier facility in Saskatchewan. To classify sow birth weight phenotype, the average litter birth weight for individual litters was compared to the population mean while controlling for parity and liveborn litter size. The difference between these two values was converted to a standard deviation score (Z-score), and termed as ‘high’ (HBW) or ‘low’ (LBW) if above or below the population mean respectively (Figure 3). *Note: A Z-Score is a statistical measure, which tells us how a single data point (in this case, average litter birth weight from a single parity) compares to normal data. It is an important measure not only because it shows whether the point was above or below average, but how unusual the measurement is.*

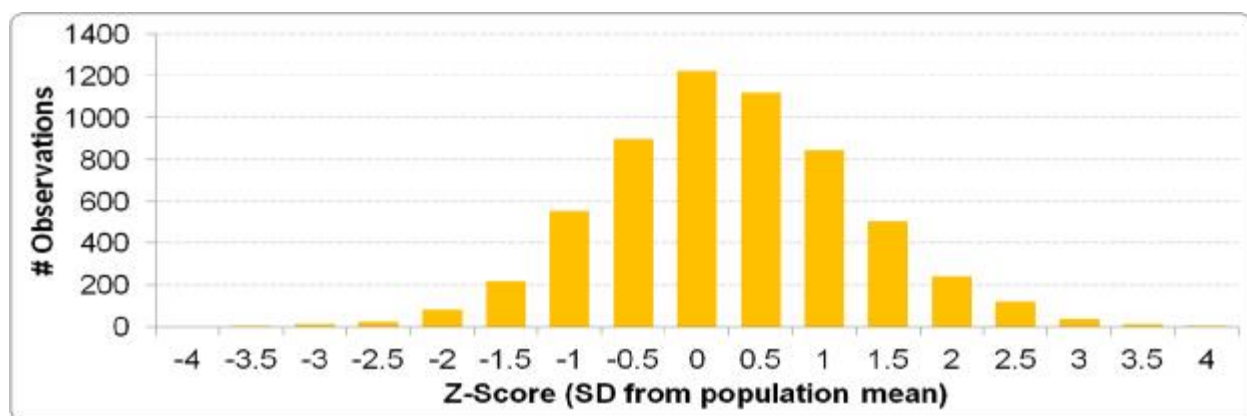


Figure 3. Calculated Z-Score for each parity record.

How closely Z-scores are related between parity records for individual females (Pearson correlation coefficients) are shown in Table 1. The z-score at parity 1 (P1) is positively correlated with z-score at parity 2 (P2) ($r = 0.33$), and the correlation between P1 Z-score and subsequent parities becomes weaker within increasing parity (P3-6). The lack of association between P1 and subsequent parities is likely due to uncontrolled factors in gilts at mating such as selection rate, body weight, physiological age and immunity level to name a few (Patterson et al., 2011). For this reason, any management decision related to the low weight phenotype should not include parity one females.

Between each parity record the overall correlation is significant and positive, but not necessarily considered biologically strong (a correlation of 0 means two variables are not related at all, a correlation of 1 means they are perfectly correlated) (Table 1). In most situations, the highest correlations noted are between subsequent parities and become stronger in more mature sows. This is consistent as to that expected, as the more mature “prolific” sows are most susceptible to exhibit the “low” birth weight phenotype in older parities (Knol et al., 2010; Foxcroft et al., 2007). It is the increasing ovulation rates in mature sows combined with higher levels of uterine crowding (Patterson et al., 2008) that may contribute to the time the low litter weight phenotype is fully expressed.

Table 1. Pearson correlation coefficients (r) between parity records for average born alive litter weight.

Parity	Value	Parity					
		1	2	3	4	5	6
1	R	1	0.330	0.287	0.275	0.202	0.225
	P-Value		<.0001	<.0001	<.0001	<.0001	<.0001
	N	2165	1716	1459	1225	947	673
2	R		1	0.383	0.377	0.399	0.350
	P-Value			<.0001	<.0001	<.0001	<.0001
	N		1738	1459	1229	949	677
3	R			1	0.409	0.409	0.393
	P-Value				<.0001	<.0001	<.0001
	N			1478	1226	946	673
4	R				1	0.414	0.417
	P-Value					<.0001	<.0001
	N				1242	953	678
5	R					1	0.389
	P-Value						<.0001
	N					961	675

PREDICTING LITTER PHENOTYPE

The probability of a sow delivering below average birth weight litters based on the sow's past performance over 1, 2 or 3 parities is predictable phenomenon. As shown in Table 2, if a sow delivered "low" in P2, the probability she delivered a below average BW P3 litter was 0.62 (Table 2). Recall that there is a 0.5 probability due to chance alone (similar to flipping a coin). If the same sow delivered 2 consecutive "low" litters (P2 and P3) she was far more likely to deliver a below average BW litter in her 4th parity (probability=0.73) (Table 2). A P4 sow that has delivered 3 consecutive "low" BW litters (P2, P3 and P4) is very likely to produce another above average BW litter in P5 (probability = 0.84) (Table 2). Approximately 14.5% of all females that farrowed 6 parities were classified as low in every parity.

Predicting above average litter weights is also possible based on past performance (Table 3). If a sow delivers "high" in P2, the probability that she will deliver an above average BW litter in P3 is 0.63 (a slight increase over chance alone). If this same sow delivers "high" in both P2 and P3, the probability of delivering "high" in P4 only increases to 0.72 (Table 3). Parity 4 sows that have delivered any 2 of 3 litters "high" will have a slightly higher probability (0.50-0.54) of delivering an above average BW litter in P5 (Table 3). Importantly, a P4 sow that has delivered 3 consecutive "high" BW litters (P2, P3 and P4) is very likely to produce another above average

BW litter in P5 (probability = 0.75) (Table 3). The probability of predictability increases to 0.84 when a sow farrows 4 consecutive parities as “high”.

Table 2. Predicted probabilities of delivering a *below average* birth weight litter in the next parity (shaded grey) based on past performance.

Observed Parity (ies)	Predicted Parity	2	3	4	5	6	Prediction Probability of a <i>below average</i> litter weight
2	3	L	L	-	-	-	0.622
2, 3	4*	L	H	L	-	-	0.509
		L	L	L	-	-	0.729
2, 3, 4	5	L	H	H	L	-	0.380
		L	H	L	L	-	0.593
		L	L	H	L	-	0.623
		L	L	L	L	-	0.837
		L	H	H	H	L	0.263
		L	L	H	H	L	0.318
2,3,4,5	6	L	H	L	H	L	0.489
		L	H	H	L	L	0.510
		L	L	L	H	L	0.544
		L	L	H	L	L	0.565
		L	H	L	L	L	0.736
		L	L	L	L	L	0.791

CONCLUSIONS - USING THIS DATA TO MAKE MANAGEMENT DECISIONS

Although this is a lot of probability data to digest, simple trends become apparent with time. In another words, litter average birth weight is predictable within sows. This can be used as tool to aid the producer making appropriate management decisions during the sow’s productive life.

Firstly, by comparing the probabilities in Tables 2 and 3 (the dark outline around cells), it is apparent that sows producing *below average BW litters* can be most accurately predicted after parity 3. This is when producers can make important management decisions – delaying intervention until after parity 4 does not increase the accuracy of prediction.

Secondly, sows producing *above average BW litters* are most accurately predicted after their 3rd parity, but most accurately in later parities. This may be because uterine capacity could limit the full expression of birth weight in younger parities.

As previously mentioned, possible management strategies may include segregating sows into farrowing rooms based on expected birth weight phenotype, segregating different birth-weight

litters into different nursery/grow-finish flows, adjusting nutrient requirements to reflect expected lean growth potential and/or targeted nutritional intervention of sows with the low-repeating phenotype. Potentially culling of sows may be recommended for those that consistently repeat the low phenotype and litter weights fall greater than 0.8 standard deviations from the population mean.

Table 3. Predicted probabilities of delivering an *above average* birth weight litter in the next parity (shaded grey) based on past performance.

Observed Parity (ies)	Predicted Parity	2	3	4	5	6	Prediction Probability of a <i>ABOVE</i> average litter weight
2	3	H	H	-	-	-	0.625
2, 3	4	H	L	H	-	-	0.502
		H	H	H	-	-	0.723
		H	L	L	H	-	0.295
2, 3, 4*	5	H	L	H	H	-	0.509
		H	H	L	H	-	0.539
		H	H	H	H	-	0.752
		H	L	L	L	H	0.265
		H	H	L	L	H	0.368
2,3,4,5	6	H	L	L	H	H	0.559
		H	L	H	L	H	0.538
		H	H	L	H	H	0.614
		H	H	H	L	H	0.593
		H	L	H	H	H	0.785
		H	H	H	H	H	0.840

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Maximizing Weaning Capacity of Sow and Crate

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Goals

- To utilize all developed teats on sows to produce the most saleable pigs per crate.
- To maximize the weaning capacity of each sow to decrease the cost per piglet.

Why

- Increased feed cost has resulted in a push to decreased feed usage.
- A trend to a higher lactation length has resulting in a farrowing space shortage.
- She wants to work!

Targets

- Gilts with a minimum of 14 well-placed and well-developed teats.
- Nurse the number of sows needed to hit breeding targets. Cull the rest at farrowing.
- 80% of parity 1 litters weaning 12+ pigs.
- 70 % of parity 2 litters weaning 12+ pigs.
- 60% of total litters weaning 12+ pigs.

How

- Think outside of traditional practices.
- Load P1 sows with 15-17 smaller pigs depending on available teats.
- Load P2 sows with 14-15 pigs regardless of what she weaned the previous lactation.
- Load the rest of the sows to their historic weaning average plus one.
- Piglet mortality within the first 24hrs: replace with a piglet born from the same time period.
- Never wean a sow less than 17 days, or a gilt less than 21 days intended for breeding.
- Wean P1 sows at 17-20 days and use as nurse sows for fade outs.
- Use P1 sows as replacement sows for cull sows/poor milkers etc.
 - For example, cull a sow nursing 10 and replace with a P1 that weaned 14 and add 4-5 fade outs.

Observations

- Observant and dedicated staff is crucial.
- Ad-lib feeding system is beneficial to making it work.
- Same pre-wean mortality.
- More uniform loads.
- Reduced Wean to estrus interval
- Reduced feed usage/piglet.

Tables 1 and 2 demonstrates the benefits of maximizing weaning capacity of the parity one sow. The trend illustrates that a P1 will wean 12+ pigs in the first lactation with no negative impact on estrus interval. A sow that is loaded up in first parity has the potential to wean more in the following lactations.

Table 1. Feed usage and inventory data.

	Sept-Dec 2011	Jul-Dec 2012
Total tonnage	945	1260
Avg. sow inventory	2408	2563
Avg. mated inventory	2333	2368
Piglets sold for full value	20207	31982
Feed usage /sow/year	1177	983
Feed allocation /piglet sold	46.7	39.4

Table 2. Production report for 2011-2014.

Farm: KHB
 Period: 3 '1 year', 2011-01-01 through 2013-02-14
 Parity: 1,2,3,4+
 Gline: ALL
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Parity:	1	2	3	4+	TOTAL	
Weaning Performance						
Litters weaned						
2011-01-01 - 2011-12-31	1607	1081	489	2031	5208	
2012-01-01 - 2012-12-31	880	912	1209	2605	5606	
2013-01-01 - 2013-02-14	116	128	53	413	710	
TOTAL	2603	2121	1751	5049	11524	
Pigs weaned/litter weaned						
2011-01-01 - 2011-12-31	9.91	11.40	11.28	8.79	9.91	
2012-01-01 - 2012-12-31	11.72	11.42	11.27	9.98	10.77	
2013-01-01 - 2013-02-14	12.94	12.34	12.40	10.74	11.51	
TOTAL	10.66	11.47	11.30	9.56	10.42	
Sows weaned						
2011-01-01 - 2011-12-31	1616	1094	499	2312	5521	
2012-01-01 - 2012-12-31	823	920	1217	2826	5786	
2013-01-01 - 2013-02-14	102	129	55	480	766	
TOTAL	2541	2143	1771	5618	12073	
Pigs weaned/sow weaned						
2011-01-01 - 2011-12-31	9.82	11.26	11.05	7.72	9.34	
2012-01-01 - 2012-12-31	12.56	11.32	11.19	9.20	10.43	
2013-01-01 - 2013-02-14	13.96	12.15	11.95	9.24	10.55	
TOTAL	10.87	11.34	11.18	8.59	9.94	
Avg weaning age						
2011-01-01 - 2011-12-31	21.54	20.03	19.82	19.66	20.35	
2012-01-01 - 2012-12-31	22.62	20.16	20.29	20.41	20.69	
2013-01-01 - 2013-02-14	22.76	20.52	20.61	20.60	20.95	
TOTAL	21.99	20.12	20.17	20.15	20.56	
Pigs weaned/crate/year						
2011-01-01 - 2011-12-31	37.9	29.3	13.1	42.5	122.9	
2012-01-01 - 2012-12-31	24.5	24.7	32.3	61.7	143.3	
2013-01-01 - 2013-02-14	29.0	30.5	12.7	85.6	157.8	
TOTAL	31.1	27.2	22.2	54.1	134.5	
Wean to estrus interval						
2011-01-01 - 2011-12-31	8.1	6.0	5.7	4.6	6.2	
2012-01-01 - 2012-12-31	5.7	5.4	5.6	4.9	5.3	
2013-01-01 - 2013-02-14	5.8	4.6	6.4	4.2	4.7	
TOTAL	7.2	5.7	5.6	4.7	5.6	
Lactlen						
2011-01-01 - 2011-12-31	21.3	19.8	19.6	17.3	19.2	
2012-01-01 - 2012-12-31	23.7	20.0	20.1	18.8	20.0	
2013-01-01 - 2013-02-14	24.4	20.1	19.9	17.8	19.2	
TOTAL	22.2	19.9	20.0	18.1	19.6	
% Sows weaning 12+ pigs						
2011-01-01 - 2011-12-31	26.61	51.65	55.51	5.84	25.48	
2012-01-01 - 2012-12-31	58.69	51.20	48.81	30.04	41.43	
2013-01-01 - 2013-02-14	85.29	71.32	76.36	38.54	53.00	
TOTAL	39.35	52.64	51.55	20.81	34.87	

Note that pigs weaned is after nursery off sort at delivery and only full value pigs are accounted for.

Day 2: Wean to Finish

Feed, Caloric and Financial Efficiency
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ABSTRACT

Meeting the energy specifications of a typical grower diet represents about 85% of the total cost of that diet and thus more than half of the total cost of pork production. With the cost of dietary energy more than doubling in the past 8 years, the challenge is clear: how to optimize the efficiency with which dietary energy is utilized while also ensuring that overall net income for the farm is maximized. This may mean that energy will be looked upon differently, since maximizing barn throughput may no longer be the most financially advantageous strategy.

There are different sources of energy in the diet, and the efficiency with which each is used depends on where it comes from, and also how it is used. This makes the management of dietary energy much more complex than the nutrients such as amino acids, minerals and vitamins. Dietary energy is used for three purposes: maintenance, lean gain and fat gain. Successful barn management will include strategies to minimize the quantity of energy used for maintenance and for fat gain. To further complicate the picture, fat in the diet can impact the quality and composition of the carcass. Finally, successful management of dietary energy requires an understanding of the pig's response to changes in dietary energy on an individual farm or system basis. It has a very significant impact on the decision making process, as it relates to selecting the concentration of energy in the diet, and because this response varies widely among farms. Opportunities exist to utilize dietary energy more efficiently and effectively, but improvements will not come easily or simply.

INTRODUCTION

Feed represents 55 to 70% of the total cost of pork production. Furthermore, about 85% of the total cost of a diet formulation accrues from simply meeting the energy specification (Gutierrez and Patience, 2012). Thus, meeting the energy specifications for feed represents between 50% and 60% of the total cost of pork production; no other single production budget item comes close. For this reason, any discussion on feed efficiency and financial success must include a very serious consideration of how to best meet the energy needs of the pig.

Before setting guidelines for diet formulation, the objectives of the farm, and the objectives of the feeding program within the farm, must be clearly enunciated. From a dietary energy perspective, one of the most critical questions revolves around the relationship among caloric density of the diet, daily caloric intake by the pig and pig growth rate – which in turns relates to barn throughput.

When diets in Ontario were based on corn and soybean meal and perhaps some added fat, the thrust of the feeding program was getting pigs to market as quickly as possible with an acceptable carcass quality. Faster barn throughput was closely linked with low feed cost and with maximizing net income. Barn throughput was a very high priority for most producers.

However, with rising feed costs, maintaining barn throughput has become increasingly expensive, and net income and barn throughput are less linked to each other than they used to be.

For some farms, throughput remains the highest priority, but for other farms, pig growth rate is being reduced to increase net income.

Table 1. Relative cost of diet components in a complete swine grower diet.

Ingredient	Prices,	Energy	Energy plus	Energy plus amino acids
		only	amino acids	plus vitamins/minerals
	\$/ton	%	%	%
Corn	220	54.93	47.65	47.01
Corn DDGS	190	30.00	25.58	27.68
Wheat midds	200	7.60	5.50	-
Soybean meal	300	-	13.50	14.19
Bakery product	230	7.50	7.50	7.50
L-lysine HCl	2500	-	0.30	0.30
Limestone	50	-	-	1.10
Salt	90	-	-	0.45
Vitamin premix	1750	-	-	0.15
TM premix	1000	-	-	0.12
Phytase	5000	-	-	0.08
A-V fat blend	900	-	-	1.16
Sum		100.00	100.00	100.00
Cost		\$210.24	\$229.58	\$244.00
Relative to total cost		86.2%	94.1%	100.0%

ENERGY IS UNIQUE

Energy is a rather unique component of the diet. While we talk about energy as if it is nutrient, it really is not a nutrient. It is a characteristic of the diet that is provided by 4 different sources: starch, protein, fat and fiber (Figure 1). Functionally, energy is obtained from glucose (starch), amino acids (protein), fatty acids (fat) and volatile fatty acids (fiber). Each is used with a different degree of efficiency and the efficiency with which it is used is dependent on its fate in metabolism. For example, fat is used with much greater efficiency if it is deposited directly in the body than if it is used as a source of energy to drive various metabolic processes (Table 2).

If a nutritionist is studying phosphorus, phosphorus can be measured directly and as a single nutrient. If a nutritionist wants to study lysine, it can be measured directly and as a single nutrient. This is not the case with energy and makes the study of energy particularly challenging. However, the study of energy cannot be ignored because it represents such a large portion of the cost of the diet. This presents a real dilemma and explains, in part, why there are a number of different energy systems in use around the world – and why nutritionists have such strong opinions about which is the best!

Finally, energy is complicated by the fact that its supply in the diet can also influence the quality of the carcass. Certainly, amino acid levels can influence carcass quality, but a specific source of energy – namely the type of fat – can influence the quality of the carcass in terms of processing outcomes and shelf life.

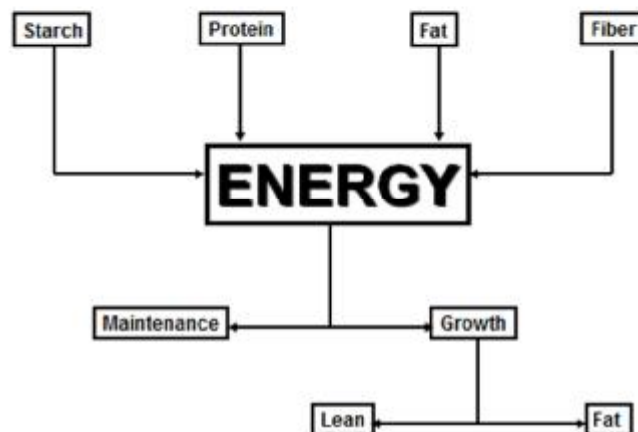


Figure 1. Sources of energy utilized by the pig for growth and maintenance.

Table 2. Marginal energetic efficiency of using digestible nutrients for generating ATP or depositing lipid.

Source	Generating ATP		Depositing Lipid	
	Efficiency	% relative to fatty acids	Efficiency	% relative to fatty acids
Fatty Acids	66	100	90	100
Glucose	68	103	74	82
Amino Acids	58	88	53	59
Crude Fat	50	76	62	69

Source: Black, 1995, as adapted by Birkett and de Lange, 2001a.

THE COST OF DIETARY ENERGY

When diets were simpler, adjusting to rising and falling ingredient prices was quite simple; least cost formulation would adjust the composition of the few ingredients being used to maximize the dollars invested in the diet. While this is still true, the situation has become more complex as we use more ingredients, consciously adjust diet energy content upwards or downwards according to the market and invest heavily in contracting ingredient supplies well into the future.

The problem is illustrated in Table 3, which summarizes the cost of dietary energy supplied by different ingredients. Two time periods are presented: 2005 – before the current run-up in corn prices – and today. Traditionally, we would look at this table horizontally, to see how prices of different ingredients have changed over time. However, we must now also look at this table vertically, to see the changing price relationships among ingredients. For example, in 2005, energy from fat cost about 60% more than energy from corn; today, that differential is only 36%. Energy from DDGS used to cost 41% more than from corn, but today, it is only 16% more. These changing price relationships will influence how much of a given ingredient is likely to be used in a feeding program. This, in turn, will put pressure on upper limits a nutritionist assigns

to certain ingredients and can change purchasing practices, especially if forward booking is employed.

Thus, the net impact of the changing landscape of energy cost can be minimized by considering all aspects of pricing changes, including ingredient cost relationships.

Table 3. The changing cost of dietary energy.

Ingredient	Energy Content Mcal NE/kg ¹	2005 Cost		2013 Cost	
		\$/tonne	¢/Mcal NE	\$/tonne	¢/Mcal NE
Corn	2.67	103	3.86	259	9.70
Soybean meal	2.13	302	14.18	524	24.60
Corn DDGS	2.11	115	5.45	238	11.28
Wheat shorts	2.04	83	4.07	238	11.07
Fat: AV blend	7.24	445	6.15	955	13.18

¹ NE values as presented by NRC (2012); Corn DDGS assumed to contain about 8.5% ether extract (fat).
Ingredient prices gratefully obtained from Matt Ische, KenPal Farm Products Inc., Centralia, ON

THE COST OF MAINTENANCE

Energy is utilized for maintenance, lean gain and fat gain. Maintenance is a very important aspect of energy utilization in the pig, but is often overlooked. Let us consider a typical pig weighing 70 kg and growing 860 g/d, laying down 138 gram of protein per day and eating 2.2 kg/d of a diet containing 3.34 Mcal ME/kg (Patience, 2012; Table 4). We can see that energy used for maintenance represents 34% of the total energy consumed by this pig, a portion that I suspect is much higher than many people realize. The literature presents estimates of maintenance energy that range from about 25% to 35% of total intake (Oresanya et al., 2008).

However, precise estimates of maintenance requirements are difficult to obtain experimentally for a variety of reasons, ranging from difficulties with defining maintenance exactly to differences in maintenance among genotypes and under differing conditions.

A simplified definition of maintenance suggests that any energy consumed by the pig that is not used for lean or fat gain is maintenance. This extends well beyond what was originally intended by those working to define maintenance energy requirements precisely (Birkett and deLange, 2001b; van Milgen and Noblet, 2003); however, it serves a useful purpose in production because it focuses attention on so-called non-productive uses of energy: keeping the pig warm in cold conditions or cool in hot conditions, fighting disease or other stimulation of the immune system, dealing with social stresses, etc. Intuitively, any energy consumed by the pig that is not used for body weight gain represents a loss in efficiency.

While energy diverted to non-growth purposes represents a loss in efficiency, there is another contributor to maintenance cost and that is the cost associated with slow growth and longer days to market. Every additional day that the pig is in the barn represents another day's worth of maintenance, so this maintenance cost is very much under the control of the producer. The challenge, however, is how to manage this cost; it may, in fact, be financially advantageous to feed a less expensive diet and accept the associated slower growth because the overall cost of production is lower. Clearly, the optimum growth rate – or barn turnover – will vary among farms because it is dependent on many factors: cost differential between higher and lower cost

feeding programs, availability of additional growout floor space to accommodate slower barn turnover while still maintaining optimum market weights, etc. In any case, this is the type of calculation that should be undertaken by individual producers to ensure they are optimizing – in financial terms – pig growth rate and barn turnover. The answer could be very different when NE costs 3.9 cents/Mcal versus 9.7 cents/Mcal! Certainly, in the traditional corn belt of the U.S., the trend to lower energy diets is very clear, and is one of the drivers for the construction of new growout facilities.

Table 4. How daily energy intake is partitioned among maintenance, protein gain and lipid gain in a 70 kg pig.

Gain		Partitioning of ME intake	
		Mcal/d	% of total
Maintenance	-	2.52	34
Protein gain	138 g/d (16% of total gain)	1.38	19
Fat gain	294 g/d (34% of total gain)	3.45	47
Total	860 g/d (100% of total gain)	7.35	100

ENERGY USED FOR GAIN

The efficiency with which the pig uses available energy to deposit protein and fat in the body is similar. Protein deposition is slightly more efficient than lipid (10.03 versus 11.65 kcal ME/g deposited; Patience, 2012). However, lean accretion, as distinct from protein gain, is much, much more efficient than fat due to the water associated with lean gain. Lean gain is approximately equal to protein gain X 2.55 (NRC, 1998), explaining the magnitude of this difference.

Pork producers have little if any control over the efficiency with which the pig uses dietary energy for gain, with one major exception: the proportion of gain that is lean relative to fat. With the large difference in energetic efficiency, producing leaner pigs has great economic – as well as market - appeal.

However, leaner pigs may not be more efficient overall if leanness is achieved by slowing pig growth. This explains why the vast majority of the North American industry embraces *ad lib* feeding; the extra time spent in the barn due to reduced growth rate results in increased need for maintenance energy, which is a direct function of time (Gutierrez and Patience, 2012). Unless there is a very large premium being paid for lean carcasses, or a large penalty charged for lean yield falling below a minimum threshold, the advantage in financial returns normally goes to faster growing pigs that achieve lean requirements through genetic selection and proper diet formulation.

ENERGY INTAKE

It is critically important to differentiate between energy concentration in the diet and daily energy intake by the pig. It is generally – but not always – true that increasing dietary energy concentration will increase daily energy intake and decreasing energy concentration in the diet decreases daily energy intake. It is important to acknowledge that under most commercial conditions, this will be true, but it is not always true.

It depends on the capacity of the pig to increase daily feed intake when dietary energy concentration is reduced, in order to maintain constant energy intake. Under most commercial conditions, pigs do not have this capability, because other factors are limiting the pig's ability to increase feed intake. These factors may be health, access to feed, access to water, social stressors, environmental temperature or genetic capacity for feed intake.

The relationship between dietary energy concentration and daily ME intake is illustrated in Table 5. Pigs were offered diets with 5 different levels of ME concentration; as ME was lowered from 3.35 Mcal/kg to 3.15 Mcal/kg, daily energy intake remained largely constant – and growth rate was preserved. However, when dietary energy concentration was further lowered, pigs could not increase daily feed intake further and as a consequence, daily energy intake declined, along with growth rate. Please note that the drop in ADG was not statistically significant (Beaulieu et al., 2009).

Two very important considerations arise from these types of studies. The first is that pigs have a threshold for daily energy intake. Increasing dietary energy concentration above a certain level will result in improved feed efficiency in all cases, but not necessarily increased growth rate. Under commercial conditions, we believe that the majority of pigs are not able to consume sufficient feed to reach this threshold, and as a result, any increase in dietary energy concentration will result in increased daily energy intake, and thus increased growth rate. This may be less true as the pigs approach market weight.

By the same token, under most commercial conditions, lowering dietary energy concentration is likely to reduce daily energy intake and thus growth rate. There are exceptions to this broad generalization; if your farm is one of these exceptions, you have much greater flexibility in adjusting dietary energy concentration than would otherwise be the case, because you have the option of feeding a lower energy diet and maintaining growth rate.

Table 5. Impact of decreasing dietary energy concentration on daily energy intake and growth rate.

Diet ME, Mcal/kg	2.95	3.05	3.15	3.25	3.35
Initial wt., kg	31.2	31.1	31.5	31.2	31.1
Final wt., kg	115.1	115.3	115.1	115.0	115.5
Daily gain, kg	1.00	1.01	1.03	1.03	1.03
Daily feed, kg ¹	2.80	2.66	2.64	2.61	2.47
Feed conversion ¹	2.78	2.63	2.56	2.56	2.38
ME intake, Mcal/d	8.21	8.20	8.38	8.45	8.38

¹ Effect of diet ME concentration significant, $P < 0.05$; Source: Beaulieu et al., 2009

The second consideration is that daily energy intake varies widely among studies. We assume the same situation applies on-farm, and have production data to support this assumption. Some studies have shown daily ME intakes in the range of 7.0 to 7.5 Mcal/d while others have reported intakes as high as 9.0 Mcal/d (De la Llata et al., 2001; Patience et al., 2005). It is therefore very

dangerous to extrapolate data from one set of conditions to another; the response to changes in dietary energy concentration on one farm can be very different from that of a neighbour.

The solution to this problem is clear. Individual farms or systems must develop their own feed intake curves that apply to their farm, and not depend on universal data obtained from some other remote, and possibly very different, location. Dr. de Lange, who will also speak at this conference, has been promoting the benefit of developing farm-specific feed intake curves for at least 20 years (de Lange, personal communication). I hope people have been listening.

ENERGY SOURCE AND CARCASS FAT QUALITY

Both the quantity and composition of dietary fat will have an impact on the quality and composition of fat in the carcass. Fat in the carcass can be derived from what is called “de novo” synthesis or dietary fat can be deposited directly. In the case of the former, the pig synthesizes fat from available components in the circulation such as glucose or amino acids. In this instance, the carcass fat will tend to be firmer and contain more saturated fatty acids.

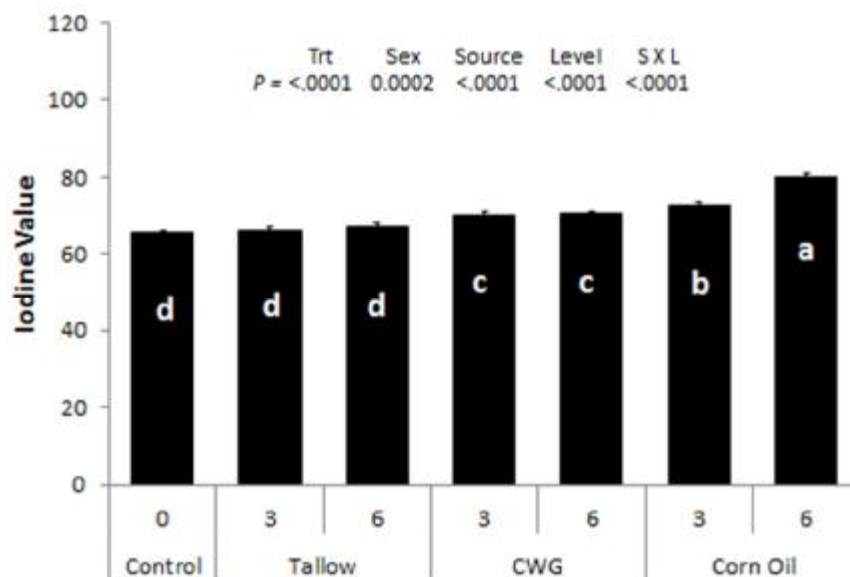


Figure 2. Impact of level of addition and source of dietary fat on iodine value of carcass fat (Kellner et al., 2012).

In the latter instance, the pig is able to direct fatty acids from the diet directly into carcass fat; this occurs when the energy contained in dietary fat is not required for higher priority energy needs. However, even when energy is in short supply, the pig is genetically programmed to deposit a minimum quantity of fat relative to protein; in previous research, we found the minimum fat:protein ratio to be about 1.2 (Patience et al., 2001); this minimum ratio is believed to differ among genotypes. Therefore, carcass fat will reflect dietary fat even when energy is limited. The impact tends to be greater when energy is in generous supply in the diet.

CONCLUSIONS

With the cost of dietary energy rising, increasing attention is being directed at how to manage it more efficiently, with the objective being to maximize net income of the overall farming operation. This may mean that the previous emphasis placed on maximizing growth rate may no longer support the highest level of profit. Sourcing dietary energy is a critical first step in the process, and requires greater analysis than was previously the case. Understanding that energy is the most expensive component of the diet places our commitment to optimizing dietary energy concentration into perspective, relative to other tasks we face in the development of feeding programs and the management of our pig herd. Understanding daily energy intake is crucial to success, as it provides the foundational knowledge required to determine how the pig will respond to changes in diet cost and energy content. Finally, when the diet contains fat, either through the basal ingredients or through the addition of specific fat sources, carcass fat quality and composition may be impacted – either positively or negatively.

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Finally, I would like to acknowledge, with gratitude and pride, my team of graduate students and research staff, without whom this research could not have been completed.

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Why We Should Reduce Antibiotic Usage and Ways To Do It

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ABSTRACT

Antibiotics are vital for the health and wellbeing of both animals and man. The development of resistance to antibiotics is a major concern, and for that reason their use is under increased scrutiny. As is the case in the US and Mexico, the quantity of antibiotics used to raise pigs in Canada is significantly greater than in Denmark, where efforts to reduce their usage have been made for many years. This paper discusses reasons why we should try to reduce antibiotic usage in Canada, and ways that can be used to obtain that result. Strategies abroad found to be successful on a country basis will be summarized, as well as options that individual producers could consider in their own herd.

INTRODUCTION

Since the discovery of penicillin by Sir Alexander Fleming in the 1920s, antibiotics have played an enormous role in man's quest for a better and longer life. Today these products are still extremely important for the well-being of both humans and animals, and for that reason everything that can alter their efficacy is closely scrutinized. Antibiotics are used in swine production with various objectives in mind. This paper will briefly touch on reasons why we should try to limit their usage whenever possible, and on how we can do it.

1. WHY WE SHOULD TRY TO REDUCE ANTIBIOTIC USAGE

For some time now the use of antibiotics in animals, particularly food producing animals, has been a hot topic. The main concern behind these discussions is that if antibiotics are used a lot in animals, veterinary pathogens or commensals may become more resistant to antimicrobials, and if so, could transfer that resistance to human pathogens. Furthermore some organisms carried by pigs have the potential to create problems in humans, and these organisms may be directly transferred to people through manipulation or consumption of meat products. If these strains of organisms are resistant to antibiotics, the treatment of these conditions obviously becomes an issue. The extent to which resistance in human pathogens could be associated with antibiotic usage in animals remains an open question, and the same is true for the impact that restricting access to antibiotics could have on animal health, economic performance and welfare. This being said there seems to be little doubt that pressure to reduce antibiotic usage in animals will grow, and we certainly have had examples of that pressure recently in North America. In March 2012 a poll involving 1000 US residents revealed that 72% of consumers were extremely or very concerned about overuse of antibiotics in animal feed, and 60% were ready to pay five cents or more per lb for meat of animals raised without antibiotics (Moreno, 2012). On April 6, 2012, the US Food and Drug Administration's ban prohibiting the use of cephalosporins at unapproved doses, frequencies, duration or routes of administration, and perhaps more importantly, for disease prevention, became effective (US Food and Drug Administration, 2012). In June 2012 an editorial in the Canadian Medical Association Journal was titled 'Farm-grown superbugs:

While the world acts, Canada dawdles' (Sibbald, 2012). The editorial asked for stricter regulations on antibiotic use in animals in Canada, particularly for classes of antibiotics which are of primary importance in human medicine. But this issue of antibiotic usage and resistance is indeed a global one. In a speech given last year at a conference on antimicrobial resistance in Copenhagen, Dr. Margaret Chan, director-general of the World Health Organisation, stated: "The antimicrobial threat is easy to describe. It has an irrefutable logic. Antimicrobial resistance is on the rise in Europe, and elsewhere in the world. We are losing our first-line antimicrobials. Replacement treatments are more costly, more toxic, need much longer durations of treatment, and may require treatment in intensive care units. For patients infected with some drug-resistant pathogens, mortality has been shown to increase by around 50%." (Chan, 2012). All this suggests that the pressure from the human medical side for tighter controls and reduced usage of antibiotics in animals will increase. This is particularly true when efforts made elsewhere have proven that it was possible to raise animals, including pigs, with less antibiotics.

But the concerns over the potential impact that antibiotic usage in animals may have on human pathogens is only one aspect to consider. Animals also get sick and have to be treated, and for that effective antibiotics are needed. Since it is believed that the introduction of new antibiotic molecules for use in animals is likely to be very limited in the future, we need to make sure that those we have today remain effective on a long term basis. For example, in Quebec resistance of porcine *Escherichia coli* isolates to ceftiofur, one of our last resort drugs, went from close to zero in 1994 to more than 20% in 2011 (MAPAQ, 2012). In Italy, Luppi et al. (2012) reported that none of the *E. coli* strains isolated from swine and tested in 2002 was resistant to more than 10 antibiotics, while it gradually increased to 25.8% of the strains in 2011. In a recent study conducted in Ontario (Park, 2013), 97% of the *Staphylococcus hyicus* (the cause of exudative epidermitis, or greasy pig disease) isolates, were resistant to penicillin G and ampicillin, and 71% to ceftiofur. Not all data sets on antibiotic resistance in swine pathogens are showing that kind of negative progression or picture, but we should all be concerned about the potential danger it represents.

2. WHERE DO CANADA AND NORTH AMERICA STAND?

Before we get into ways that can be used to reduce antibiotic usage, it appears logical to look at where we, in North America, stand. In other words, are we using less, the same or more antibiotics in Canada, the US and Mexico than countries like Denmark for example, where special efforts towards antibiotic usage reduction have been made for many years? At the 2010 International Pig Veterinary Society meeting in Vancouver, Danish authors reported that between 2004 and 2009, the total quantity of antibiotics used in pigs in their country varied between 3.54 to 4.03 gr per pig (Stege, 2010). Because no such data were seemingly available in North America, in the summer of 2011 I tried to compile numbers on antibiotic usage in a few herds or companies in Canada, the US and Mexico that I thought were representative of the North American industry. Since this evaluation involved a very small number of farms and had no scientific pretensions at all, the numbers will not be mentioned here, but they suggested that while not worse than in the US and Mexico, the situation in Canada can be improved. Of course the total quantity of antibiotic used in pigs and other animals is only one parameter to evaluate. The type of antibiotic used is another very important one. As we will see later, chlortetracycline does not have the same relative importance as fluoroquinolones or third and fourth generation cephalosporins. Nevertheless, an important point can already be made at this stage: We need to know how much of the various antibiotics we are using in pig production in Canada. We need

scientifically sound data that will allow us to accurately know where we currently stand. With this in hand not only can we compare ourselves with other countries, but we can also determine if the actions we will eventually take are producing results or not. Putting that aside, let us assume that we can do better, and the rest of this document will look at some of the ways that can be used to reduce antibiotic usage in swine production.

3. WHAT HAVE OTHER COUNTRIES DONE?

A logical approach seems to be looking at what other countries have already done to reduce antibiotic usage in animals, and we will use Denmark and The Netherlands as examples. Efforts to reduce antibiotic usage in animals in Denmark have been the topic of many articles and discussions, some being very positive, others suggesting that their strategy has actually not improved their consumption much over the years. Where does truth actually lie? Figure 1 shows the antimicrobial consumption in Danish pork production from 1992 to 2008. Antimicrobial consumption is defined as the number of milligrams of active compound per kilogram of pig produced (Aarestrup, 2010).

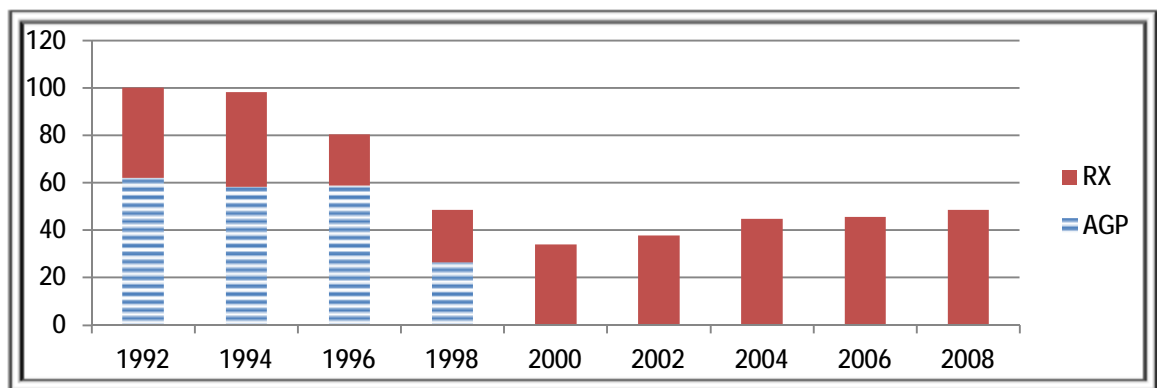


Figure 1. Therapeutic (RX) and growth promotion (AGP) antimicrobial consumption (mg antibiotics per kg of pig) in Danish pigs from 1992 to 2008.

As can be seen, more antibiotics were used for growth promotion than for therapeutic use in 1992. But then various measures were taken to phase out growth promotion use of antimicrobials and in 2000 antimicrobials were not used anymore for that purpose. This did create an increase in the therapeutic use of these products, but the end result is still that by 2008, Danish pig production was using less than 50% of the total they were using in 1992. An international review panel, set up by WHO at the request of the Danish government, concluded that the ban reduced human health risks without significantly harming animal health or farmers' incomes. In fact, Danish government and industry data showed that livestock and poultry production actually increased following the ban, while antibiotic resistance on farms and in meat declined (Chan, 2012). Nevertheless, as the antimicrobial consumption was steadily increasing after 2000, they decided in 2010 to put in place some additional measures to stop and hopefully reverse that trend. Since then, if a producer uses two times or more the average quantity of antimicrobials used by Danish producers, he/she receives a yellow card. The producer then has 9 months, working with his or her herd veterinarian, to correct the situation. If this does not work, another veterinarian gets involved in the farm, and if this still does not produce the desired

results after 5 months, other measures are discussed but not currently implemented. One of the potential measures would be a decrease of animal inventory until antimicrobial consumption goals are met. The yellow card system was initiated in July 2010, and the Danish figures are showing an impressive decrease of 19% in pig antimicrobial consumption in 2011 (News, 2012). While this may not be totally due to the new system, the results are very encouraging. Furthermore, Alban et al. (2012) reported that this substantial decrease was obtained without animal health and welfare being deteriorated.

In 2009 a plan was instituted in the Netherlands to reduce antibiotic usage in animals by 20% in 2011, and by 50% in 2013. If the objectives were not reached one of the measures considered was for veterinarians to lose the right to sell drugs. Veterinary prescriptions are mandatorily declared to public authorities through an information system called VetCis. The emphasis has been placed on biosecurity, nutritional strategies and vaccination, and between 2009 and 2011 the total sales of antibiotics decreased by nearly 32% overall for the five livestock sectors considered (Bondt, 2012). Specifically on the swine side the number of daily dosages per sow and piglets (a different way to calculate antibiotic consumption) went from 25 daily dosages per year in 2009, to 13 in 2011, and from 16 to 8 daily dosages per year in finishing pigs.

On a country basis, there are thus collective measures, guidelines or laws that have been used successfully to reduce antimicrobial usage in animals. But what about what producers and veterinarians can do in individual farms? Many different ways and alternatives can be considered, and the rest of this paper will briefly describe some of them.

4. WAYS TO REDUCE ANTIBIOTIC USAGE IN SWINE PRODUCTION

4.1 Health improvement and maintenance

The most effective way to reduce antibiotic usage in pigs is to improve their health status, and maintain it at that improved level. Of course this is not always easy, but the example I will use for this particular point is, in my opinion, quite impressive. Five different pathogens (toxigenic *Pasteurella multocida*, *Sarcoptes scabiei*, *Mycoplasma hyopneumoniae*, *Actinobacillus pleuropneumoniae* and PRRS virus) were eliminated from a small purebred herd of 100 sows selling replacement gilts and boars (Desrosiers, 2001). Dr Réal Boutin implemented a program based on early weaning (oldest pigs were 10 days old), vaccination (for *Mycoplasma*, APP, toxigenic *Pasteurella* and PRRS) and medication (doramectin, ceftiofur, lincomycin and tiamulin). Since the buildings were old and would have needed major repairs anyway, it was decided to build a new farrow-to-finish barn on the same site, about 75 meters from the existing facilities, that would receive the 'clean' piglets weaned within the program. Following a strict biosecurity protocol, these piglets would then be raised without any direct or indirect contact with the infected population, and become the new sows and boars of that herd. The reason why the owner opted to try such a complicated and risky program is because genetics in his herd were of great value, and he wanted to preserve that. The program was a success, and all 5 organisms were eliminated from the herd. Table 1 shows the lesions in pigs from that herd before and after the program, for periods of 6 months each. As can be seen, the picture was dramatically changed. The first clean piglets were produced in January 1999. Ten years later the lesions were still at very low levels.

The same spectacular results were obtained as far as antibiotics usage is concerned. Before the program the approximate quantity of antibiotics used in the feed was about 80 g/pig, while no antibiotics at all were used in the feed, or in the water, after completion of the program. After

the program the mortality in that herd was about 2.5% from weaning to slaughter. It should be mentioned that the herd is not located in a hog dense area, and is 4 km away from the next pigs. One might say that such health improvement programs are limited to farms located in areas with few pigs, but there are herds in France located in very hog dense areas that have maintained a high health status over many years. These are farms using HEPA air filtration with positive pressure. While this particular air filtration system is very expensive, cheaper alternatives have been developed, and hopefully the search for effective and even cheaper systems will continue.

Table 1. Respiratory and liver lesions for periods of 6 months before and after the program.

Lesions	Before the program (%)	After the program (%)
Milk spots on liver	32	1
Cranioventral lesions < 10 %	54	4
Cranioventral lesions > 10 %	9	0
Pleuritis less than 6 inches	16	1
Pleuritis more than 6 inches	8	1

4.2 Management

A 250-sow herd produces 25 kg pigs that are raised in two different finishing sites. On the first site the small 500-place capacity building (Barn A) is filled in one month, but usually emptied before the next batch of pigs is introduced, so it is an all-out system by building. On the second site the barn is too big (2000 places; Barn B) to be run all in-all out by building with such a small source of piglets, so pigs are introduced every week in an all in-all out system by room. Table 2 shows the results in these two finishing units in terms of lung lesions at slaughter, mortality and need for added medication (Miclette J, personal communication, 2011).

Table 2. Lung lesions, mortality and feed antibiotic usage in two finishing units receiving the same piglets and the same feed.

	January to April 2011	
	Barn A	Barn B
# lungs examined	322	1144
Cranioventral lesions < 10%	1%	26%
Cranioventral lesions > 10%	0%	8%
Mortality	~3%	~6%
Antibiotic supplementation needed	No	Yes

The results obtained are all in favour of Barn A, for which no antibiotic supplementation is necessary. A diagnostic investigation revealed that PRRS virus was circulating in Barn B, but not in Barn A. Since Barn B is never emptied, viral circulation is maintained even though the

sow herd supplying the piglets produces PRRS-negative pigs. Similarly the levels of cranioventral lung lesions in Barn A and in Barn B strongly suggest that *Mycoplasma hyopneumoniae* is circulating in Barn B, but not in Barn A. In essence, different ways of managing the same pigs produce different results in terms of health status and in terms of need for antibiotic supplementation.

4.3 Environment

A farm in England had a problem with *Streptococcus suis* meningitis (Smith, 2012). Treatment with in-water and injectable potentiated amoxycillins along with the reduced performance and increased mortality of weaners was proving costly. It was decided to modify the weaners' environment to reduce the dependence on medication. The main stressor suspected of triggering an outbreak was chilling and temperature fluctuations. An artificial ceiling was constructed from tarpaulin on a roller with an incline of 15° in the autumn. The temperatures in the weaners' sleeping area became warmer and less daily fluctuations were observed. The number of treatments, which was 2309 on average in 2009 and 2010, dropped to 3 in 2011. Similarly Holtcamp (2002) reported that in a US farm nursery mortality, which was mainly associated with *S. suis*, went from almost 9% to 2.5% following improvements made in the nursery environment. A vigorous medication program had shown limited success, but the change following environment modifications was dramatic. The changes allowed for continuous air exchange and the elimination of some potential drafts.

4.4 Weaning age

This one is quite straight forward. Alban et al. (2010) reported that in Denmark antibiotic consumption in weaner pigs was 6,692 kg for respiratory conditions, and 23,840 kg for enteric conditions. So more than three times the quantity of antibiotics is used to control diarrhea compared to that used to control respiratory diseases. It is well known that the younger weaning age is, the more likely pigs are to develop diarrhea post-weaning. In that respect weaning pigs at an older age is clearly a way to reduce the need for antibiotics. In a paper presented at the 2012 AASV meeting and involving a challenge with an F18 strain of *Escherichia coli* at 26 days of age, piglets weaned at 16 days developed diarrhea earlier and more severely than pigs weaned at 20 days of age (McLamb, 2012). Furthermore, gain reduction was much more pronounced in pigs weaned at 16 days of age (89%) compared to those weaned at 20 days (18%). Finally, weaning older and heavier pigs can not only have a benefit in terms of antibiotic usage, but also in terms of performance. Kim et al. (2012) recently reported that within the same herd, the 70 day weights of pigs weaned at 14, 21 or 28 days of age were respectively 17.48, 26.13 and 28.17 kg, and their feed efficiencies 2.21, 1.41 and 1.24.

4.5 Feed

There is a multitude of papers reporting the positive impact of various feed ingredients as alternatives to antibiotics. In one of them, Evelsizer et al. (2010) used essential oregano oil to prevent problems associated with what we were calling hemorrhagic bowel syndrome, and/or intestinal torsions. For 14,090 control pigs the mortality associated with these problems, which are often prevented using low to moderate antibiotic levels, was 1.29%, while it was only 0.16% for 17,923 pigs receiving the oregano based product. Buddle (2002) has suggested that hemorrhagic bowel syndrome and intestinal torsions were different manifestations of the same condition, and proposed a different name: porcine intestinal distension syndrome.

4.6 Season

The Iowa State University Veterinary Diagnostic Laboratory maintains data of the various diagnostics made each year. In an 8 year compilation (2003-2010) of enzootic pneumonia diagnostics, it was found that the number in September-October was close to 3 times what it is between February and June (Schwartz K, personal communication, 2011). This suggests that there are situations where instead of using antibiotics year round to control that condition, there may be opportunities to design antibiotic programs according to the relative seasonal risk. In other words, a reduced antibiotic usage in periods of reduced risks.

4.7 Genetics

In my opinion this is an area where we are likely to make significant progress in the coming years. In an evaluation conducted in Denmark, 12 Duroc boars, 700 sow and 12,268 pigs were used. The pigs from the different boars were born and raised in the same 3 farrow to finish farms that had been selected because they had respiratory disease problems (Nielsen et al., 2006). It was found that in the nursery phase, one of the boars produced piglets that had a mortality rate of 3% while it was 10% for another one. Similarly, in the finishing phase one boar produced pigs with a mortality of 2% while another one had a 10% mortality in its progeny. The mortality differences between boars were highly significant statistically ($p < 0.002$ in the nursery and $p < 0.0007$ in finishing). Differences between the progeny of boars were also found in pleuritis (44% for the best and 68% for the worst, $p < 0.0001$) and pneumonia (18% for the best and 57% for the worst, $p < 0.0001$). These results, where pigs from different boars were raised side by side in the same environment clearly indicate that some boars produce pigs that have a better survivability and resistance to disease than others. Using such genitors would evidently increase the possibilities of raising pigs with reduced dependence on antibiotics.

4.8 Gender

Pommier et al. (2008) found differences between genders in the percentage of lungs with pleuritis (9.1% for females, 11.0% for males; $p = 0.02$) and pneumonia (54.4% for females and 61.9% for males; $p < 0.001$) at slaughter. In a study involving 6 finishing units and 7,982 pigs, 68% of the pigs that died were males and 32% were females (Surprenant C, personal communication, 2011). In another study involving close to half a million pigs, mortality in gilts receiving no antibiotics was at 4.26%, while it was 6.41% for barrows receiving antibiotics (Moreau, 2001). Since females are less sick and survive better than males, raising them separately increases the possibilities of reduced antibiotic usage for at least half the production. Furthermore a recent study by Jungst et al. (2012) showed that due to the difference in top quality pigs and feed cost savings, there was an advantage of \$4.22 per pig when barrows and gilts were raised separately, compared to raised together.

4.9 Parity segregation

Moore (2003) reported on a strategy called parity segregation where piglets born from gilts are raised separately from piglets born from sows of other parities. Piglets born from gilts are more susceptible to different conditions and may thus require more aggressive preventive control programs. Table 3 shows the results that were obtained. All parameters evaluated, including drug cost, were improved in piglets born from multiparous sows. Parity segregation thus offers the possibility to reduce antibiotic usage for about 75% of the pigs produced.

Table 3. Results obtained in piglets born from primiparous vs multiparous sows.

	Piglets from P1	Piglets from P2+
Nursery mortality, %	2.96	1.52
Nursery ADG, g	430	465
Finisher mortality, %	3.8	3.25
Finisher ADG, g	795	820
Total drug cost, \$	3.30	1.77

4.10 Individual treatments

One of the reasons why Denmark is able to produce pigs with less antibiotics than many other countries is that they rely much less on treatment of the whole population than we do for example in North America. They will treat individual pigs, or pens, but generally not the whole group of pigs. In some situations treating individual pigs has been shown to produce better results, at lower costs than treating all the animals with antibiotics in the feed or water. Table 4 shows the results that were obtained in a Quebec company where pigs affected with porcine pleuropneumonia were either treated individually by injection, or the total group was treated in the feed and/or water (Desrosiers, 1986).

Table 4. Comparative results of pigs that were affected with porcine pleuropneumonia and treated either by oral medication in the feed and/or water, individually by injection, or not affected with the condition.

	# units	# pigs	% mortality	Drug cost, \$
Oral	3	3,613	11.4	4.79
Injection	35	46,059	2.34	3.03
Controls	62	84,599	1.92	1.97

Not only were the results obtained clearly better with individual treatments, but the antibiotic cost associated with it was also much lower. It should be mentioned that when this study was conducted, the choice of antibiotics that could be used in the feed or water was more limited than it is today. Nevertheless, particularly for acute conditions like porcine pleuropneumonia which reduce feed and water consumption of affected animals, injection of sick pigs is often more cost effective than oral treatment of the whole group.

4.11 Vaccines

Obviously using vaccines to prevent disease rather than antibiotics is an easy way to reduce antibiotic usage. In a study conducted in Denmark on 20 farms, those using a live *Lawsonia intracellularis* vaccine used less antibiotics than those that did not (11.4 ADD per 100 weaned pigs vs 14.8) (Bundgaard, 2012).

4.12 Single source vs multi-source

Martano et al. (2012) have reported the mortality rates obtained in finishing units in Italy depending on whether the piglets came from one source or more. The data were compiled over the period of January 2006 to December 2010, and involved 454,620 pigs. The average mortality rate of single source pigs was 3.43% against 5.60% for those coming from more than one source, and the difference was statistically significant ($p < 0.05$). The reduced mortality rate in single source pigs shows that this way of raising pigs is less likely to be a problem on a health basis, and thus has the potential to reduce the need for medication. It should be kept in mind however that there are situations where it may be preferable to introduce more than one source of pigs on a site, if it allows this site to work on an all in-all out basis by site, rather than by room or building.

4.13 Try and see

Brumm et al. (2012) compared groups of pigs that received 5 different medication programs in the feed to pigs that had no medication. The study involved 1800 pigs that were evaluated from day 45 to 159 post-weaning. One of the medication programs included the following antibiotics and schedule: chlortetracycline and tiamulin for 2 weeks, then chlortetracycline for 2 weeks, then tylosin for 2 weeks, then chlortetracycline and tiamulin for 2 weeks, then tylosin up to slaughter. Another one included tylosin from the beginning to the end at decreasing dosages. There was no effect of any of experimental treatments on the number of pigs dead, pigs removed or morbidity as measured by the number of pigs given injectable treatments. Table 5 shows the results that were obtained in terms of average daily gain (ADG) and feed per gain (F/G) for the unmedicated control group and the 5 medicated groups.

Table 5. Average daily gain and feed per gain of control pigs receiving no antibiotics in the feed and pigs that received one of 5 feed medication programs.

	Control	1	2	3	4	5
ADG, lb	2.09	2.07	2.09	2.10	2.10	2.05
F/G	2.62	2.63	2.62	2.66	2.60	2.63

There was no significant difference in either ADG or F/G results. The group receiving non medicated feeds did as well as the other ones. This shows that including antibiotics to feeds, particularly in the finishing units, does not automatically result in an improved performance.

Producers who are not convinced that a medication program installed a while ago is still cost effective could try to remove or reduce that medication program and see if it does or does not produce the expected benefits.

4.14 Other options

There are other options to reduce antibiotic usage in swine production. Improving biosecurity in a way that allows reducing the introduction of new pathogens or strains in a given herd is an obvious one, the PRRS virus being an easy example of that. Producers have a tendency to think that if a little is good, more is better, and there are cases where the dosage used to treat a condition is much higher than necessary. Some antibiotics can be effective at dosages (mgs of antibiotic per kg of pig) that are a lot lower than others, so switching to these products

automatically reduces the grams of antibiotics per pig, but in this case other issues obviously need to be considered. Using pulse treatments rather than continuous medication can not only reduce the total dosage of antibiotics used, but may also allow the pig to mount an immune response to the organism targeted. In a recent study electrostatic particle ionization was shown to significantly improve air quality, gain and mortality of nursery pigs and may thus reduce antibiotic usage by allowing raising healthier pigs (Rademacher, 2012). The options described in this paper are not inclusive, and we should keep an open mind to any product, strategy or technique that has the potential to reduce antibiotic usage in our production.

5. CHOICE OF ANTIBIOTICS USED

But antibiotic usage *per se* is only one aspect of the problem. The choice of antibiotic used is another important one. Some antibiotics are considered as the last resort therapeutic compounds against certain human and swine diseases, and it is of paramount importance to make sure that these antibiotics remain effective on a long term basis. This is particularly true when considering that access to new antibiotics is, as mentioned before, likely to be rather limited in the future. For that reason, their usage should be limited to situations where they are really necessary. The Canadian Veterinary Medical Association produced a document in which it categorized the various antibiotics available according to their strategic importance in human medicine (Agriculture and Agri-Food Canada, 2008). This categorization is shown in Table 6.

Table 6. Categorization according to their relative importance in humans of antibiotics that can be used in swine.

Category	Definition	Products
1 Very high importance		Cephalosporins (third & fourth generations) fluoroquinolones; penicillins – lactamase inhibitor combinations; polymixins
2 High importance		Aminoglycosides; lincosamides; macrolides; penicillins; trimethoprim-sulfamethoxazole; streptogramins (moved from category 1 to category 2 in 2009)
3 Medium importance		Aminocyclitols; bacitracins; nitrofurans; phenicols; sulphonamides; tetracyclines
4 Low importance		Flavophospholipols; ionophores

CONCLUSIONS

To what extent antibiotic usage in animals is responsible for the developing resistance of human pathogens to some key antimicrobial molecules remains a topic of vivid discussions. Some say it is of marginal importance, others state that it is significant and that it would be irresponsible not to address it. But which side serves us better? Putting energy, time and money trying to prove that the use we make of antibiotics in animals is ‘not that bad’, or changing our ways so that the human medical authorities appreciate the effort we make to address the issue and eventually become more collaborative and conciliatory with livestock producers and animal health professionals? Independently of pressures from the human side, we need to keep in mind that

increasing antibiotic resistance to swine pathogens is also a concern. Pigs can get sick, and when they do, they need to be effectively treated and this will be compromised if antibiotic resistance to some important pathogens continues to increase. Finally, producing pigs that are raised with less antibiotic usage is something that can be used as a comparative advantage, when it comes time to offer Canadian pork to local and export markets. A limited and judicious use of antibiotics in swine production would thus seem to be in the best interest of all those involved in our industry.

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Top Profit Robbers, Nursery-Finish

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ABSTRACT

The key profit drivers in the nursery-finish segments are driven by feed efficiency, cost of gain, average daily gain, mortality, morbidity and carcass quality. These profit driver measurements represent outcomes of other decisions. This article summarizes some of the principles and approaches we use, seeking to maximize nursery-finish barn profit drivers.

TOP PROFIT ROBBERS, NURSERY-FINISH

Sometimes, too much effort is placed measuring outcomes without giving sufficient thought to what brings about successful performance measures in the nursery-finish barn.

The following outlines some key principles we use in our production system:

1. Don't have to live in the barn, but be fully mentally engaged when there;
2. Fix before it's broken – equipment does not heal itself;
3. Stable Health critical – health status, feed ingredients, facilities. We will spend (invest) on vaccines and treatments; I fear the term “dial back cost” as it relates to health spending. I also don't want to be foolish – unnecessary health costs are also foolish. When measuring against other farms, we tend to have higher health costs per pig produced but are usually among the lowest for mortality and morbidity;
4. We will not tolerate animal vices – at cost perhaps of reduced feed efficiency and ADG. We seek mental congruence – it is not congruent to “preach” animal husbandry and care while placing animals that may be prone to aggression and/or having a barn environment that may stimulate aggressive behaviour. We will also relentlessly seek to identify and fix the causes of any animal aggression that does occur;
5. “Chores” are what you do before breakfast, then get on with day – NO!! This risks fitting the needs of caring for animals into a specific allotted time. However, since nursery and finishing barn management are not usually full-time jobs, a confusion of priorities can happen, especially when the animals are doing well and extensive additional time is not needed to properly care for them;
6. Individual pig care is critical to being among the best nursery-finish operators. However, this will not overcome inattention to overall group care items such as ventilation, temperature and draft management, water management, feeder settings, equipment and building maintenance;
7. Finish segment: a great deal of effort goes into preparing a high quality feeder pig. Receiving a high quality feeder pig can make the responsibilities of managing the finishing barn appear easy. However, most of the cost of producing a market hog is allocated to the finishing segment, especially in these times of high feed costs.

Hence, a great deal of responsibility rests with the finishing operator to manage all the “fine tuning” aspects of this stage in order to achieve the best possible performance measures noted above;

8. Successful farming should be busy but relaxing and may well include positive stresses. However, negative stress (not always on edge worrying about breakdowns, health challenges, etc.) must be minimized. The most successful livestock and crop producers make the job appear easy, but are actually enjoying the outcomes of a great deal of planning, effort and investment.

Top Profit Robbers Wean to Finish
Clare Schlegel
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Interesting title, “Top Profit Robbers Wean to Finish”. This assumes there is “profit” and there obviously must be long term, otherwise no pigs would be produced. So the context of the discussion must be to minimize expenses and maximize revenue. Either one can expand the margin. The additional concept is that of a “robber”. To me this leads to concepts of stealing, taking things that actually belong. In our discussion, one thinks about areas that should be avoided. Often this implies areas that can easily be missed in common day to day activity, slipping by without much consideration and at some point in the future realizing that the margin has been “robbed”.

Wean to Finish, ~ 7kg to 25kg and then ~25kg to 125kg. The obvious large expense is feed, but perhaps robbers, while certainly feed, are in many other smaller areas. Often it is tempting to think that an effect of only \$0.25 per pig is small when one considers the animal at market may be worth ~\$175. Yet when one considers that the usual margin for this animal may be only \$25, the \$0.25 area is now huge. Most everyone do the large areas well, (for instance, get the pigs fed), but many fail (including our operation) to do the little things, the \$0.25 areas, as well as they could be and should be.

So here is a top ten list, from an experiential perspective instead of scientific. You could argue with any of these, and you could certainly contest the priority.

- 1) “Do the little things and the big things will take care of themselves”. Pay attention to the details. I would suggest the difference between good managers and great managers is exactly this! And perhaps this is the most difficult area to teach and learn.
- 2) Healthy Animals...PRRS, myco, strep etc....nothing beats healthy animals. And every animal deserves daily attention, and immediate response.
- 3) Barn environment. No drafts, minimum daily fluctuation in temperature in fan controlled barns to reduce stress.
- 4) Proper feed. Grind Size (smaller grind = better feed conversion), pelleting ration instead of mash, proper nutrition for stage of growth. Minimum cost formulation etc. We all know about this, can we minimize input costs?
- 5) Not surprising with feed being the largest expense, and perhaps this should be number 1, feeder adjustments, reduce feed wastage while not limiting growth rate.
- 6) Similar health status for co-mingling of pigs into nurseries a finishing barns. By far the best if it can be accomplished is single source or even farrow to finish as long as general health status is high enough.
- 7) Maximize revenue to hitting the sweet spots on market grids. Monitor standard deviation and average index.
- 8) Along the same line, if you are “all in, all out”, minimize number of days between barn fills. It costs somewhere between \$0.15-\$0.20 per pig space per day.

- 9) Euthanize pigs quickly. This is one of the most difficult jobs. No one likes to kill animals, yet, this is the most humane option if an animal is in pain and will never fully recover. Very hard to do, but important.
- 10) Target setting and Records. Most of us do not like paper work yet this is one of the most important areas. This is both in terms of costs, average prices and also in barn productivity numbers. We need to become more like the chicken industry with good industry numbers.

Top Profit Robbers Wean To Finish

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ABSTRACT

Key drivers in the nursery and finishing stages are mainly health, cost of production, and performance. This article will look into the specific things we monitor in our facilities to ensure maximum profit and performance.

NUTRITION

Feeding the proper amount of each feed stage to maximize performance is essential. Incorrect diets cost huge on under-performance or feeding too much of an expensive ration. You need to be constantly monitoring your herd and working closely with your nutritionist and veterinarian to ensure peak performance and the least cost rations to get you there. Feeder adjustment must also be managed to maximize performance; too tight and pigs can't get enough feed, too open and feed is wasted. Feed withdrawal before shipping is also important; the pigs move and load easier and you aren't sending a belly full of feed to the processing plant. Also, you need to monitor feed quality, from ingredients and nutrients to particle size. Another area to consider is split sex feeding; if it can be done in your facilities there are definite advantages.

ENVIRONMENT

It is extremely important to get each and every group off to the best start possible. Temperature needs to be comfortable for the pigs, too cold and energy is wasted for them trying to keep warm, too hot and you are just throwing money out the fans! Furthermore, barn temperatures that are too cold or too hot can also open the doors for various health problems, which increase costs and lower production. Rooms and pens need to be clean and dry and up to temperature before pigs enter the area.

HERD HEALTH

Constant monitoring of herd health is vital to your farms success. Poor-doing pigs consume disproportionate amounts of feed for the amount of gain; daily walk-through of pens and identification of at-risk pigs will improve timely treatment or euthanasia as needed. Work closely with your veterinarian to maintain a herd health plan to ensure products are used properly and you are getting the best value from them. Ensure you and your staff are up to date with current products and that their usage is done properly; do not cut corners with treatments or vaccines.

ACKNOWLEDGEMENTS

I would like to thank my co-presenters James Reesor and Clare Schlegel as well as Cameron Farrell for their help and knowledge.

Plenty to Think About
Jose Cardenas
Director, Global Marketing
Elanco Animal Health

(Editor's Note: This talk is based on the publication "Technology's Role in the 21st Century: Making safe, affordable and abundant food a global reality". The full source article can be viewed at:

<http://plentytothinkabout.org/wp-content/uploads/2011/03/Three-Rights-White-Paper-Revised.pdf>.

What follows is an Executive Summary taken from the article.)

EXECUTIVE SUMMARY

By 2050, we'll need 100 percent more food^{1,2} and according to the U.N. FAO, 70 percent of it must come from efficiency-enhancing technologies.³

Technology defined:

1. Practices – Doing it better
2. Products – Using new, innovative tools and technologies
3. Genetics – To enhance desired traits in plants and animals

We must call a truce to the debate about the role of technology in the sustainable production of safe, affordable and abundant food if we are to protect the Three Rights:

1. Ensuring the human right of all people around the world to have access to affordable food.
2. Protecting all consumers' rights to spend their food budget on the widest variety of food choices.
3. Creating a sustainable global food production system, which is environmentally right.

Key Point

The challenge of world hunger is complex and multifaceted. Allowing the entire food chain access to safe, efficiency-enhancing technologies is an essential component of a comprehensive solution to the challenge – both locally and globally. In addition, protecting the right to choose these technologies can make the dream of safe, affordable and abundant food a reality worldwide.

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Day 2: Workshop Sessions

Hog Crush Margins

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ABSTRACT

The original idea of “crush margin” comes from the soybean processing industry. The term “crush” refers to the crushing of soybeans to produce meal and oil. Market traders use the soybean, soybean meal and soybean oil futures to generate margin numbers to manage for profit opportunities.

In the hog industry, the purchasing of weaned or feeder pigs, corn and soybean meal and the selling of market hogs generates both input and output price risks for hog producers. Therefore by managing the prices of market hogs, weaned or feeder pigs, corn and soybean meal, a margin can be protected.

This paper examines two hog crush margin calculators, The Gross Feed Margin Model and the Hog Margin Tracker.

WHY UTILIZE A CRUSH MARGIN?

Feed, weaned pig and feeder pig prices account for a significant portion of the input costs within a hog operation. These inputs are volatile, increasing a producer’s price risks. Purchasing corn, soybean meal, and weaned or feeder pigs to raise them to market hog weight exposes a producer to both input cost and output revenue price risk. Managing these risks is a challenging process, but necessary and vital to estimate profitability.

Today’s crush margin and historical recorded margin estimates can be used in a quick and time efficient manner to identify times when risk management opportunities exist or when troubled waters lie ahead. This tool provides producers an easy way to monitor feed and hog markets in order to gain greater control over input booking and selling market hogs.

Crush margin calculations only consider corn, soybean meal, and weaned or feeder pigs on the input side of the equation. The remaining fixed and other variable costs need to be subtracted to arrive at a return on profit estimate.

Advantages to using crush margins:

- Simple and straightforward strategy for managing price risks.
- Allows for a mechanical based risk management plan that further removes emotions from the decision making process.
- Margins can be calculated as far out as eighteen months into the future, providing a forward looking market picture to base input cost planning and marketing decisions on.

Disadvantages to using crush margins:

- If acceptable margins are not available, an alternative risk management strategy needs to be considered.
- Seasonal price trends that may be present in agricultural commodity markets are not considered when calculating the raw difference between feed and market hog prices.
- Other costs associated with the operation need to be subtracted from the margin estimate. Examples of those costs include barn costs, transportation, marketing, interest, labour and health.

THE GROSS FEED MARGIN MODEL (GFM)

The Simpson/Caputo Group of RBC Dominion Securities Inc. in Waterloo have developed a tool to provide their producers with a customized return on feed estimate. They built this tool with the intention of:

- Providing their clients with a simple, straightforward, and time efficient risk management tool.
- Providing their clients with a customized risk management tool, based on their information, which provides them with personalized historical benchmarks.

The sample snapshot (Figure 1) of the Gross Feed Margin Model is understood as:

1. This column lists the margins. The numbers show what revenue is left over after taking feed input costs into consideration, referred to as a return on feed. The formula is: (2 x lean hog price) – (corn price converted to total pounds (lb.) fed) – (wheat price converted to total lb. fed) – (meal price converted to total short tons fed). For example, on 02/21/13 the March estimated return on feed was \$86.23. Staying with the March delivery period as an example, the margin calculation here uses the April lean hog futures contract and the March corn, wheat, and meal contracts. Once the March feed contract expires, the margins are calculated using the May feed contracts until the April lean hogs expire.
2. This column lists the 90th percentiles for the corresponding delivery period and margin calculation that is shown under the margin column. The percentile figure is included to use as a benchmark and possible opportunity to hedge margins. The 90th percentile means that 90% of the time, margins have been equal to or lower than the stated value. For example, the March 2013 90th percentile is stated at \$107.03. This means that we have only been above this figure 10% of the time since 2007.
3. This bar chart simply displays the gross feed margin figures in chart form.
4. This table is a one pig feed budget and is essential in calculating margins. The table is broken down into sow feed (lb.) and pig feed (lb.) for corn, wheat, and soybean meal. A producer's personalized feed amounts are listed here and used in the formula to calculate the gross feed margin for each delivery period. Feed amounts are converted to pounds as lean hog futures contracts are traded in 40,000 lb. increments. For example, the snap shot above shows this producer using 451.95 lb. of corn and 103.62 lb. of soybean meal to raise one pig. Also included in this table is the number of hogs marketed on a monthly basis and the percentage of hogs that are to be hedged if a favourable margin is available.
5. This table shows the quantity of futures contracts that need to be traded in order to hedge a margin, based on the information provided in the one pig feed budget. You will notice two

figures for hogs, corn, wheat, and soybean meal. The first is the projected number of contracts to be traded and is based on actual feed usage and hog marketing's listed in the one pig feed budget. Projected quantities show fractions of futures contracts that would need to be traded, but these fractions cannot be traded. This is a disadvantage to using crush margins for smaller operations or for smaller percentages to hedge and is an issue that needs to be addressed. A producer has numerous options when dealing with this issue. For example, one can use forwards via their feed supplier and futures for hogs. Also, you can test the percentages to hedge to determine acceptable hedging increments that arrive at more even numbers. The second figure shown is the actual quantities; this shows how many futures contracts that would actually be traded.

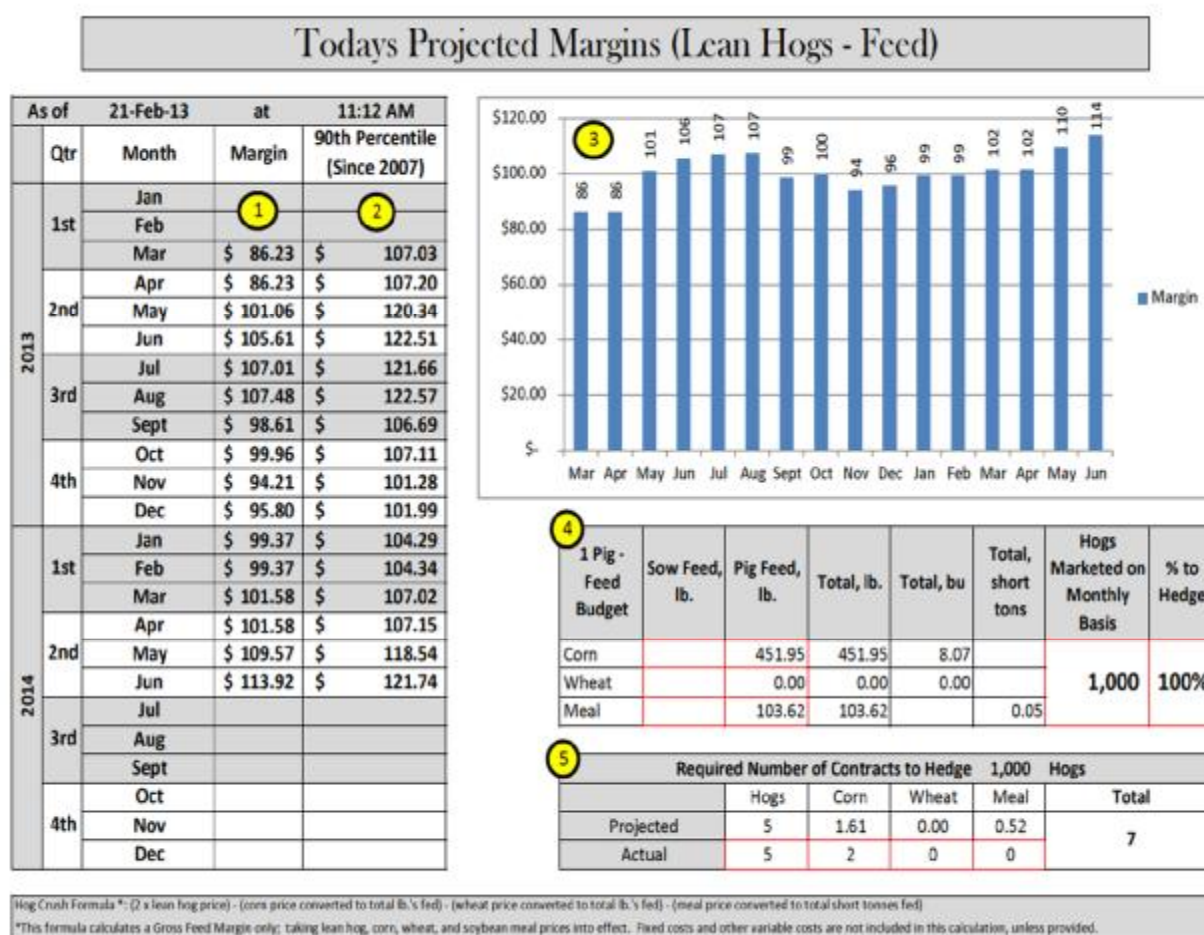


Figure 1: Snap shot of sample Gross Feed Margin Model (GFM; see text for explanation of numbered highlights).

How margins are calculated:

- The gross feed margin is calculated daily using real time prices and is based on the current 'best bid' price for the hog contract and the 'best offer' prices for the corn, wheat and soybean meal contracts.
- The formula is: (2 x lean hog price) – (corn price converted to total lb. fed) – (wheat price converted to total lb. fed) – (meal price converted to total short tons fed)

- Hog futures prices are multiplied by 2 to convert them into a 200 lb. carcass price.
- All gross feed margins shown are in US dollars.
- If a producer feels that the projected margin calculated by the model is attractive, then they can execute a package of trades that could protect it. Those trades consist of selling lean hog futures contracts and buying corn and soybean meal contracts in the appropriate quantities.

Model Features

This model is customized to each individual farm operation. Some of the features the model provides are:

- Provides historical gross feed margins for each month going back to the 2007 lean hog futures contract year. This historical data is used to calculate the 90th percentile figures used as personalized benchmarks.
- Margin targets can be set. If a target is reached, parties involved are contacted.
- Reports and tracks prior day's margins based on closing prices.
- Margins begin tracking once a new hog futures contract month is added to the board, margins are currently tracking 18 months into the future.
- Provides the approximate amount of initial margin required to finance the position.
- A scenario analysis is included to show what the cash-flow risk would be if gross feed margins were to continue higher after a package was executed. Four different scenarios are included, all based on margins increasing and requiring more working capital to finance the position.
 - § Note that initial margin rates are subject to change.
- Provides the approximate amount of commission charged per package, on a round turn basis.
 - § Note that commission rates are subject to change.

THE HOG MARGIN TRACKER

The Hog Margin Tracker (Figure 2) is a weekly marketing tool to demonstrate to producers the potential of using a “Crush Margin” as a decision making tool to manage price risk. Through the margin calculation, by looking at both historical and forward looking margins, it provides a quick indicator of risk management opportunities or challenges. It acts as a monitor of both the current and future markets for the hog and feed markets.

The Hog Margin Tracker is an indicator of the margin after accounting for the variables with the greatest price risk (market hog, feeder pig, corn and soybean meal). The margin is the return to cover all other costs and provide a profit. Margin is simply the market hog value less the feeder pig and feed costs. Once a favourable margin is indicated, pricing opportunities for market hogs and/or feed inputs should be reviewed. Depending on the current market assessment and risk implications for the farm business, the appropriate action should be taken.

Time Periods on Hog Margin Tracker (Figure 2) and Report (Figure 3):

- Actual - Market pigs have been marketed – final result (figures will not change)
- Pigs on Feed - Feeder pigs purchased and on feed in the barn – feeder pig value will not change but projected market hog values, feed costs, and margins will change weekly based on the futures

- Looking Forward - All values are projected and will change weekly based on the futures
- \$25 Margin – This is the assumed benchmark margin value needed to cover all other expected costs

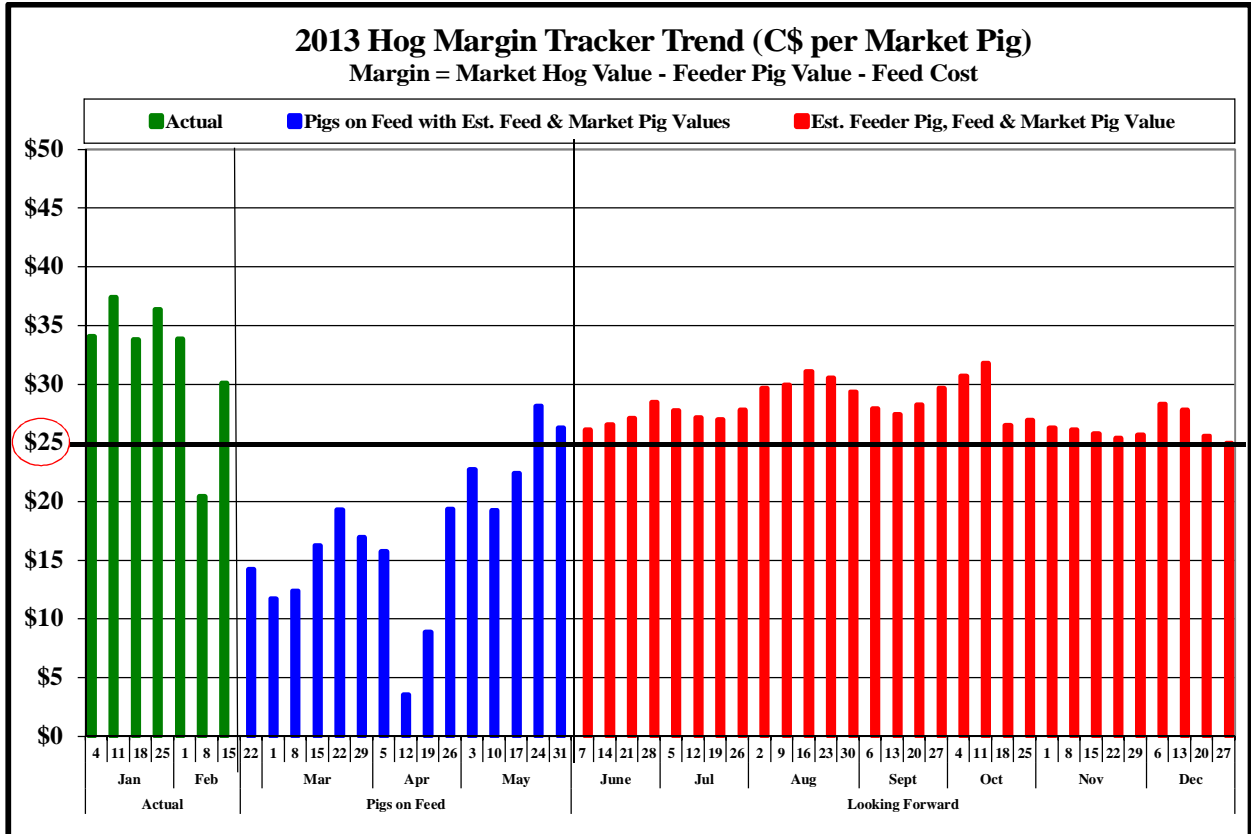


Figure 2: 2013 Hog Margin Tracker Trend (C\$ per Market Hog) – February 15, 2013.

Margin (\$/pig)=Market Hog Value (\$/pig)–Feeder Pig Value (\$/25 kg pig)–Feed Cost (\$/pig):

- Market Hog Value = 101% of weekly base price X 110 index X weekly average dressed weight + \$2 premium
- Feeder Pig Value (25 kg) = 70% of the (Market Hog Value (15 weeks out) – Current Weeks's Feed Cost
- Feed Cost is based on 15 week average using Corn (Avg. of Huron FOB Farm and Western Ontario Feed Corn), Hamilton Soybean Meal plus \$20/tonne, commercial premix, and \$20 per tonne (handling and mixing), 2.75 feed conversion, growing pig from 25 kg to market weight
- Projected values used for feed (corn and soybean meal) and market hogs are calculated using basis adjusted futures values at the close of the futures market on Thursday each week
- The Expected Margin (right hand column of Figure 3) is the estimated margin the week the feeder pig is placed on feed. This figure will not change and is a benchmark figure to

compare the realized margin with . It is based on the initial calculated values for market hog, feeder pig, and feed. This calculation is done fifteen (15) weeks prior to the indicated date of the sale week.

All figures are \$/pig	Sale Week		Market Hog Value	Feeder Pig Value	Feed Cost	Realized Margin	Expected Margin*
	Month	Friday					
Actual	Jan	4	\$165	\$29	\$102	\$34	\$13
		11	\$167	\$29	\$101	\$37	\$12
		18	\$168	\$35	\$100	\$34	\$15
		25	\$174	\$39	\$98	\$36	\$17
	Feb	1	\$176	\$45	\$98	\$34	\$19
		8	\$124	\$44	\$60	\$20	\$19
		15	\$177	\$50	\$97	\$30	\$21
		22	\$160	\$51	\$95	\$14	\$22
Pigs on Feed	Mar	1	\$161	\$55	\$95	\$12	\$24
		8	\$162	\$55	\$94	\$12	\$24
		15	\$165	\$54	\$94	\$16	\$23
		22	\$162	\$49	\$94	\$19	\$21
		29	\$160	\$50	\$93	\$17	\$21
	Apr	5	\$162	\$53	\$93	\$16	\$23
		12	\$160	\$63	\$93	\$4	\$27
		19	\$164	\$63	\$93	\$9	\$27
		26	\$172	\$59	\$93	\$19	\$25
	May	3	\$179	\$63	\$93	\$23	\$27
		10	\$178	\$66	\$93	\$19	\$28
		17	\$182	\$67	\$93	\$22	\$29
		24	\$188	\$67	\$93	\$28	\$29
		31	\$181	\$62	\$92	\$26	\$27
Looking Forward	June	7	\$181	\$63	\$93	\$26	\$27
		14	\$182	\$63	\$93	\$26	\$27
		21	\$184	\$65	\$93	\$27	\$28
		28	\$189	\$68	\$93	\$28	\$29

Figure 3. Hog Margin Tracker Report – February 15, 2013.

Putting a hog crush margin into action!

Now that you have gained an understanding on how a hog crush functions and its role in managing risk, it is time to put one into action. The steps are:

1. Develop a feed budget for your swine operation

2. Determine what a good margin is for your swine operation. This means looking at all the other costs associated with raising pigs that are not included in the crush margin calculation.
3. Implement your crush margin based on your farm data. If you can determine some historical margins they can be used as benchmark data when looking at forwarding looking margins.
4. If an attractive margin is available, it should be hedged. Consider the various price risk management tools available with the forward and/or futures markets.
5. If an attractive margin is not available, look at alternative hedge strategies. This could mean separating the hog and feed price risks and hedging them at different times.
6. Use the marketing resources and information available to assist in making your decisions.

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New Tools for Precision Feeding: NRC (2012)

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ABSTRACT

The current high feed costs increase the need for developing cost-effective feeding strategies for growing-finishing pigs. Well-tested mathematical models that represent nutrient utilization for growth allow for a systematic approach to optimizing feeding programs for individual pig units, considering local pig performance potentials and available feed ingredients, as well as environmental and economic conditions. In this short paper examples are given where the NRC (2012) Nutrient Requirements of Swine model for growing-finishing pigs is used to explore effects of gender, pig performance potentials, feed intake, and use of high fiber co-products as feed ingredients on nutrient requirements. These examples stress the need to closely monitor current performance and to regularly evaluate feeding programs.

INTRODUCTION

Feed cost is by far the largest cost in commercial pork production (about 70%), and growing-finishing pigs account for about 80% of feed consumed. The extremely high feed costs in 2012 support the need for developing cost-effective feeding strategies, especially for growing-finishing pigs. As such, the pigs' performance potentials and maximizing utilization of locally-available feed ingredients must be considered to match dietary energy and nutrient supply with the pigs' requirements to reduce feed cost per kg of carcass weight.

It has been well established that the optimum feeding strategy differs among pig units, and should reflect pig performance potentials, health, gender, available feed ingredients, the pigs' environments (e.g. space and effective temperature), feed delivery, as well as costs (especially of energy in feed ingredients), pork prices and carcass payment systems.

Examples of the benefit of using models for a systematic evaluation of alternative feeding strategies have been presented in the past (e.g., de Lange et al., 2001; van Milgen et al., 2008). Additional examples will be presented in the two subsequent short papers at this conference, by Drs. Ferguson (Nutreco Canada Inc.) and Marty (Agribands Purina Canada). In this short paper the nutrient requirement models from NRC (2012) will be described briefly and estimated nutrient requirements for different groups of pigs are presented.

NRC (2012) SWINE NUTRIENT REQUIREMENT MODELS

The 11th revised edition of the US National Academy of Science book "Nutrient Requirements of Swine" comes with three relatively simple models (gestating sows, lactating sows, growing-finishing pigs) to estimate nutrient requirements of different groups of pigs at varying levels of performance and under varying environmental conditions. These models are programmed in Microsoft ExcelTM, are reasonably easy to use, and can be downloaded for free from the internet, with user guide and case studies to illustrate model use (NRC, 2012).

An important feature of these models is that observed levels of performance (e.g., feed intake, growth rate, back fat thickness) and current feeding programs can be entered in the models and used to adjust model inputs (e.g., the pig's lean growth potential) to match observed with model predicted performance. When observed performance is in close agreement with model predicted performance the user can have more confidence in model estimated nutrient requirements. The models can also be used to gain a better understanding of the complex interactions between feed intake, feed ingredients, pig performance potentials, environmental conditions, back fat thickness and nutrient requirements.

As with any model, the NRC (2012) nutrient requirement models have boundaries and limitations, and a basic understanding of their underlying biology is required for effective use. Background information is provided in detail NRC (2012), making all model calculations transparent. For a trained swine nutritionist it is not too difficult to become familiar with the models, including their limitations. There are two key limitations of the NRC (2012) models: (1) they do not allow cost-benefit analyses, and (2) they are unlikely to yield accurate predictions of feed intake. Given the complex interactions among the many factors that affect feed intake (Torrallardona and Roura, 2009), it is suggested that feed intake is measured and used as a model input and that the model user gains an understanding of environmental factors that should be considered when managing feed intake.

EXAMPLES OF NUTRIENT REQUIREMENTS ACCORDING TO NRC (2012)

Examples of estimated nutrient requirements for different genders of finishing pigs are presented in Table 1. These nutrient requirements are generated using the NRC (2012) growing-finishing pig model, by choosing default options for each of the genders, defining when (i.e., enter initial body weight) and how much Ractopamine (PayleanTM) is fed, or at what body weight entire males are immunologically castrated against gonadotropin releasing hormone (GnRH) to control boar taint. The differences in nutrient requirements provide a basis for split-sex feeding. The results show that differences in feed efficiency and nutrient requirements between entire males and gilts is larger than that between gilts and barrows. Therefore, as we are moving towards using entire males for pork production the value of split-sex feeding will increase. These results also show the large effect of feeding Ractopamine or immunological castration of entire males on growth performance and nutrient requirements.

The interactive effect of feeding level and pig performance potential on estimated nutrient requirements according to NRC (2012) is presented in Table 2. Performance potentials are expressed as mean whole body protein deposition rates between 25 and 125 kg body weight (mean Pd), which is closely associated with lean tissue growth. These results illustrate the importance of increasing pig performance potentials to maximize feed efficiency and carcass value. These results also stress the need to properly estimating pig performance potentials and feed intake levels for determining nutrient requirements. Underfeeding pigs with high performance potentials or low feed intakes will compromise growth performance, while overfeeding pigs with low performance potentials or high feed intakes represents a waste of expensive nutrients. An interesting observation is that for pigs with high lean growth potentials nutrient requirements, expressed as % of diet, are identical at the medium and low feeding levels (scenarion5 vs. 6). At these levels of feed intake pigs are in the so-called energy intake dependent phase of lean gain; in that case the required nutrient to energy ratios are largely independent of feeding level.

Table 1. Effects of gender, feeding Ractopamine (Paylean™) and immunological castration of entire males on estimated nutrient requirements of finishing pigs between 90 and 120 kg body weight (diet NE content 2475 kcal/kg; fermentable fiber content 10.5%; NRC 2012).

Scenario	Gilts	Barrows	Barrows fed Racto- pamine ^a	Entire males	Immuno- logically castrated males ^b
Inputs					
Gender	Gilts	Barrows	Barrows	Entire males	Entire males
Immunized against GnRH?	No	No	No	No	Yes
Feed Ractopamine?	No	No	Yes	No	No
Results					
Probe back fat at slaughter body weight, mm	16.4	19.7	17.5	13.7	16.4
Carcass lean yield, % ^c	61.6	60.1	61.1	63.0	61.7
Average feed intake + wastage, kg/day	2.723	2.935	2.904	2.643	3.076
Average body weight gain, g/day	879	910	993	925	1038
Gain : (Feed intake + wastage), kg/kg	0.323	0.310	0.342	0.350	0.337
Average SID ^d Lys requirement, %	0.69	0.62	0.76	0.78	0.65
Average SID Lys requirement, g/day	17.9	17.4	21.1	19.5	18.9
Avg. SID Thr requirem., Ratio to Lys × 100	64.2	65.8	63.3	62.6	64.9
Avg. STTD ^d phosphorus requirem., %	0.24	0.21	0.25	0.28	0.23

^a 5 ppm is fed between 100 and 120 kg body weight (20 days).

^b The 2 immunization dose is injected at 90 kg body weight.

^c Estimated from modelled probe back fat.

^d SID: standardized ileal digestible; STTD: standardized total track digestible; these are considered the most appropriate means to routinely estimate bio-availability of amino acids and phosphorus in pig feed ingredients (NRC, 2012).

The effect of feeding reduced energy and co-product containing diets on nutrient requirements of growing pigs is presented in Table 3. In these analyses it is assumed that feeding the reduced energy and co-product containing diets results in reductions in the daily energy intake, as reported previously by De la Llata (2001) and Barnes et al. (2011). As a result, body weight gain and probe back fat at the final body weight are somewhat reduced. Obviously, feed efficiency will be poorer when pigs are fed co-product containing diets with reduced energy content. However, body weight gain per unit of net energy intake is similar for both feeding programs. Therefore, feeding programs should be compared based on cost per unit of energy – whereby all other dietary nutrients are balanced against diet net energy content – rather than feed efficiency. The data also show that amino acid levels and ratios among key amino acids (e.g., threonine to lysine ratio) should be adjusted when feeding high fiber containing co-products to pigs. Ultimately, the use of co-products should be determined based on cost-benefit analyses, considering effects on carcass value, ingredient costs, and the value of throughput in the growing-finishing barn. Such cost-benefit analyses will be addressed in subsequent papers in this workshop.

Table 2. Interactive effect of feeding level and pig performance potential (mean Pd) on estimated nutrient requirements of finishing pigs between 90 and 120 kg body weight (typical barrows and gilts; diet NE content 2475 kcal/kg; fermentable fiber content 10.5%; NRC 2012).

Scenario	1	2	3	4	5	6
Inputs						
Actual mean feed intake + wastage, kg/day ^a	2.300	2.100	1.950	2.300	2.100	1.950
User defined mean Pd, g/day ^a	120	120	120	160	160	160
Results						
Probe back fat at slaughter body weight, mm	21.0	18.5	17.5	14.4	12.9	12.6
Carcass lean yield, % ^b	59.5	60.6	61.1	62.7	63.5	63.7
Average feed intake + wastage, kg/day	2.853	2.607	2.422	2.852	2.609	2.423
Average body weight gain, g/day	851	785	724	990	921	828
Gain : (Feed intake + wastage), kg/kg	0.298	0.301	0.299	0.347	0.353	0.342
Average SID ^c Lys requirement, %	0.61	0.67	0.69	0.71	0.77	0.76
Average SID Lys requirement, g/day	16.6	16.5	15.9	19.3	19.0	17.4
Avg. SID Thr requirem., ratio to Lys × 100	66.4	66.8	66.7	63.5	65.6	62.8
Avg. STTD ^c phosphorus requirem., %	0.20	0.22	0.23	0.26	0.28	0.28

^a Mean values between 25 and 125 kg body weight.

^b Estimated from modelled probe back fat.

^c See Table 1.

Table 3. Estimated nutrient requirements according to NRC (2012) of finishing pigs (barrows and gilts; typical performance levels; 90 to 120 kg body weight) that are fed either corn and soybean meal based diets (CoSBM) or diets containing 30% corn DDGS (6-9% fat) and 20% wheat shorts (Co-products).

	Feeding program	
	CoSBM	Co-products
Average diet NE content, kcal/kg	2513	2328 (-7.4%)
Average NE intake, kcal/day	6656	6400 (-3.7%)
Probe back fat at slaughter body weight, mm	17.9	16.8 (-6%)
Carcass lean yield, % ^a	60.9	61.4 (+0.8%)
Average feed intake + wastage, kg/day	2.788	2.893 (+3.7%)
Average body weight gain, g/day	894	867 (-3.0%)
Gain : (Feed intake + wastage), kg/kg	0.321	0.300 (-6.5%)
Average body weight gain : NE intake (g/Mcal)	0.134	0.135(+0.9%)
Average SID ^b Lys requirement, %	0.67	0.64 (-4.4%)
Average SID Lys requirement, g/day	17.6	17.7 (+0.6%)
Average SID Thr requirements, ratio to Lys × 100	64.4	69.0 (+7.1%)
Average STTD ^b Phosphorus requirements, %	0.23	0.22 (-4.3%)

^a Estimated from modelled probe back fat.

^b See Table 1.

CONCLUSIONS

1. The current high feed costs increase the need for developing cost-effective feeding strategies for growing-finishing pigs.
2. Modelling nutrient utilization allows for a systematic approach to optimize feeding programs for individual pig units, considering local pig performance potentials and available feed ingredients, as well as environmental and economic conditions.
3. NRC (2012) nutrient requirements models provide a tool to better understand the complex interactions between feed intake, pig performance potentials, available feed ingredients, environmental conditions, carcass quality and nutrient requirements; these models can be used to estimate the unique nutrient requirements for individual groups of pigs.
4. Two key limitations of the NRC (2012) models: (1) they do not allow cost-benefit analyses, and (2) they are unlikely to yield accurate predictions of feed intake.
5. Performance of growing-finishing pigs (feed intake, growth, and carcass quality) should be monitored closely and feeding programs should be evaluated regularly.

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Animal Variation and the Derivation of Optimal Shipping Strategies for Finishing Pigs

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ABSTRACT

Defining the optimum strategy to ship finisher pigs is essential for increasing farm profitability, and conversely if shipping management is inappropriately applied, loss of revenue can occur. The complexity of performance and economic interactions and options available for pig producers to market their pigs makes it imperative to use appropriate integrated growth models to help determine the optimum (maximize farm income) solution. The prediction of what shipping strategy should be adopted will depend on many factors but the essential components include understanding the consequences of animal variation and the main causes of variation, including social stressors, as well as the capacity to optimize over a range of production, nutrition and shipping scenarios. The ability of an individual animal to cope with social stress is a major source of variation between animals within a population. Therefore any introduction of animal variation into growth models must incorporate this genetic characteristic as well as the interactions between this ability to cope and the social stressor(s) most commonly observed in commercial conditions, namely stocking density, feeder space allowance and health challenges. The individual animal's ability to cope to suboptimal conditions will influence its potential protein growth rate as well as the extent stocking density and feeder space allowance will affect the potential growth and voluntary feed intake. A study on two different shipping strategies provides an example of how important it is to define the optimum marketing strategy based on the production system and the grading grid(s).

INTRODUCTION

Most integrated pig growth models are concerned with the response of the 'average' individual within the herd (population) and assumes this is a good representation of the population. In most practical cases this assumption may hold true. However, it has been shown that the overall close-out (mean of the population) responses can differ significantly from the average individual response due to the variation in growth potential between individual animals within the herd (Curnow, 1973, Knap, 2000; Pomar et al., 2003; Brossard et al., 2009). The extent of the difference between the average individual and the population mean response will depend on how large are the differences between individual genotypes within the population, the correlation between the genetic parameters defining the genotype, and the individual animal's ability to cope with social stressors (Wellock et al., 2003 and 2004). The more individuals vary within a population (or the greater the weight variation), the more inappropriate it is to use the average individual response as a means of predicting the population mean response. For example predicting nutrient requirements for a population based on the single deterministic response will introduce a bias against individuals with a higher nutrient requirement. These errors can be magnified during the optimization process which is dependent on the herd nutrient responses. Not only is the introduction of animal genetic variation essential for more accurate nutritional optimization but according to Knap (1995), it also influences financial outcomes because of the

effect animal variation has on the variation in production characteristics (feed intakes, growth rates, backfat, hot carcass weight, lean yield and MOFC. In the monthly Hormel Report (Dec 2005) they indicated that a reduction in shipping weight variation or having more pigs shipped at ideal weight, may result in a \$5.70/pig increase, and similarly in the Manitoba Pork Marketing Co-operative monthly report (January, 2008) they suggested a \$2.00/pig improvement. Further reasons for considering between-animal variation in pig modelling are 1) to more accurately predicting the optimum strategy for shipping pigs to market to increase the proportion of “full-value” pigs per close-out; and 2) enhance production through better utilization of space and minimizing performance failures. There are other sources of variation (health, feed and physical environment) that influence the individual’s response and therefore the population response besides the genetic and social variation. However, for the purposes of this paper, these latter sources of variation will not be addressed, and attention will be given to the effect social interactions influence variation between individual animals and how between-animal variation may affect the derivation of optimal shipping strategies

DRIVERS OF ANIMAL VARIATION

Genetic Potential

As described in previous papers (Ferguson, 2006) and other similar models (Knap 2000; Pomar et al., 2003; Wellock et al., 2003) the genetic potential growth of an individual pig can be defined by 4 components: 1) potential rate of maturing (B), 2) mature protein weight (Pm); 3) inherent fatness or desired fat level relative to protein weight (LPm); and 4) the amount of water relative to protein weight (WPm). For the most part these parameters are independent of each other (uncorrelated) and are assumed to be normally distributed, such that the genetic parameters of individuals can be randomly generated around the mean and standard deviation (Ferguson et al., 1997). The exception is the strong correlation between Pm and B, but this will not be discussed further.

Initial size (body weight for a given age)

Individuals within a population are likely to have different body weights for a given age, and therefore different amounts of protein, lipid, water and ash. Assuming a fixed starting age, initial body weight will vary according to the population mean weight and standard deviation. This variation at the start of the growing period will be a significant factor affecting the variation in body weights at slaughter. Based on previous grower-finisher trials within Nutreco Canada, the coefficient of variation of body weights close to 25kg varied from 6%-17% with an average of 11%. Part of the variation in Starting weight will be derived from the individual’s potential growth rate, and therefore Start weight should be correlated with the genetic parameters (Wellock et al., 2004). Individuals with the highest growth potential will tend to have the highest Start weight.

Social interactions

Earlier studies have clearly demonstrated that individual pigs within a pen interact differently with each other, and these interactions can affect individual performances (Tindsley and Lean, 1984). Data from Giroux et al., (2000) indicate that social interactions can account for 9% of the variation in ADG in growing pigs. Socially dominant individuals, often larger individuals, are less affected by social stresses and tend to perform better than their subordinates when exposed to suboptimal conditions (e.g high stocking density, inadequate feeder space)

(Botermans, 1999). Wellock et al. (2003) introduced a genetic parameter to facilitate the interaction between an individual pig and its social environment, and subsequent effects on performance. This parameter describes the ability of an individual pig to cope when exposed to suboptimal conditions (A2C) and would be used to define both when an individual becomes stressed and by how much the stressor decreases performance. The mechanism by which A2C exerts its influence involves both the ability to attain potential growth and changes to feeding behaviour. Socially stressed animals (low A2C) will have a lower capacity to achieve potential (protein) growth as well as reduced accessibility to food, and therefore their performance is expected to be reduced. The evidence for these mechanisms are more circumstantial than exact, but nevertheless support the idea that stressed animals do not attain their potential and their normal feeding behaviour is disrupted. (Nielsen et al., 1995; Turner et al., 2002; Anil et al., 2007). This is certainly evident when comparing individual versus group housed pigs (Gonyou et al., 1992; Ferguson et al., 2001). It is likely that both time at the feeder and the rate of feeding will be adversely affected by socially stressed pigs (Nielsen, 1999; Turner et al., 2002). Nielsen (1999) suggested that one of the reasons social constraints will adversely affect ad libitum feed intake is due to the desire to eat simultaneously with other pigs in the pen and therefore have to cope with increased competition for feeder space. The main social stressors that interact with A2C include stocking density, feeder space and health status (Figure 1).

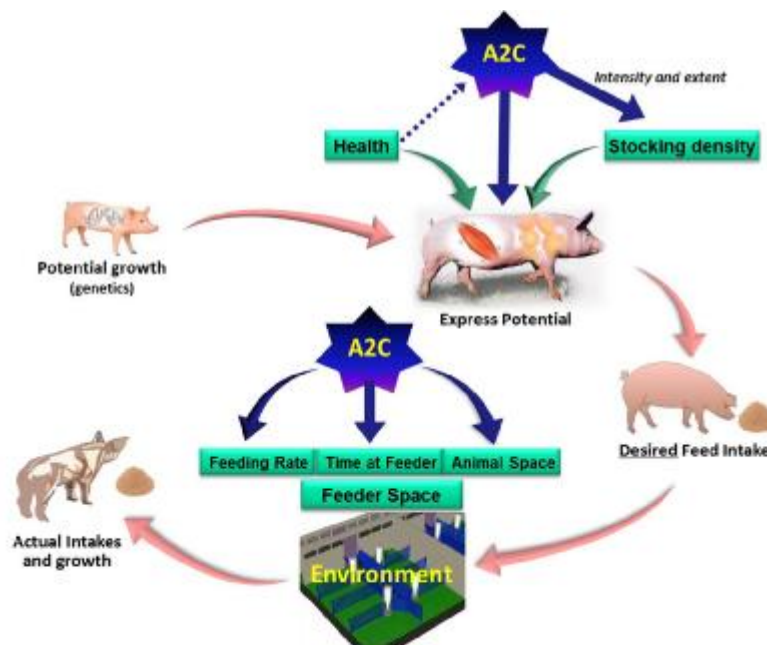


Figure 1. Interactions between social stressors, ability to cope (A2C), and subsequent effects on performance.

Because of the strong correlation between size and dominance (Tindsley and Lean, 1984; D'Eath, 2002), it is reasonable to assume that there is a strong positive correlation between live weight and A2C. Turner et al. (2002) observed a greater reduction in growth rates in smaller pigs than larger pigs when grown under more stressful conditions (low feeder space and large group size). There is likely to be an increase in within-pen body weight variation when the level of stress increases. This was observed by Anil et al. (2007) when pigs kept in acceptable

stocking density levels ($>0.74 \text{ m}^2/\text{pig}$) had body weight standard deviations of 7.6-14.9kg compared to those pigs with less space ($0.64 \text{ m}^2/\text{pig}$) of 11.7-16.6kg. Although these differences were not statistically different they do highlight the possibility that the weight differences between the small and large pigs in a pen may increase with higher levels of stress. Tindsley and Lean (1984) noted that dominant pigs were generally the heaviest pigs and that the variation in ability to dominate may be responsible for live weight variations. Pigs with a low ability to cope with stress will require more space and if this is limiting then they will be more severely affected than individuals with a higher A2C. Conversely, pigs with a very high ability to cope with stress will realize their potential growth at much lower space allowances and when their potential is constrained, the extent will be lower than pigs with a low A2C. DeDecker et al. (2005) concluded from their study that increasing feeder space benefitted the smaller pigs more than the heavier pigs as they grew proportionally faster and became heavier than smaller pigs with less space. Individual differences in voluntary feed intake can be explained partly by the variation in feeding behaviour associated with social ranking (Giroux et al., 2000). Feeding time and the rate of feeding change when there is limited feeding space, but the extent of the change will depend on the social hierarchy (Nielsen, 1999; Turner et al., 2002). Therefore, individuals with a lower social standing will probably have less time at the feeder than the socially dominant pig(s). A further source of variation between animals within a group, is related to their immuno-competence (Knap and Bishop, 2000; Flori et al., 2011). Clapperton et al. (2009) observed substantial genetic variation in immunity traits pigs in general, and therefore it can be assumed that individual pigs in a population will have different abilities to fight health challenges. It is expected that in a batch of pigs that on average show a low health status there is likely to be more variation than a high health herd, because there will still be some pigs showing a strong immunocompetency. There is likely to be some interaction between A2C and health status, especially in better health conditions. Healthier individuals can cope better with stress than less healthy.

OPTIMIZATION

Optimizing nutritional strategies based on economic returns or animal performance, rather than least cost formulation for a defined set of nutrient requirements, is the most appropriate method for improving performance and profitability at the farm level. Gous and Berhe (2006) define the criteria required for optimization as: 1) feed costs at defined nutrient levels; 2) animal responses to changing nutrient profiles; 3) fixed and variable costs associated with the production system; and 4) definition of revenue generating processes. Figure 2 illustrates the relationship between animal biology, optimization and animal variation defined in Watson 2.0¹.

The optimization process is started by passing initial specifications (nutrients) to a feed formulator to determine the least cost feeds (Formulation) which in turn are fed to the animal biology component to produce a specific performance, including feed intake, growth, carcass characteristics. From the performance output it is possible to generate the costs and revenue (Economics) which is passed back to the optimizer to complete the cycle. This process is repeated before identifying the 'best' solution to meet the optimization objective. Currently in Watson 2.0 the processes to be optimized include energy content, nutrient density, amino acid responses, carcass weights and feeding phases, while the objectives include maximizing growth

¹ Watson 2.0 Swine Performance Investigator
<http://www.nutrecocanada.com/shur-gain/animal-nutrition/swine/swine-research/-watson-2.0>

rates, margin over feed costs, net profit per pig and minimizing feed:gain, cost/kg gain, and nutrient excretion. Within a batch of finishing pigs there is sufficient between-animal variation in protein and fat deposition, feed intake and subsequent efficiency of nutrient utilization to ensure differences in nutrient responses between the single average individual and the batch mean (Pomar et al., 2003; Brossard et al., 2009; de Lange et al., 2012). However, the incremental cost of increasing the dietary amino acid level may not be offset by the increase in revenue generated from improved feed efficiency and/or higher carcass lean, resulting in differences in amino acid requirements between minimizing feed:gain and maximizing margin over feed costs. As individual pigs will have different optimum performance and economic responses to amino acid intakes, it is necessary to incorporate this between-animal variation into the optimization process.

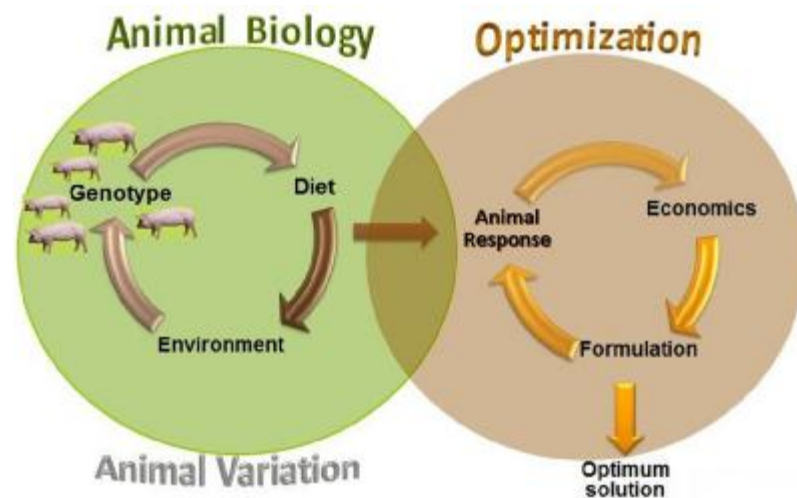


Figure 2. Relationship between animal biology, animal variation, and optimization processes.

SHIPPING MANAGEMENT STRATEGIES

One of the most important drivers of profitability in pig production is the revenue per pig carcass, and therefore the higher, and less variable the income generated per batch of pigs, the more profitable the operation. It is imperative for the producer to strive to optimize when individual pigs should be shipped, in order to maximize profitability. For this reason animal variation will be introduced into Watson, from which it will be possible to determine how many pigs are at, or close to, the minimum ideal market weight and what are their performances and economics for each of the shipping weeks. To illustrate the potential opportunities, a simple example is provided illustrating how many barrows and gilts could be shipped over a 4 week period, having met producer-defined minimum shipping weights for each week of shipping. For the purposes of this exercise 2 shipping strategies were compared: 1) a fixed minimum shipping weight of 120kg, and 2) the minimum live weight for the 1st week of 120kg, followed thereafter by a minimum of 123kg. The target or ideal live weight was 125kg. It is expected that first shipments will occur at Week 14, which will result in a significantly large proportion of the population (45%) being shipped that week. As expected more barrows than gilts will be shipped earlier (Figure 3).

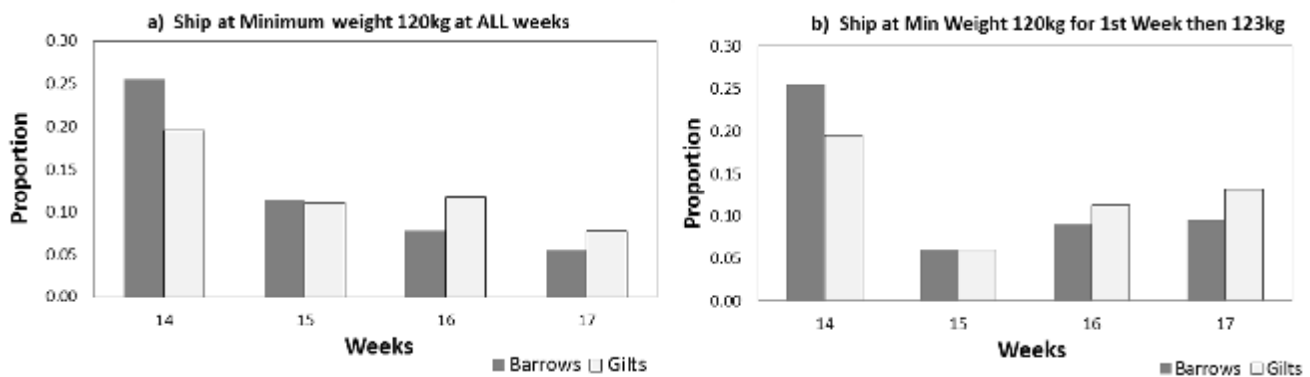


Figure 3. Proportion of Barrows and Gilts shipped over a 4 week period using different minimum shipping weights: a) 120kg for all weeks; b) 120kg for the 1st week then 123kg.

SHIPPING MANAGEMENT OPTIMIZATION

To determine the shipping strategy that will return the highest margin over feed costs (MOFC) it is necessary to define the range of either Weekly Shipping Proportions (%) or the Minimum Shipping Weight for each week. The model will generate the performance and economic data for each individual pig, and then collate the data from those individual pigs that meet the minimum shipping weight for each of the shipping weeks. For example, one combination could be: Ship 0% pigs the 1st week, the heaviest 6% in Week 2, the next 24% heaviest in Week 3, the next 18% heaviest pigs in Week 4, the next 18% heaviest in Week 5, and the remaining 34% in Week 6 (Figure 4). This would provide the solution for one shipping combination and therefore it is necessary to repeat for all possible combinations before deriving the the weekly shipping strategy that produces the highest MOFC.

CASE STUDY: COMPARISON OF CONVENTIONAL WEEKLY SHIPPING VERSUS AN ALTERNATIVE SHIPPING STRATEGY FOR HEAVY PIGS

A trial was conducted to compare the biological and economical results of a conventional (CONV) versus an alternative (ALT) shipping strategy to a grid with a constant index up to a maximum of 112kg hot carcass weight (136 kg shipping weight). For the CONV treatment shipping occurred weekly between Weeks 13 and 17 with a target weight of 128-132kg (n=20 pens), while the ALT treatment involved shipping pigs only twice (2 heaviest pigs from each pen (28%) at Week 13 and the remainder at the end of Week 17) (n=22 pens). The results are shown in Table 1.

Pigs on the ALT strategy had a significantly higher feed conversion ratio (+3% or 0.07g/g), increased feed costs (+\$6.80) and increased cost/kg gain (+\$0.023/kg), resulting in a reduced MOFC (-\$5.70/pig). The ALT strategy may reduce labour costs and increase the shipping weight at the end of 17 weeks by 2kg, but there will be more variation in shipping weight. It could be argued that under commercial conditions the ALT strategy could have a larger throughput of pigs (higher stocking density) and therefore higher gross profit per year. The economic outcomes of this study would be different if shipping to a grid that has a narrower ideal carcass weight range. The point of this case study is to highlight the opportunity to define

optimum shipping strategies based on the production constraints within the farm and the grading grids the pigs will receive payment from.

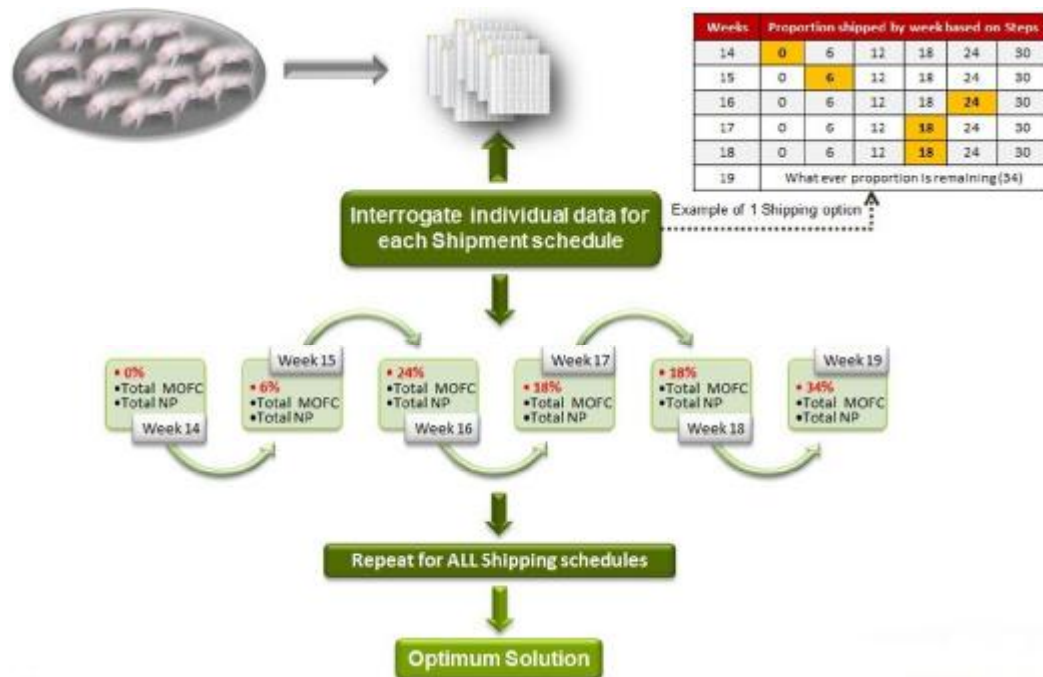


Figure 4. An example of the process to determine the optimum shipping strategy based on maximizing the MOFC.

Table 1. Whole finisher period (Day 0-119) performances of Conventional vs Alternative shipping strategies (Nutreco Canada Study ZS8555i, 2012).

	Conventional	Alternative	P
Start Weight, kg	22.06	21.98	NS
Ship Weight, kg	130.12	132.04	0.009
Ship Weight Variation, CV%	3.4	7.7	0.011
ADFI, kg/d	2.445	2.504	0.102
ADG, kg/d	0.963	0.959	NS
Feed:Gain, kg/kg	2.54	2.61	0.002
Mortality, %	4.3	5.4	NS
Feed Cost, \$	92.30	99.10	0.028
Cost/kg gain, \$/kg	0.838	0.861	0.001
Revenue, \$ ¹	182.32	183.21	NS
MOFC, \$	89.90	84.20	0.078
Backfat, mm	18.7	19.4	NS
Lean Yield,	60.7	60.4	NS

¹ Revenue based on average hog price (\$155.71)

CONCLUSIONS

The complexity of animal performance and economic interactions on the options available for pig producers to market their pigs makes it imperative to use appropriate integrated growth models to help determine the optimum (maximize farm income) solution. The consequences of not optimizing the shipping strategy for a specific grid(s) can significantly reduce farm income. To be able to define the optimum shipping strategy, it is necessary to understand how animal variation impacts when individual pigs are marketed and the optimization process. Gous and Berhe (2006) summarize the importance of incorporating animal variation into the optimization process as follows:

“Models of individuals may be adequate for an understanding of the theory of growth and feed intake, as well as for ‘what-if’ scenario planning. However, for purposes of optimization, it is imperative to account for the variation inherent in the system if a realistic assessment of the population response is to be simulated.”

Managing between-animal variation and applying the optimum shipping strategy for a given slaughter plant(s) has the potential to significantly improve farm profitability.

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New Tools For Precision Feeding
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ABSTRACT

Sophisticated nutrition technologies developed in recent years permit more efficient pig production while minimizing overfeeding and waste. To apply these technologies in practice well-designed mathematical models have been created. PorcTech™ is a nutrition decision support system with a strong emphasis on nutrient evaluation of ingredients providing a common nutrient vocabulary from nutrient supply to nutrient demand. Simple proximate nutrients are used as input to calculate complex digestible nutrients and net energy. This data is used to assess ingredients, set nutrient demands, and project animal performance for nutrient formulations that fit business expectations.

INTRODUCTION

During the last 20 years many nutritional developments have been introduced. The transition from ingredient formulation to systems based on digestible nutrients and net energy, and the definition of nutrient requirements using a factorial approach have been among the most influential (Patience, 2013). The goal of these developments has been to maximize nutrient utilization in swine production while avoiding overfeeding and waste. Sophisticated energy and amino acid systems have been established but the practical application of these technologies at the farm level remains a challenge. Electronic decision support tools are ideally suited to evaluate interacting factors such as housing conditions, genetics, ingredient quality, and feeding management. As a complement to the conference workshop on “New Tools for Grower-Finisher Pigs” this paper outlines key concepts of PorcTech™, a nutrition decision support system used by Agribands Purina (Burghardi et al., 2005). Emphasis will be given to nutrient evaluation in support of better on-farm value decisions for ingredient selection and feed cost reduction.

CORE NUTRITION SUPPORT

Nutrient Supply

Nourishing animals begins with nutrients and it starts with knowing the nutrient supply delivered by feed ingredients. Central to PorcTech™ is a vast database of ingredient raw materials ranging from cereals to oil seeds in addition to a whole host of by-products from plant and animal origins. For quick reference these ingredients are provided with characteristic nutrient levels using the Cargill nutrient vocabulary.

The nutrient matrix is extended through PorcTech's™ capability to dynamically recalculate sophisticated digestible nutrients and net energy values from a few simple nutrients such as protein, fat, NDF, ash and moisture. This functionality, trademarked as AutoCalc™, is based on countless ingredient specific coefficients. Based on research from Cargill's Innovation Center numerous digestible nutrients are available in PorcTech™. This includes production stage specific net energy values for sows, piglets and grower-finisher pigs, standardized ileal digestible amino acids, fermentable fiber or digestible phosphorus to name just a few.

The user can thus select ingredients from the database and is then able to customize the nutrient matrix with the analytical data he has available. This requires routine ingredient analysis and the maintenance of farm specific nutrient databases, which identify ingredients and suppliers, has been shown to be of great value. Such databases permit feed formulation with supplier specific nutrient averages and allow detailed economic analysis of ingredients. Analytical cost is kept low with AutoCalc™ requiring only basic nutrient inputs.

In addition to its cost effectiveness and simplicity for quick nutrient recalculation, the AutoCalc™ approach ensures a consistent nutrient vocabulary for all nutrient valuation. The latter is frequently overlooked when unrelated nutrient systems are used to connect nutrient supply with nutrient demand. It is important to ensure that a common nutrient evaluation system is used for the nutrient supply from all ingredients as well as for the evaluation of the pig's nutrient demand.

Nutrient Demand

PorcTech™ can determine nutrient demands for various production stages (piglets, grower-finisher, and sows) and translate them into nutrient specifications for diets. These nutrient requirements are generated based on model inputs such as the pig's lean growth potential, environmental factors or feed intake. An important practice when working with a given farm situation is the calibration of model predictions to observed performance through adjustment of model inputs. Once current performance is accurately predicted PorcTech™ can be used to evaluate alternative feed management strategies focused upon farm specific value expectations.

DECISION SUPPORT TOOL IN PRACTICE

Finer grinding, thus reducing particle size of corn is well known to improve digestibility and net energy content. With the functionality of AutoCalc™ the impact of processing on the nutritional and economic value of corn can be evaluated. Particle size of ground corn can be determined on-farm using the Purina particle score tool and with this input AutoCalc™ adjusts the net energy value of corn. To estimate the economic impact of a 350 micrometer reduction in corn particle size (750 vs 1100 µm) we projected the growth of pigs in PorcTech™ using conventional corn-soybean meal diets in a four phase feeding program. With the finer particle size corn using February 2013 ingredient costs PorcTech™ predicted a reduction in feed cost of \$1.94 per pig as presented in Table 1.

Table 1. Effect of feeding corn with different particle size on performance and feed cost in pigs grown from 25 to 120 kg body weight.

		Corn Particle Size		
		750 µm	1100 µm	Difference
Average daily gain	g/day	910	890	-20
Feed to gain		2.65	2.71	0.06
Carcass lean yield	%	60.5	60.6	0.1
Feed cost	\$/pig	92.28	94.22	1.94

To reduce formulation cost increasingly ingredients such as distillers or bakery are used in addition to more traditional ingredients like corn and soybean meal, but such ingredients also display substantial nutrient variability. We recently surveyed by-products commonly used for on-farm mixing of swine rations in Ontario and used PorcTech™ to estimate the cost associated

with unaccounted nutrient variation from such ingredients. For this evaluation ingredient samples were selected based on extremes (High and Low) in either crude protein (corn, DDGS, soybean meal) or fat (bakery) and AutoCalc™ was used to adjust other nutrients. Diets were formulated for a four phase feeding program using the four High ingredients plus an animal-vegetable fat blend and a Purina Sup-R-Mix basemix. Subsequently while maintaining the inclusion levels the High ingredients in all four phases were substituted with the nutrient profiles of the Low ingredients from the survey. As shown in Table 2 the resulting differences in nutrient values are substantial.

Table 2. Diets formulated using the nutrient profiles of High ingredients; diet nutrient profiles shown are calculated using the High or Low ingredients from a survey of Ontario on-farm mixed raw materials.

Body Weight Range, kg		25-45	45-65	65-90	90-120
Bakery	%	20.0	20.0	20.0	20.0
Corn, 800 um	%	37.6	37.3	36.3	36.2
DDGS	%	10.0	15.0	20.0	25.0
Soybean meal	%	24.5	20.5	16.9	12.6
AV Fat	%	2.9	2.6	2.5	2.2
Sup-R-Mix	%	5.0	4.6	4.3	4.0
Feed cost	\$/MT	380.4	367.7	357.2	344.3

Ingredient Quality		High	Low	High	Low	High	Low	High	Low
Protein	%	20.8	19.4	20.2	18.7	19.8	18.1	19.0	17.2
SI Lysine	%	0.98	0.94	0.89	0.85	0.81	0.77	0.71	0.67
Net Energy	kcal/kg	2400	2272	2400	2268	2400	2262	2400	2258

The resulting two feeding programs reflecting the nutrient profiles of the High and Low ingredients were then used in PorcTech™ to predict performances for pigs in the weight range from 25 to 120 kg assuming an above average lean gain potential and an average feed intake. Results are illustrated in Table 3. As expected body weight gain and feed efficiency was much poorer when pigs were fed the lower nutrient dense ingredients without proper reformulation. The economic impact in additional feed cost was calculated to be \$4.39 per pig. This illustrates that regular analysis of ingredients is crucial for the accurate assessment of ingredient value, diet design and ultimately animal and economic performance. More frequent nutrient analysis is required for accurate assessment and support of business goals when feeding non-traditional ingredients that vary greatly in nutrient concentration.

Table 3. Estimated impact of feeding diets properly formulated for analyzed High nutrient densities versus diets substituted with ingredients of Low nutrient densities; pig performance and feed cost in pigs grown from 25 to 120 kg body weight.

		Ingredient Quality		
		High	Low	Difference
Average daily gain	g/day	920	880	-40
Feed to gain		2.67	2.80	0.13
Carcass lean yield	%	60.8	61.0	0.2
Feed cost	\$/pig	91.60	95.99	4.39

SUMMARY AND CONCLUSIONS

1. To effectively apply current nutrition knowledge to practical feeding and to properly evaluate interactive effects, software such as PorcTech™ that can model nutrient utilization is required.
2. A common nutrient vocabulary must be used to connect the assessment of ingredients, set nutrient demands, and project animal performance for nutrient formulations that fit business needs.
3. As more non-traditional feedstuffs are used in diet formulations, digestible nutrients and net energy based system translate into more precise nutrient intake and more consistent pig performance.
4. To effectively utilize non-traditional feedstuffs, with typically higher variation in nutrient content, requires regular nutrient analysis to support animal performance and long-term business goals.

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New Applications in Nursery Nutrition and Management: Giving Piglets the Best Possible Start with Practical Management Tips and Nutrition Concepts

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INTRODUCTION

The breadth of the topic of nursery pig management and nutrition is enormous and beyond the scope of a single paper, indeed there are entire books devoted to this area (e.g. The Weaner Pig Nutrition and management; Varley and Wiseman, 2001). Consequently, rather than try to be an exhaustive review, even on a few select topics of interest, we prefer only to make passing comments on some key areas. Our principle has been to include what we have found useful in guiding our thinking for farm advisory work. For more detailed information on nursery management, including some of the topics briefly covered here, see the paper of Wilcock (2009) previously presented at this conference.

In this paper we will begin by discussing the phenomena of compensatory, or ‘catch up’ growth as understanding the merits of compensatory growth may impact on how we choose to feed and manage piglets in the nursery. If we believe pigs will catch up any lost early growth later on in life, nutrition in the nursery may not be that important. It may also not be important to manage them correctly – why worry about getting the best out of piglets if any lost growth in the nursery can be caught up later? If however, we believe the way we feed and look after piglets in the nursery has lifetime performance and economic consequences, then we might pay attention to both nursery nutrition and management and the critical importance of feed intake to give them the best possible start.

Following some tips on how to increase nursery feed intake, we will briefly discuss a recent nutrition concept, superdosing phytase, one of our major research focuses over the past 3 years, before some final thoughts on how in our view a suitable nursery diet regime should be selected: if indeed we’ve managed to convince you it’s plays an important role in efficient, profitable and sustainable pork production!

COMPENSATORY GROWTH OR A LOST OPPORTUNITY?

Pig producers appear to have an unlimited optimism in their belief that pigs will compensate or catch up for any loss in their early growth caused by feeding a suboptimal starter diet or poor nursery management. This is perhaps not surprising as compensatory growth offers several advantages; mainly decreased overall feed costs as the lower performance caused by feeding a ‘cheaper’, lower quality, starter diet need no longer worry us because it will be cancelled out by compensatory growth on the lower cost per tonne grower/finisher diets. So with all this producer optimism and these apparent benefits why isn’t every commercial pig producer using a ‘compensatory growth’ feeding programme? Let’s look at the evidence; does compensatory growth occur, if so under what circumstances and then most important of all how can we take commercial advantage of it.

First we must have a clear definition of compensatory growth, which in itself is often not clear. The common definition is that for compensatory growth to have occurred, pigs which have been exposed to a period of restricted growth, through either insufficient feed intake (e.g., causes such as health and management factors including stocking density and feeder space) or an imbalance in the diet (e.g., protein to energy ratio, amino acid imbalance), must after a period of catch up growth regain a position that were similar, or at least not significantly different, to pigs that were unrestricted in their growth. With this definition in mind let's look at the evidence. There are numerous scientific papers on compensatory growth that are relevant to what we do in commercial production. A brief literature search on the effect of dietary amino acid restriction in the starter period on subsequent performance highlights 12 published papers with clear evidence for compensatory growth (Hogberg and Zimmerman, 1978; Critser et al., 1995; Chiba, 1995; Chiba et al., 1999; Fabian et al., 2004; Reynolds and O'Doherty, 2006; O'Connell et al., 2006; Heyer and Lebre, 2007; Martinez-Ramirez et al., 2008, 2009; Fernández and Nørgaard, 2009; Yang et al., 2009), whereby a significant difference in body weight at the end of the restriction period disappears by the end of the trial. That is to say there is no significant difference in end weight between restricted and non-restricted pigs and so the pigs have apparently caught up.

Should we be happy with this evidence that compensatory growth can and does commonly occur and may therefore be commercially exploited? Before we answer this question, it's important to look how these trials were conducted, in particular how well replicated they were, and also the normal variation in body weight we expect to see in a population of pigs. While much of the data clearly shows the significant difference in body weight (BW) at the end of the restriction (nursery) period is no longer significant at slaughter, we argue the reason for this may be not that the pigs have caught up, but rather that the experiment was not sensitive enough (i.e. was not well enough replicated) to pick up the observed difference in end weight as statistically significant. For example, a 1 kg difference in BW at the end of the starter period is equivalent to 6.6% of a mean BW of 15 kg. This 1 kg difference in BW which may remain through the pigs' life represents less than 0.9% of a typical slaughter weight of 115 kg. It is perhaps not surprising therefore we can't pick this difference up with experiments designed to look only for differences in the starter period. A difference in BW of 7.67 kg at 115 kg would need to be achieved to observe the same 6.6% difference in BW as seen at the end of the starter period.

Not only do we have to deal with the mathematics of relative differences in BW outlined above, but we also have to understand the pigs themselves and the expected level of variation in a given population of pigs. Unpublished data collected by Harper Adam University College, UK, and supplied by JSR Genetics demonstrates this beautifully (Figure 1). This is data from 480 pigs of the same genotype on the same unit under the same management and feeding regime. What is clear to see is that variation in BW increases as pigs increase in weight/age. The standard deviation (Stdev) in BW increases from 1.82 kg (mean BW = 8.17 kg) at 26 days of age (weaning) to 3.09 kg (mean BW = 15.55 kg) at 48 days of age to 10.39 kg (mean BW = 85.53 kg) at 130 days of age. Day 130 is the last time point all pigs were weighed as the fastest growing pigs achieved slaughter weight. Of course we manage pigs to minimise slaughter weight variation by selecting pigs from differing batches/drafts so it would be rare a commercial enterprise saw this level of variation in their grading slips, unless they were a strict all-in-all-out system with all pigs going to slaughter on the same day.

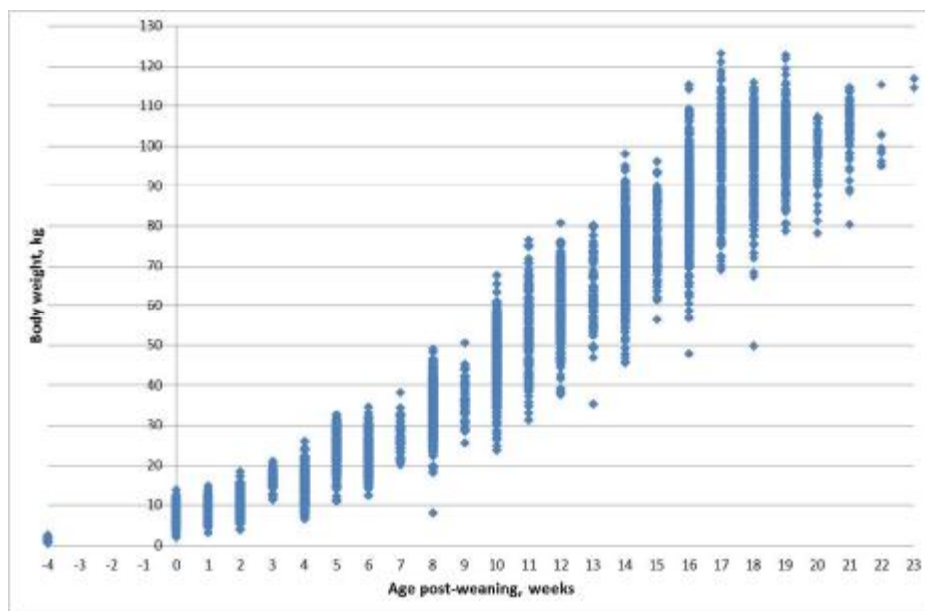


Figure 1. Individual body weight over time of a group of 480 pigs of the same genotype on the same unit (Harper Adams University College, UK) under the same management and feeding regime. Data kindly supplied by JSR Genetics.

Looking at the normal level of variation that exists between pigs it's perhaps not surprising that pigs appear to catch up 1 kg of lost growth in nursery by the time they reach slaughter. Power calculations with the above data demonstrate we would need 26 replicates (individually housed pigs in this case) to detect 1 kg at nursery exit compared to 279 replicates at day 130 of age. With only 26 replicates we would only be able to detect a difference of 3.3 kg at day 130; less than 33% of the observed standard deviation. Most experiments are of course conducted on pen replicates. Mean pen BW (\pm Stdev) of these same pigs (46 pens of 9-12 pigs) at day 48 and 130 of age were 15.48 (\pm 3.17) kg and 86.63 (\pm 6.32) kg respectively. We would therefore require 10 pens per treatment to detect a 1 kg difference in BW at day 48 and 108 pens per treatment to detect a 1 kg difference at 130 of age. With 10 pens per treatment the minimum difference we could be confident in detecting is 3.4 kg at day 130. How many trials have the luxury of the required replication and were set up to detect this level of difference?

So what we need is (i) better replicated experiments, and (ii) perhaps a better definition of compensatory growth for this large number of under replicated trials. Rather than define compensatory growth as a lack of difference in BW at the defined catch up point, let's rather define compensatory growth as restricted pigs exhibiting a significantly faster rate of gain than their non-restricted counterparts in the period of catch up growth in addition to no significant difference in body weight at the end of the catch up period. Going back to the same 12 scientific papers on compensatory growth with our new definition, only 5 of these now exhibit true compensatory gain (Critser et al., 1995; O'Connell et al., 2006; Heyer and Lebre, 2007; Martinez-Ramirez et al., 2008, 2009). Perhaps a little less convincing, although clear evidence compensatory gain can and does occur.

Where we do observe significantly faster rates of gain in the catch up period, does this provide enough information to understand and commercially exploit compensatory growth? Firstly, we need also to be sure that it is indeed the restricted pigs that did indeed grow faster and catch up,

rather than we slowed down the unrestricted pigs or at least didn't allow them to fulfil their genetic potential, through either suboptimal nutrition or management (bigger pigs would be heavier stocked for example). We need also to be sure pigs don't require a better diet to allow them to compensate as demonstrated by Whang et al., (2003) and that the additional cost of these higher specification diets don't cancel out any earlier saving made. Lastly, there is the issue of reproducible and consistent results. Both Wahlstrom and Libal (1983) and Taylor et al., (submitted) reported the presence and absence of compensatory live weight gain when summarising their own series of four experiments conducted under the same conditions. These conflicting results are yet to be fully understood.

We are willing to concede there is some foundation in the pig producer's optimism around compensatory growth but more work is necessary before science unravels enough of the complex factors to allow compensatory growth feed programmes to be commercially exploited. When we dig deeper into the science we see many variables that may influence the likelihood of observing compensatory growth; sex, genotype, length and severity of restriction and timing. That's before we even start to look at the conflicting evidence of which body fractions are able to demonstrate compensatory gain (e.g., Bikker et al., 1996).

In terms of compensatory growth we are struggling to see the 'wood for the trees' at the scientific level so believe producers have little chance at exploiting it at commercial farm level without taking what would appear to be an inappropriate risk. Let's rather try and minimise the lost opportunity of growth rather than try and exploit this poorly, currently at least, understood phenomena of compensatory growth. Better to get the pigs off to a better start through appropriate nutrition and management to ensure a quicker and more economical journey to slaughter allowing more profitable and sustainable pig production. A number of authors have shown that improving early nursery performance leads to a better lifetime performance with an average benefit of 1 kg out of the nursery equating to approximately 4 days saving to slaughter or put another way 3 to 4 kg extra gain (e.g., Tokach et al., 1992; Pluske et al., 1995, 1999; Dunshea et al., 1997; Slade et al., 2000; Kim et al., 2001; Lawlor et al., 2002; Broom et al., 2003).

HOW TO IMPROVE POST-WEANING FEED INTAKE

Our understanding of commercial practice is that the factor dominating both performance and health remains the level of feed intake pre- and post-weaning, with diet composition playing a vitally important yet less significant supporting role. The importance of feed intake and how this can be impacted by both nutrition and management is covered in the following section.

The importance of feed intake post-weaning

In the majority of modern pig production systems, piglets are weaned into a nursery facility where they must be adapt to a solid diet rapidly in order to survive and thrive in their new environment. During this transition, many newly weaned pigs experience a 1 to 3 day period of anorexia resulting in growth stasis that can be detrimental to their health and productivity: the post-weaning growth check. While the precise mechanisms associated with this period of anorexia are not fully understood, it's routinely attributed to several factors; maternal separation, stress associated with their new environmental, social surroundings and exposure to new pathogens.

Understanding and subsequently reducing the post-weaning growth check becomes even more challenging given the individual piglet variation that exists in behaviour and response to weaning, which is ultimately linked to lifetime feed intake and growth. Even a successful transition at weaning is rarely without an associated biological and economic cost. Therefore, one of the biggest challenges, and potentially lucrative opportunities, in pig production is the ability to prevent or decrease the amount of time that young pigs spend in this weaning induced period of anorexia by being able to stimulate feed intake (and growth).

What is ‘average’ post-weaning feed intake?

Before tackling the issue of how we might increase post-weaning feed intake it’s useful to have a feel for what is a ‘normal’. Understanding what is ‘normal’ or ‘average’ is much harder than it might appear because not only is post-weaning feed intake highly variable between individual units due to differences in disease pressure, genetics and housing, it is also highly variable between individuals of similar weights in the same pen. Not only that but very few farms adequately record intake in the nursery.

Given the right conditions piglets are able to consume impressive amounts of feed in the immediate post-weaning period. This is shown by the black line in Figure 2 which represents the average daily feed intake collected from 4 week weaned piglets housed individually under experimental conditions (i.e., minimal environmental constraints) and will be close to the piglet’s maximum potential (unpublished data from Wellock et al., 2006). Clearly the piglet isn’t the limiting factor given suitable conditions and minimal disease pressure. Under commercial conditions where a number of constraints exist, of which disease pressure is often the most important, intake is typically much lower as shown by the yellow line in Figure 2. This represents the average daily feed intake recorded at Primary Diets principal trial site, Leeds University, in over 25 recent experimental trials and represents intake of over 5000 individually tagged pigs housed in 600 pens. Leeds University is a conventional health indoor slatted unit and typical of average UK conditions. This ‘Conventional Health’ intake curve (yellow line) has been compared against data from over 150 commercial trials (brown line) and can be considered a good representation of the average UK farm. To account for the variation that exists between commercial units due to factors mentioned earlier a lower (red line) and upper range (green line) have been added to Figure 2 to capture the majority of commercial units. Our challenge as nutritionists and pig producers must be to increase intake post-weaning.

Seven ways to improve post-weaning intake

There are a number of nutritional and management factors that have been shown to have a dramatic effect on post-weaning feed intake. The following list (summarized in Table 1) highlights some of these factors which are relatively easy to employ on farm.

1. Creep feeding

The importance of creep feeding is often overlooked perhaps due to the small amount eaten pre-weaning, typically around 200-250 g/pig. However, creep feeding from an early age has been demonstrated to improve the transition to solid food at weaning, and thus improve post-weaning intake and performance in pigs weaned at both 21 days (Sulabo et al., 2010) and 28 days (Bruininx et al., 2002a). Creep feed should be offered from around 4 to 10 days of age as studies have shown that the earlier creep feed is offered the greater proportion (80%) of the litter will be eating creep by weaning (Sulabo et al., 2010); even then not all pigs eat, often those on front teat with plentiful milk supply, and it often these that are the problem weaners. Piglets which

consume creep pre-weaning make the transition to solid feed post-weaning much easier, due to both an improvement in gastrointestinal tract morphology and health and learnt feeding behaviour. This results in improved post-weaning feed intakes of around 40 g/day (Sulabo et al., 2010) and improves lifetime performance (Klindt, 2003).

Recent studies have shown the importance that specialist creep can have on both pre and post-weaning performance. It has now been realised that not only the raw material composition (Fraser et al., 1994) but the manufacture process (Primary diets unpublished) of the creep feed can play an important part in how pigs respond in terms of pre and post-weaning performance. These specialist creep feeds have been shown not only to improve pre and post-weaning weight but also reduce piglet mortality making them highly cost effective when compared to a standard starter feed used as a creep feed. Figure 3 (unpublished data collected by Primary Diets at Harper Adams University college, UK) shows the lifetime effect of creep feeding a high lactose (>40%) specialised creep feed manufactured by a unique cold press technique (I4) versus a normal manufactured creep feed (Control; $\approx 15\%$ lactose) on lifetime performance. All pigs were exposed to the same management and feeding regime post-weaning. Pigs fed I4 pre-weaning exited the nursery at 49 days of age an average of +1.1 kg heavier ($P = 0.006$) than control fed piglets and were +4.3 kg (heavier $P = 0.251$) at day 133 of age. It is acknowledged that the significant difference in BW between the two treatment groups on day 49 (1.1 kg), although it had increased to over 4 kg, was not statistically significant on day 133 and so may be viewed by some as compensatory gain with the control fed pigs having caught up. We prefer to view this as a problem of under replication ($n = 10$) and a good example of a better start better finish.

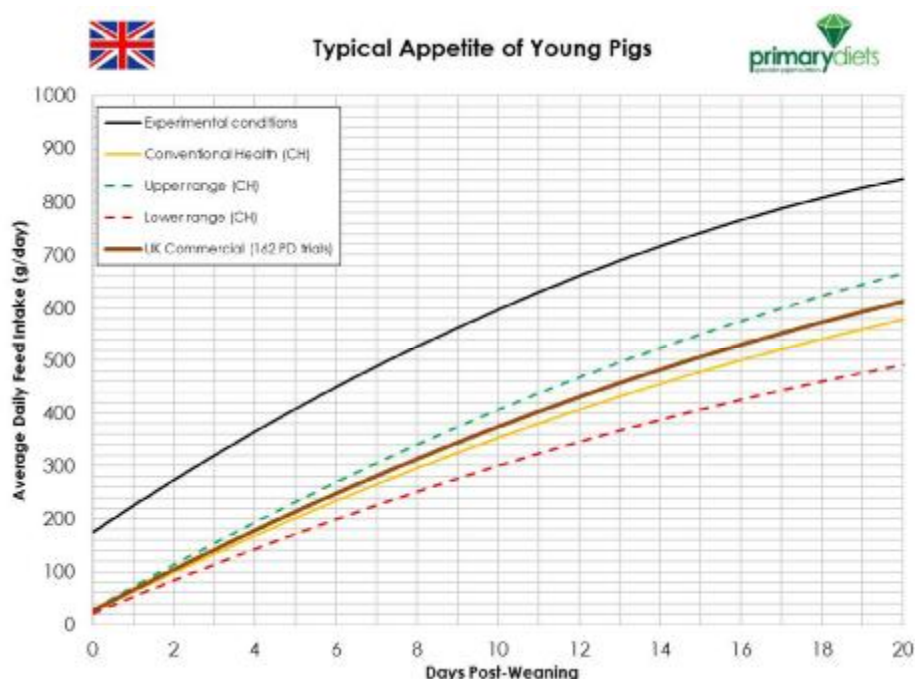


Figure 2: Typical UK post-weaning intake. Experimental conditions data (unpublished daily intake from Wellock et al., 2006); Conventional Health data (Primary Diets, unpublished). UK commercial data compiled from over 150 commercial farm trials.

Table 1. Seven ways to improve post-weaning feed intake.

Factor	How to improve?
Creep feeding	Creep feed early (ideally start between 4 and 10 days of age) Feed little and often Avoid changing diet at weaning
Nutrition	Feed highly palatable, nutrient dense diets Blend diets between change over to avoid sudden changes
Feeder space	Ensure extra feeder space at weaning Ideal feeder space allowance is 100 mm/pig
Water supply	Ensure adequate supply of fresh clean water 1 nipple drinker per 10 pigs or 1 bowl per 20 pigs Minimum flow rate of 0.7 litre/min
Temperature	Pigs will reduce feed intake when hot Air temperature should be 28 °C at weaning; Reduced to 22 °C by 20 kg
Lighting	Pigs won't consume their first meal in the dark Increase the period of lighting for first 48 hours post-weaning
Weaning stress	Avoid additional stress at weaning where possible (e.g. vaccination etc.)



Figure 3. Effect of pre-weaning creep feeding regime (I4 vs control) on lifetime performance (Primary Diets unpublished data conducted at Harper Adams University College, 2012).

2. *Feed high quality starter diets*

Ensuring optimal nutrition by investing in good quality starter diets is essential to maximise palatability and nutrient intake. Feeding complex starter diets containing highly digestible ingredients, such as milk products, fish and processed cereals have been shown to better facilitate the weaning process and increase post-weaning intake more than simple starter diets (Mahan et al., 2004). Blend diets to minimise the reduction in feed intake commonly observed at diets changeover.

3. *Ensure sufficient feeder space*

A minimum of 100 mm feeder space per pig should be provided where possible to allow newly weaned pigs to feed together as a group, as this is how they would have fed from their mother pre-weaning. Adding extra feeders, ideally long flat troughs, for the first week post-weaning is recommended.

4. *Adequate water supply*

Adequate supply of fresh clean water is critical post-weaning. A piglet that doesn't drink doesn't eat! Water intake is typically around 2-3 times feed intake and will be concentrated around the time of feeding. In addition, newly weaned pigs have a tendency to drink excessively for the first few days as a response to hunger. Don't forget they were obtaining the majority of their nutrients from sow's milk prior to weaning. Consequently, adequate water supply is essential post-weaning to allow for this increase in water consumption and to accommodate for the preference of pigs to feed in groups during this time. Classic indicators of inadequate water supply include left feed, dirty drinkers, drinking all night, and crowding and fighting around drinkers. A minimum of 1 nipple drinker per 10 pigs or 1 bowl per 20 pigs, with a flow rate of at least 0.7 litre/min in the first week post-weaning will ensure adequate water supply. As with feeder space, providing extra drinkers for the first week post-weaning, such as turkey drinkers allowing pigs to see water, is highly recommended.

5. *Optimum temperature*

If the pigs are too hot they will reduce feed intake to minimise the heat produced from growth and feeding. Conversely, if piglets are too cold they will huddle to keep warm and avoid feeding. In slatted accommodation, ambient air should be 28 °C at weaning; reducing to 22 °C by the time the piglets reach 20 kg. When bedded on straw the temperature should be a few degrees cooler.

6. *Increased period of lighting*

Piglets which have not eaten creep pre-weaning will not take their first meal in the dark (Bruininx et al., 2001). Increasing the period of light exposure therefore improves post-weaning feed intake. Research suggests increased daily length needs to be for at least one week post-weaning but no longer than two. For example, piglets exposed to 23 hours of light and 1 hour of darkness (23:1) for 2 weeks post weaning showed an increased feed intake, resulting in a higher growth rate than those exposed to normal lighting regime (8:16) (Bruininx et al., 2002b). Some farm assurance schemes may prohibit increased day length so it's important to check first.

7. *Minimise weaning stress*

Try to avoid any additional stressors at weaning such as vaccinations, over-handling etc. which may further reduce feed intake.

It's all about intake!

The above briefly discusses a number of ways to increase feed intake in the critical post-weaning period and has focused on management changes that are able to be made on pig units rather than the specific detail of starter diet specification and formulations. This is deliberate as increasing feed intake in the first few days post-weaning, which can have a dramatic effect on lifetime performance and productivity, is likely to have a much greater impact than a relatively minor change in diet specification. For example, whilst important, increasing the lysine level of a diet by 0.1% from 1.5 to 1.6%, will increase lysine intake by only +0.1 g/d assuming an intake of 100 g/d. However, increasing intake from 100 to 150 g/d (eminently possible in the first few days post weaning) increases lysine intake by +0.75 g/d assuming a 1.5% lysine diet is fed. Increasing the post-weaning intake of nutrients such as lysine is important and whilst this can be achieved through diet specification and diet quality the most important factor is increasing feed intake.

Finally, understanding both target and actual intake is an important management tool and is not commonly monitored on commercial farms. Knowing how much a group of pigs on a given unit should have eaten over a given time period allows for any deviation from normality to be easily identified. Once this is established the producer can focus on understanding and rectifying if necessary any causes for this deviation.

A NUTRITION CONCEPT: LOW PHYTATE NUTRITION

In conjunction with targeting improved feed intake it's important to maximise the nutrient utilisation of the feed. Typically in starter feeds the improved nutrient utilisation is reflected by the use of high digestible raw materials such as milk proteins, plasma and fishmeal etc. In addition the level of anti-nutrients present in raw materials used in starter feed is reduced. A common example of this is soy protein concentrate where soybean has been processed and trypsin inhibitor (inhibits protease activity in the pig) is reduced. In addition feed ingredients can be utilised to improve nutrient utilisation and one area of key research conducted by Primary Diets and AB Vista focused on the use of high levels of phytase (> 1250 FTU/g of a modified *E Coli* Phytase) to breakdown phytate as an anti-nutrient.

Dietary phytate has been shown to be an anti-nutrient and has a negative impact on nursery performance and the authors direct the readers to the following paper for a more detailed review: Cowieson et al (2009). It is known that higher dietary phytate reduces mineral bioavailability, increases pancreatic and intestinal mucus secretions, increases amino acid endogenous losses, reduces protein solubility and increases luminal sodium levels impacting active transport. This anti-nutrient effect of phytate on pig performance was confirmed in research by Woyengo et al., (2011) at the University of Manitoba. In this trial the addition of phytase (2%) to a synthetic diet containing no phytate reduced 3 week post-weaning average daily gain (ADG) by 118 g/d and FCR by 43 points (Figure 4).

Based on phytate being negative in terms of pig performance it was a target of Primary Diets and AB Vista to reduce the dietary phytate level by using high levels of Quantum phytase. This phytase was selected due to its key characteristic of breaking down phytate quickly. The speed of phytate breakdown is critical in this application as if phytate is not broken down in the stomach (low pH), where phytate is soluble, quickly it will make proteins insoluble and bind minerals. The results of this are increased endogenous losses resulting in poorer nutrient utilisation and poorer mineral bioavailability.

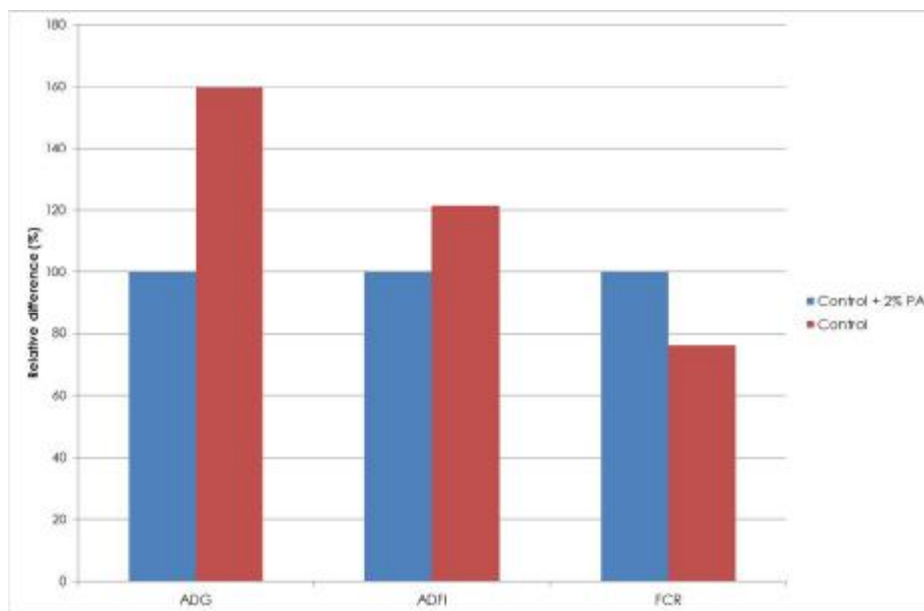


Figure 4. Effect of high phytate (control + 2% phytic acid) on 3 week post-weaning performance (from Woyengo et al., 2011).

After a series of university trials and commercial evaluations Primary Diets launched the low phytate nutrition concept in 2010 and the results showed that this new program improved 3 week post-weaning performance; 11% ADG, 4% FCR and 7% ADFI. This performance benefit can be attributed to lower levels of dietary phytate achieved with the superdosing level of phytase. Also notice that this low phytate concept positively targeted one of the key factors of this paper; feed intake.

This low phytate concept has been expanded globally by AB Vista since 2010 and now with 40 nursery comparisons globally the average response in different diets and markets has shown a 6% improvement in ADG and 4% improvement in FCR. This concept has helped lower the costs of pork production and has also lead to new avenues of research in low phytate nutrition diets that have already started to enhance post-weaning piglet performance further.

CONCLUDING REMARKS

How to choose the correct starter feed regime

Pig production is a commercial business. Performance has a value and a cost so it is important to judge how they interact to achieve the best return per pig. We believe the best way to determine the most appropriate feed program for a given unit, is to run a trial and let the pigs decide which dietary regime work best .

Of course, there are different measures to judge a diet or feeding program. Margin over feed (MOF) is our preferred measure, calculated from the value of weight gain per pig in the nursery phase less the feed cost associated with this gain. We believe that in loss making times as well as profitable ones MOF is given greatest importance or chosen as the sole determining factor in assessing which starter diet regime to use.

A commercial trial conducted by Primary Diets is shown in Table 2. The producer wanted to compare their current starter feed regime (Regime 1) against an alternative supplied by Primary Diets (Regime 2). The trial was well conducted with 6 pens of pigs per dietary regime, in the same air space and balanced for number, sex and weaning weight as far as possible. Slightly differing amounts of starter feed (Diets 1 and 2) per pig were fed before moving onto a common (12-20 kg) diet (Diet 3) until exit from the nursery on day 22 post-weaning.

Table 2. The effect of starter feed regime on performance 22 days post-weaning.

	Regime 1	Regime 2
*Diet 1, kg/pig	1.01	1.47
*Diet 2, kg/pig	5.06	5.44
*Diet 3, kg/pig	1.30	1.30
Wean weight, kg	7.62	7.46
Day 22 weight, kg	13.27	14.18
Weight gain in nursery period, kg	5.65	6.72
ADG, g/day	257	305
ADFI, g/day	335	373
FCR	1.30	1.22
Cost per tonne diet 1/2/3, £	810/620/350	850/650/350
Feed cost, £/pig	4.41	5.24
Cost/kg gain, £	0.78	0.78
¹ Return, £/pig	6.78	8.06
² MOF, £/pig	2.37	2.82

*Diets 1 and 2 differed between regime and 2, whilst diet 3 was common between both treatments and fed until day 22 post-weaning.

¹Return per pig calculated using a price of £1.20 per kg live weight gained

²MOF; Margin Over Feed = Return per pig – feed cost

Initially the producer was attracted to regime 1 due to its lower cost per tonne, -£40/t (-\$60) and -£30/t (-\$45/t) for Diets 1 and 2 respectively; - £0.94 (-\$1.41)/pig according to companies suggested amounts). However, due to the improved performance of regime 2 (+0.91 kg/pig gain and -0.08 FCR), feeding the cheaper regime 1 would be a false economy. An increased MOF of +£0.45 (+\$0.68) per pig or +£69.30 (+\$103.80) per tonne of starter feed (154 pigs fed per tonne of starter feed; diets 1 and 2) was achieved on regime 2 meaning regime 2 could be +£69.30 (+\$103.80) more expensive before it was not cost effective to use. Furthermore pigs on regime 2 would be expected to reach slaughter around 3 kg heavier or 3 days earlier on regime 2 giving further economic return.

There's no doubt the right starter feed regime is critical. After all, the pig will only eat starter feed once in its life and if it is wrong, there is no opportunity to correct this with the next diet. A cost:benefit approach to diet choice remains the most appropriate way to choose the correct start feed regime.

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Nursery Management in Light of Frugal Earnings in Swine Industry

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Protocols and standard operation procedures have been set and discussed in detail on many occasions. Most producers operate their farms based on passed down experience and newly acquired knowledge picked up in conferences, training sessions, farming magazines and articles. We all know that from time to time, pig prices hit bottom low and the rebound is not substantial and most of all this does not last enough to recover losses. These are the times when micro-management tools implementation will translate into savings.

The goal of this session is to suggest and debate a number of issues related to management of key points, important in the nursery stage to produce profitable grower pigs.

I will enounce the basics and will recommend tools to maximize returns and create savings.

A warm, dry and comfortable environment upon entry will have a huge impact on creating a good start.

Environment

Proper inlet, exhaust, design and controls management will impact performance and also heat and hydro spending. The so called “Thermo Comfort Zone” is critical to assess based on specifics imposed by barn design (open to discussion).

Sanitation and bio-security could influence both short and long term health issues. The healthier the pig, the better performance is expected. Clean, wash and disinfection protocols will protect from over loading barns with germs inherited from batch to batch.

Sorting at entry has disputable value. In my personal view it is worth the effort, when weaner pigs are high priced. At least, sort together the smallest pigs; leave room for sick/treatment. Requirements: sort top and bottom 20% and everything between; it will allow shipping in weight groups to finishers. Sorting will also enable a farmer to match proper diets to the phase and age (right feed in to the right pig) and maximize performance and keep feed cost at reasonable level.

Feed Management:

The two most critical tools in nursery management are in my mind; feed/ feeder management and water management.

After discussing the basics about them, I would like to focus on the multiple roles of feed and water in the economy of nursery (and any stage) production. I am referring here to the way we manage these two vectors in delivering medication – preventive or intervention rate.

Enough feeder space to ensure equal access to feed is required (1.5” per pig/5-25kg). A rule in setting those efficiently is to aim for 1/3rd bottom of pen to be covered.

Feed grade antibiotics are routinely used in nursery diets to control clinical manifestation of certain diseases. Veterinarians prescribe a protocol; feed suppliers manufacture the feed, and from here it is up to producers to make sure the medicated feed will be efficient and justify the cost.

To explain myself: Let's follow this scenario...

A group of 500 pigs, housed in 2000 head nursery, break with acute enteric disorder. These pigs are on a second phase diet and intervention rates are prescribed. The farmer places the order indicating the bin number and location. But the bin still carries 2 tons of previous feed. The new feed is placed on top. What do you think will happen to the dosage? Will it still do the job? This is the most common mistake occurring on farms. Let alone those circumstances when medicated feed end up in the wrong bin. The consequences are dire and costly.

Water Management:

The basics are extremely important not only considering water as the cheaper nutrient but it is also used to deliver oral medication or vaccines. Consider the location of nipples to allow access, the type (fixed or hanging), bowls ...etc. as these, apparently small, details will have a critical impact. Always adapt the number of pigs to water availability (1 nipple for 10 pigs or 1 bowl for 15 pigs). When 2 nipples are suspended on a chain, consider only 10 pigs (5 for each). Ensure proper flow rates of 0.5- 0.7 litre/min and proper pressure (< 25psi). Water quality should be assessed 1-2 times per year.

Know your water PH, total dissolved solids etc... as it becomes important when water meds are used. Adjusting PH (acidifying) will increase palatability and water intake which leads to higher feed intake. Ask your vet if prescribed drugs are acid stable and as a general rule, inform him/her about sanitizing measures on your farm (chlorinators, peroxide pumps etc.,) as these maybe important in the pharmacological dynamics of the drugs. When expensive medication is used via water it is critical to ensure availability. To avoid any wastage, it is recommended to check all nipples for proper function in the barn, before delivering and drugs or vaccines. Make sure you are using the proper dilution rates and check pump integrity. Prepare and monitor fresh stock solutions, and estimate disappearance of solution by calculating approximate water consumptions over 24 hours. Use the formula No. of pigs x 10% body weight (e.g. 40kg pigs = 4L/day). If the pump is set to 1:100; find out the No. of stock solution litres that are necessary to mix for 24 hours. This is crucial for efficiency of treatment as any interruption in delivery will result in infection relapse.

The take home message is that profitable dollars are lost; mortality and attrition will add cost through treatment failure, and drug misuse, if some of these principles are neglected or ignored.

Management Practices That Maximize Feed Efficiency

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ABSTRACT

Feed efficiency is a very challenging indicator of farm success. It is a highly valuable measurement, providing essential information on a key component of the cost of production. While it is important and valuable, it can also mislead and result in decisions that will achieve outcomes that actually decrease net income rather than increase it. So it is critical that the right measures of feed efficiency are utilized and applied correctly as decision-making tools. Feed efficiency can be influenced by many variables, including the pig's environment, genetics, herd health, diet composition and pig management. With so many moving parts, achieving the best possible feed conversion is very, very difficult, but like other challenging tasks, breaking it down into constituent parts is the best path to long-term success. The financial rewards of improved feed efficiency, if undertaken properly, will be significant, and can mean the difference between profit and loss when margins are being constantly squeezed.

FEED EFFICIENCY TARGETS

Before discussing how to maximize feed efficiency, we have to ask two very important questions. First, what do we mean by feed efficiency; it can be measured in many different ways. Following are examples:

- Kg feed per kg live weight gain
 - Traditional approach that is familiar to everyone. However, it ignores differences in dressing percentage and thus can be misleading if higher fiber diets are used.
- Kg feed per kg carcass gain
 - Increasingly common in the Midwest U.S. and in research when diets differ in fiber content.
- Mcal energy per kg (liveweight or carcass) gain
 - Is a crude measure of energy efficiency, but helps to put more focus on energy efficiency.
- Feed cost per tonne
 - Terrible measure of efficiency because it means very little, since animal performance and net income are not part of the calculation.
- Feed cost per pig placed
 - A useful measure of efficiency, in that it considers overall feed cost on a per pig basis. Not particularly useful when used alone, but is very useful when used in concert with some of the above measures of feed/energy efficiency.
- Feed cost per pig sold
 - Similar to above, but takes into account the financial penalty of mortality.

- Return over feed cost per pig place
 - Is a broad stroke measure of efficiency that, because it is expressed on a “per pig place” basis rather than “per pig basis”, acknowledges the impact of barn throughput.
- Net income
 - A very broad brush measurement of “efficiency” but it represents the most important goal of pork production – to make money, or when the markets are down, to minimize losses. No matter which measures of efficiency are used, this should always be included, to avoid focusing on improving efficiency but inadvertently lowering net income.

The second question is very simple. Do we want to maximize feed efficiency? There is no simple answer, but there is a very real risk of focusing too much on feed efficiency and not on other aspects of the cost of feed or barn management. For example, one can easily improve feed efficiency by increasing diet energy content; however, there is no guarantee that this will improve profitability. Indeed, in many instances it will have the opposite effect– but it will improve feed efficiency.

FEED EFFICIENCY: MEASUREMENT

Measuring feed efficiency is relatively easy, at least in all-in-all-out production, but interpreting the results of the calculation is the really hard part. The following table (Table 1) illustrates this point very well. If feed conversion was calculated in the traditional manner, one would conclude that the two fills had essentially the same results. However, pigs in Fill B weighed less at entry and less at market, meaning they had an advantage over Fill A because smaller pigs typically will have a better feed conversion. Adjusting for entry and exit weights results in a very different conclusion: that Fill A had superior feed efficiency compared to Fill B.

Also, Fill B had lower mortality, and since mortality can influence feed efficiency, needs to be taken into account. Once again, adjusting for mortality resulted in a differing conclusion about the comparison of Fill A versus Fill B.

Table 1. Interpreting closeout data when the entry weights and market weights differ.

Item	Fill A	Fill B
Weight in, kg	25.9	20.4
Weight out, kg	123.4	120.2
Mortality, %	4.9	3.7
Daily gain, kg	0.853	0.848
Feed:gain (unadjusted)	2.84	2.86
Feed:gain (adjusted for differing weights)	2.66	2.80
Feed:gain (adjusted for mortality)	2.62	2.77

Source: Gaines et al., 2012

Therefore, it is important to ensure that such comparisons within a farm or system is done correctly, so that the right conclusions are drawn. The situation is more complex when using bench-marking services to evaluate how one farm compares to its contemporaries. Differences

in diet composition, entry/exit weights, particle size, mash versus pellets, etc. can also have a very substantial impact on feed efficiency and make comparisons among farms very difficult.

FEED EFFICIENCY: THE PIG'S ENVIRONMENT

The pig's environment will have a substantial impact on performance. Temperature is an excellent case in point. The challenge is to define the lower and upper critical temperatures for growing and finishing pigs, so we can be certain that performance is not impaired by barn temperatures that are too low or too high. For example, if the temperature drops below the pigs' lower critical temperature, feed intake will increase by about 1.5% per °C NRC (2012).

The lower critical temperature is estimated to be about 23 - 24°C at 25 kg body weight, dropping to about 15°C at 100 kg (Renaudeau et al., 2012). These temperatures, especially at the heavier body weights may seem cold, because to humans, they are. However, pigs are eating as much feed as they can, and this generates a large amount of heat. Therefore, pigs will feel comfortable at cooler temperatures than most humans. These lower critical temperatures assume that the pigs are healthy, the floor is dry and there are no drafts. They also assume that the barn is well insulated. If any of these situations does not exist, then the LCT will be increased by perhaps 2 to 3 °C to accommodate the chilling impact of dampness, drafts, etc. Also, if pigs are not healthy – and therefore not eating to their full potential – their LCT will be much higher; this is why we see pigs in sick pens often huddling due to cold stress at barn temperatures that appear to be perfectly acceptable to other pigs in adjacent pens.

The limited data that are available suggest that feed conversion is minimally affected by elevated temperatures in the barn. As pigs become heat stressed, feed intake will decline by about 1% (growing pigs) and 2% (finishing pigs) for every degree above the upper critical temperature (Patience et al., 1995). The decline in feed intake is manifested in slower growth, such that changes in feed efficiency are smaller than one might expect (Renaudeau et al., 2011).

FEED EFFICIENCY: GENETICS

The North American model is to depend primarily on genetic selection of achieve lean, efficient carcass gain, as opposed to limit feeding pigs. While limit feeding will reduce carcass fat, the associated slower growth is a penalty that most North American pork producers are unwilling to accept. However, selecting for feed efficiency can be problematic, as it can result in animals with poor feed intake and thus slower growth. There are a number of solutions to this problem, one being multi-trait selection like BLUP that includes many criteria, one of which can be efficiency, but also include growth rate or lean gain. Knap and Wang (2012) argue that the use of Residual Feed Intake (RFI) is another way to achieve rapid improvement in efficiency; essentially, RFI measures actual feed intake in a pig and compares that to what it should have eaten given its growth rate and carcass fat content (Cai et al., 2008).

The results of multi-generational selection by Dr. Dekkers team at Iowa State University for RFI are presented in Table 2. Improved RFI resulted in a 13.2% reduction in feed intake but only a 6.1% reduction in growth rate. Feed efficiency was improved by about 8% and backfat was reduced by 14%. These are impressive numbers, although no loss of growth rate would have been a more desirable outcome. In any event, these data demonstrate the improvement in feed efficiency that can be achieved through genetic selection.

Table 2. Comparison of pigs selected for high (less efficient) and low (more efficient) residual feed intake.

Item	High RFI <i>Mean</i>	Low RFI <i>Mean</i>	Difference %
Initial wt., kg	39.4	37.0	
Final wt., kg	114.4	112.3	
Daily gain, kg	0.749	0.703	-6.1
Daily feed, kg	2.05	1.78	-13.2
Feed conversion	0.37	0.40	8.1
Feed conversion	2.70	2.50	7.4
Backfat, mm	17.0	14.6	-14.1

¹ Gain:feed; ² Feed:gain. Source: Jennifer Young, Iowa State University, personal communication

FEED EFFICIENCY: HERD HEALTH

Pig health is widely recognized as having a profound impact on almost all aspects of animal productivity. This only makes sense, but data to quantify this are surprisingly rare. Dritz (2012) reported the results of a study undertaken in Sioux County, Iowa, which has the highest density of pig production in the U.S. (722 pigs per km²). Herds were characterized according to PRRS status (positive or negative), Ileitis (positive or negative), biosecurity (pass or fail), site capacity (less than or greater than 2,500) and pig density (less than or greater than 5,000 pigs within a 2.4 km radius). The results are summarized in Table 3.

The herds that were PRRS positive, or had poor biosecurity procedures, had significantly poorer feed conversion than those that did not ($P < 0.05$). They also reported poorer growth rate. These field data underscore the importance of strong biosecurity and herd health procedures if feed efficiency is going to be maximized.

A very recent dataset further emphasized the importance of remaining PRRS negative. In a large, detailed study lead by Dr. Nick Gabler of Iowa State University, in collaboration with Newsham and a private pork producer, pigs from a common sow source were split between two sites, with animals at one site being infected with the PRRS virus. A very large and detailed dataset is being generated by this unique study, but the feed efficiency in Figure 1 illustrates the huge impact of a simulated PRRS outbreak in naïve pigs.

FEED EFFICIENCY: DIET COMPOSITION

Obviously, diet composition can have a very important impact on feed efficiency. Indeed, nutritionists know that in order to improve feed efficiency, simply increase the energy concentration in the diet. This change may, or may not, benefit financial performance, but it illustrates that improving feed efficiency through nutritional intervention is not a difficult goal to accomplish.

Apart from energy, the nutrients in the diet can influence feed efficiency as well. However, in this instance, nutrients would have to be deficient for any addition to result in improvement. Simply elevating amino acids levels in a diet will not improve feed efficiency, unless the diet was previously deficient in amino acids.

Obviously, the addition of certain feed additives and growth promotants can be used to improve feed efficiency.

In addition to the composition of the feed, the form of the feed can also play a role. Reducing particle size will improve feed efficiency, as will pelleting the diet. Indeed, pelleting has become more popular recently as producers seek to reduce particle size to less than 400 microns; for most farms, the only consistent way to make such feed flow through the feed delivery system is to pellet it.

Table 3. Effect of pathogen-specific and non-pathogen specific factors on growth performance in a pig dense geographic region.

Item	ADG g/d	Feed:Gain	Mortality %
PRRS virus			
- Negative	835 ^a	2.88 ^a	4.2 ^a
- Positive	804 ^b	2.93 ^b	5.7 ^b
Ileitis			
- Negative	817	2.94	5.3
- Positive	822	2.89	4.6
Biosecurity/sanitation			
- Pass	831 ^a	2.88 ^a	4.8
- Fail	804 ^b	2.97 ^b	5.5
Site capacity			
- <2,500	817	2.93	5.3
- >2,500	817	2.91	5.0
Pig density			
- <5,000	822	2.92	5.2
- >5,000	808	2.93	5.2

^{a,b} Means within a column within an item with a different superscript differ, P < 0.05. Source: Dritz, 2012

FEED EFFICIENCY: PIG MANAGEMENT

Delivery of feed to the pig may also play an important role. Poorly designed feeders, combined with poor management of the feeders, can lead to excessive feed wastage and poorer feed efficiency.

Inadequacy of feeder space may also result in poorer feed conversion (Figure 2; Weber et al., 2013). Their study showed no impact of feeder capacity until the pigs reached the final phase prior to marketing; given that the reduction in feed efficiency is modest and of short duration, it is unlikely that this reduction in feed conversion would warrant installation of new feeders in an existing barn. However, it could be a consideration in sizing feeders in new construction.

Sorting of pigs at any time during growout, including at placement, is a waste of time. It not only fails to improve pig performance, but in fact results in slower growth and poorer feed efficiency. The only justification for sorting pigs would be to place very small or compromised

animals in separate pens where they can receive special diets and daily care. Otherwise, it is a practice that is strongly discouraged.

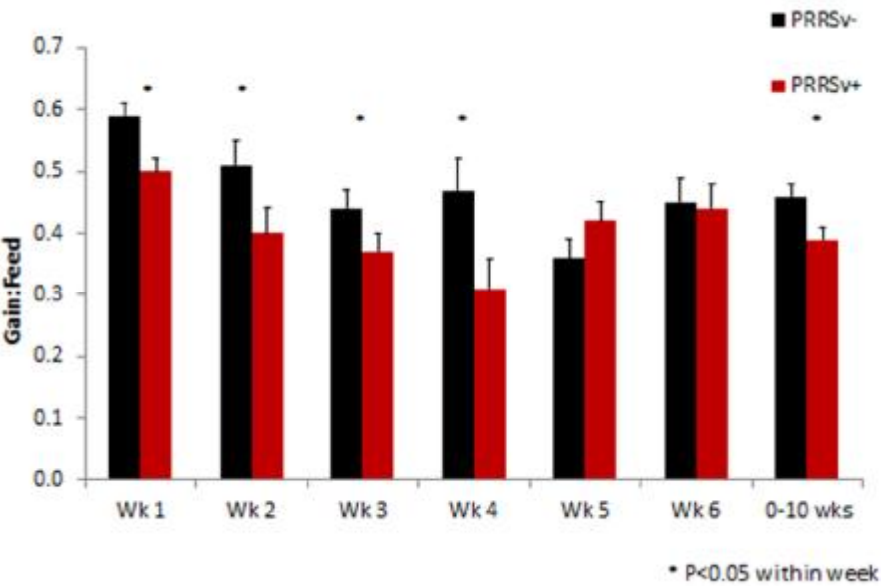


Figure 1. Impact of PRRS infection on feed efficiency in grower pigs (Source: Gabler, 2013 - unpublished data)

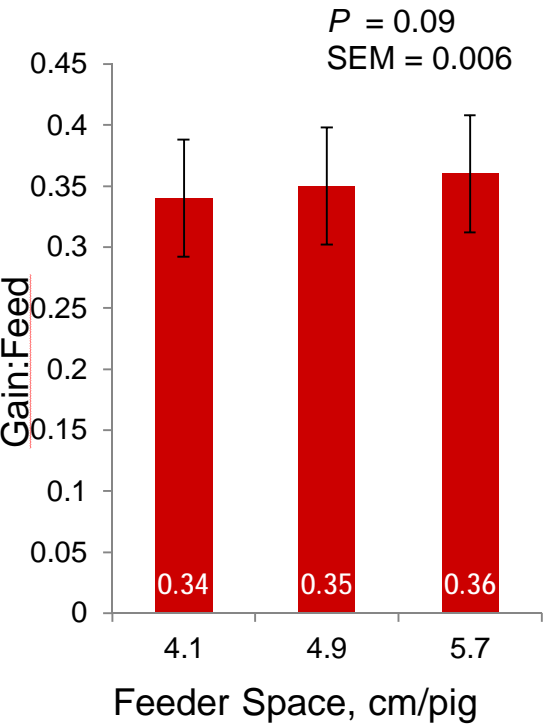


Figure 2. Impact of feeder space allowance on feed efficiency in pigs during the final phase of growout (Source: Weber et al., 2013).

CONCLUSIONS

Achieving the best possible – and most economical – feed efficiency requires the highest attention to detail on almost all aspects of pork production, including selection of the right genetics, proper diet formulation, management of barn environments and controlling disease. Many improvements through management will be incremental – and often modest in size – but when considered in totality, they represent a tremendous opportunity to minimize the impact of higher feed prices on farm net income.

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Feeding and Barn Management to Improve Feed Conversion

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Sometimes we get wrapped up dealing with the big issues and forget to manage the basics. In my experience if we get the basics done right the pigs can do their job for us. What I am referring to as the basics are;

- 1. Feed**
- 2. Water**
- 3. Environment**

Feed:

In today's market place feed commodities are very expensive and we have to make sure we get the maximum value out of them. Making sure that storage of the commodities is good to avoid nutrient loss or spoiling. Maintaining your feed making or feed delivery equipment is so important. One area that I see get neglected is the Grinder, mainly the hammers and screens. I like to visually inspect these regularly. Looking at the total grind of the feed and seeing chunks of corn come through the manure is a tell-tale sign attention is required.

Water:

In my opinion water is the cheapest nutrient we have to give to the pigs. I am very particular about checking drinkers for not only height but flow as well. I have been involved in a few scenarios where extra water drinkers have been added and the results proved it to be the right solution.

Environment

There are a few variables when discussing the environment. I always think about the fact that we as people can always walk out of the barn but the pigs can't. So if I don't like being in the barn it is certain the pigs won't either. One major area of improvement that I commonly find is the ventilation; it may be something that is simple to fix but it can make a big difference. Also follow the guidelines as to how many pigs per feeder space or drinkers. Over populating a room will have a serious impact on overall performance. One thing that I have come to realize is the pig population of a barn and can rise and fall but the drinkers and feeders don't.

Other Important Aspects

There is a lot of information that is available from either the genetic companies or feed companies that can give you some good guidance as to what your pigs are capable of performing. I have seen a lot of scenarios where producers have tried to ship on grids that don't make sense to the pig they raise. Be it on weight or cut out characteristics.

I have helped some of my customer base figure out how their pigs are performing from 100kgs live to their shipping weight currently. This can help you evaluate if it makes sense shipping your pigs heavier. IF your pigs are not maintaining a good feed conversion at the heavier weights with the cost of feed it is hard to profit from this.

Feed Conversion can be improved on making sure that you ship your pigs within the proper weight range. I have seen, too many times, pigs that are either under or over the target. This can be very costly and with a little bit of work can be avoided.

There are new commodities that are available and are worth a look at. Some are high in energy and, depending on cost, could improve your Feed Conversion.

In-Feed Antibiotics—Some of the Issues

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Why has this debate lasted 50+ years?

Availability of antimicrobials for use in human medicine, veterinary medicine food animal production is a privilege rather than a right. Given the current high level of scrutiny of antimicrobial use in all arenas, it is remarkable to think that in the 1950s antimicrobials became available for over-the-counter sale and use in food animal populations in many developed countries. Moreover, low-dose long duration feeding of antimicrobials was widely adopted in food animal production after it was recognized that this could enhance growth rate and feed efficiency in poultry and swine. At that time, the phenomenon of antimicrobial resistance emerging as a consequence of antimicrobial use was already well established (albeit of less immediate clinical consequence). It is also worth noting that unrestricted over-the-counter sale of antimicrobials remains the norm for use in both humans and animals in many developing countries. Few would argue that this is wise, and the occurrence of imprudent use is inevitably a function of availability. However, specifically with respect to animal uses, it has been difficult to establish that this has been harmful in terms of the incidence of clinical treatment failures in human infections. Until now there is no published risk assessment linking an increased risk of human clinical treatment failures with any specific antimicrobial use in food animals. A recent review of interventions employed to reduce antimicrobial use food animals in Denmark was accompanied by neither data nor claims of measurable benefits to human health consequent to this achievement.¹ This enduring uncertainty over the public health consequences of antimicrobial use in animals has frustrated groups who have avidly pursued greater regulation of antimicrobial use in food animals in the USA.

There is no dispute that antimicrobial resistance is a pressing problem in human medicine, although estimates of the public health costs attributable to antimicrobial resistance are uncertain.^{2,3} Costs are incurred as increased treatment costs and case fatality rates, and as infections in people treated with antibiotics that might otherwise not occur (i.e., in the absence of resistant organisms). There is some dichotomy of emphasis in the medical literature on antimicrobial resistance. Analyses by infectious disease experts who are focused on the control of antimicrobial resistance in human medicine seldom refer to foodborne pathogens such as *Salmonella* and *Campylobacter* or the importance of animals as sources of resistant organisms. A survey of senior medical microbiologists in Europe about the relative importance of bacterial species to the resistance problem ranked these organisms 15th and 18th respectively out of 20 organisms listed.⁴ In contrast, authors writing on antimicrobial use in agriculture primarily focus on these two organisms, but rarely provide meaningful context about their relative contribution to the overall problem of treatment failures in human clinical medicine.⁵ One widely cited modelling study estimated that antimicrobial resistance in *Salmonella* and *Campylobacter* in the USA results in an additional 12 deaths annually from *Salmonella* infections and 95 hospitalizations with *C. jejuni* infections.⁶ All incidents of illness and death are regrettable, but these modest estimates position antibiotic resistant foodborne pathogens substantially below lightning strike or dog bites as public health concerns in the USA. Foodborne disease and antimicrobial resistance are major and costly human health problems, but the contribution of the former to the latter is arguably minimal. An extensive North American review stated that “the

extent to which antibiotic use in food animals produces clinically important antibiotic resistant infections in humans is unknown”.⁷ After almost 5 decades of debate, the impact of antimicrobial use in food animals on human health is still undecided. To further muddy the waters, some efforts at quantitative assessment of the risk of human treatment failures related to specific practices of animal use have concluded the risks to be ‘vanishingly small’.⁸⁻¹¹ In addition some studies have posited possible human health benefits through improvements to animal health that translate into less carcass contamination during processing.¹²⁻¹⁴

Banning growth promotants—strategic reduction or low-hanging fruit?

Antimicrobials are important tools for ensuring the health, welfare and productivity of pigs raised for food. Banning of antimicrobial growth promotant use in Denmark, and subsequently more widely in the EU, has encouraged many entities to seek more restricted availability of antimicrobials for food animals in the USA. I have heard medical clinicians state the rather anthropocentric view that any antimicrobial use in animals is imprudent, but ‘middle of the road’ people accept that animals suffering from bacterial infections should be treated with antimicrobials (the frequency of antimicrobial use in companion animals provides reasonable support for this). As we traverse the spectrum of ‘therapy-metaphylaxis-prophylaxis-growth promotion’ uses, enthusiasm for antimicrobial use in animals will understandably decline. If we assume that any reduction of antimicrobial use is desirable (i.e., less is better) it seems logical to eliminate uses that are ‘less necessary’ or less justifiable in terms of benefitting animal health and welfare. A more strategic approach would require understanding of the relative consequences (in terms of prevalence of resistant organisms with implications for public health) of these different strategies for deploying antimicrobials in food animal populations. There is a considerable body of published literature that claims that ‘growth promotant’ uses are of particular concern regarding resistance.

We are now finalizing an appraisal of the literature cited in four specific reviews (the FDA Guidance for Industry #209; the Preservation of Antimicrobials for Medical Treatment Act; the Pew Commission on Industrial Farm Animal Production report; and the Keep Antibiotics Working Group annotated bibliography). These documents are at the centre of discussions on regulation of antimicrobial use in food animals in the USA. The FDA’s Guidance for Industry #209 suggests that some uses of low-level antimicrobials administered in feed are “injudicious”. The Preservation of Antibiotics for Medical Treatment Act calls for the discontinuation of all non-therapeutic or routine uses of certain classes of antimicrobials in animal agriculture, and has been introduced into Congress in several recent sessions. The specific objective of our study was to critically appraise the literature on antimicrobial use in pork production to determine strength of evidence that long term use of specific levels of specific antimicrobial compounds in feed contributes greater risk to public health than other food animal antimicrobial uses.

Out of over 400 references in these sources, our initial inclusive screening identified 154 papers as likely to be relevant to our core objective. These were then categorized as 1) descriptive (n = 48) if they included data on antimicrobial use or resistance without comparison groups; 2) analytical (n = 37) if the study included data on antimicrobial use or resistance and at least one comparison between groups; or 3) reviews (n = 69) if they did not present original data but summarized previous work on antimicrobial use or resistance. Two evaluation tools (one for original studies, one for reviews) were developed for systematically evaluating individual papers. Only 12 of the cited papers reported research data directly relevant to the specific purpose of this study (comparing the impact of low dose antimicrobial use to other modes of use). These papers

were reviewed in depth, and only one study in poultry presented primary evidence of a statistically significant advantage for therapeutic mode of administration over a low dose administration in feed with respect to the resistance outcomes measured. The descriptive studies, not having comparison groups, were not designed to enable comparison of treatments, and many reported only antimicrobial use or resistance data. Nonetheless, it is notable that despite the failure to measure both antimicrobial use and resistance in these descriptive studies, 16 of the 36 implicated antimicrobial use in antimicrobial resistance in the discussion or conclusions.

The vast majority the papers cited by these key sources contain no primary data to support the contention that low dose antimicrobial use exerts more selection pressure for resistant bacteria than therapeutic uses, or augments public health risks from antimicrobial resistant organisms. It is notable that these key sources cited a large proportion of review studies. Detailed examination of 37 reviews most closely related to our appraisal found that none employed systematic review methods but were narrative reviews or reports. Only one stated the search methods used to identify cited sources, and only one (different) review specified inclusion and exclusion criteria for the studies they cited. No reviews stated any criteria of validity assessment used in the selection of studies cited, or indicated any measures were taken to identify or address potential biases. Only three of the reviews discussed validity in analyzing studies or drawing inferences in their review process, and no reviews discussed potential limitations of their study. Collectively, these 37 sources cited 1,869 publications (ignoring duplications) of which 1012 (54.2%) were determined to be studies providing original data. That is, almost half the sources cited in the reviews evaluated were other reviews and reports, rather than primary sources. In summary these reviews in general reiterate the most storied examples linking antimicrobial use in animals to the emergence of resistance, but provide neither explicit information contrasting the impact of low-dose, long duration (growth promotion) administration relative to other methods of administration, nor novel insight into understanding this question.

Currently available evidence is inadequate to provide any meaningful comparison of different modes of antimicrobial resistance in relation to the emergence of antimicrobial resistance in pathogens or commensals in commercial swine populations. In the absence of evidence indicating any differential effect among modes of antimicrobial use in food animals, the conservative position would be that reducing aggregate use of antimicrobials is the most appropriate goal. FDA Guidance 209 will likely lead to the removal of most growth promotant claims in the USA within 3 years.

Being part of the solution

The process of weighing policy options related to antimicrobial use in food animals should be evidence based and arguably should include consideration of animal health and welfare, and environmental impacts, in addition to human health outcomes. As a general assumption, it is reasonable to assume that reduction in aggregate use of antimicrobials will lessen the pressure of selection for resistant organisms. It is also plausible that different patterns of use of antimicrobials (e.g., selection of drug; route of administration; dose; duration) will exert differential selection pressures both qualitatively (organisms impacted) and quantitatively. In food animal settings, these myriad of different options will presumably have diverse implications for public health (assuming all are non-zero). However, the pharmacoepidemiology of induction and dissemination of antimicrobial resistance is complex and poorly understood, and particularly in relation to public health risks linked to animal food products. Optimization of antimicrobial use in food animals will require definition of practices of greatest value to maintaining animal

health and well-being, as well as practices that are more or less likely to select for antimicrobial resistant organisms of public health importance.

We can anticipate on-going pressures for reducing antimicrobial use in all food animal industries into the future. The consequent impacts on swine health and production will depend on the nature of future restrictions. Both the Swedish and Danish bans on antimicrobial growth promotants in pigs had measurable consequences for pig health, most notably the increased incidence of enteric disease in weaned pigs and increased need for therapeutic antimicrobials.^{15,16} However, in both countries impact on finishing pigs appears to have been minimal. Recognition of the particular vulnerability, and therefore particular needs, of the weaned pig in relation to infectious disease control and prevention needs to be emphasized in discussions of strategic antimicrobial use in swine. In my opinion, the most reasonable path forward appears to be elimination, based on the precautionary principle, of in-feed use of antimicrobials for production purposes in finishing pigs, and preservation of broad treatment and prevention options in weaned pigs (say up to 10 weeks of age). This would maintain flexibility in health management during the most crucial 6-7 weeks of post-weaning life, yet should substantially reduce aggregate antimicrobial use in the final 4 months or so when feed intake is highest and use occurs most closely to the point of marketing and human consumption. A voluntary initiative by industry to implement this strategy would have been a reasonable strategy to counter the image of intransigence of industry players to cooperate in the goal of reducing antimicrobial use. Apart from the possibility of demonstrating good will to the public, this may also have provide some leverage for the future encroachments on more essential modes of use in large populations.

The goal of reduced antimicrobial use in the future should not be pursued without regard to relatively predictable costs to piglet health and welfare. However, desperate attempts to preserve the status quo regarding antimicrobial use are unlikely to be successful and may be counterproductive. Continued efforts to upgrade facilities and management to enhance pig health need to be pursued. We should expect greater involvement, direct responsibility, and accountability of veterinarians in optimizing antimicrobial use in swine herds; some management changes (such as older weaning age); and some innovation necessary to offset the health impacts of restricted antimicrobial availability.

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The Use of In-Feed Antibiotics in Quebec Pigs

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INTRODUCTION

My interest for antibiotic usage and resistance is relatively recent, so I would certainly not qualify as an expert in that field. Three years ago a paper from Denmark on that issue caught my attention (Stege, 2010). This paper reported that the quantity of antibiotics used per pig in Denmark varied between 3.54 and 4.03g for each year between 2004 and 2009. Since then I began to spend some time in better understanding what our situation in Canada was, and what could be done to improve it. This paper briefly describes the use of in-feed antibiotics in Quebec pigs, the provincial legislation, and the local efforts made to address the issue of antibiotic usage and resistance.

THE USE OF IN-FEED ANTIBIOTICS

A high proportion of Quebec pigs are raised in hog dense areas where it is difficult to remain free of diseases like PRRS, enzootic pneumonia and swine influenza. For that reason the average health status of many of our pigs can be considered as suboptimal, particularly if it is compared to Western Canada. One of the consequences is that feed antibiotics are used in the vast majority of our farms, particularly in the nursery period. In the finishing units many will medicate the first 2 to 4 weeks of production, and then either have no medication up to slaughter, or an antibiotic only at growth promoting levels. As is the case elsewhere in Canada, we do have some farms where no antibiotics at all are used, but this is for specific niche markets that would represent a very small percentage of the pigs marketed. The main antibiotics added in the feed for preventive purposes are chlortetracycline, lincomycin, tylosin, tilmicosin and tiamulin, and these would particularly target respiratory conditions, and perhaps to a lesser extent enteric conditions like ileitis. However the use of ileitis vaccine has increased significantly over the last few years in our province, and this has reduced the need to rely on antibiotics for the prevention of that condition.

To my knowledge there are no data at this time that have quantified the antibiotic consumption of pigs in our country on a per animal basis. In 2011 I conducted a small survey on antibiotic usage of some swine farms and companies in Canada, the US and Mexico. The idea for me was to roughly compare these countries to Denmark, where efforts to reduce antibiotic usage have been made since the mid 90s. If the results of this survey are accurate, it would indicate that the quantity of antibiotics used in these three countries is relatively similar, and much higher than what is used in Denmark. However, a few points need to be kept in mind here. The first one is that the study was way too small to be representative or to have any scientific authenticity. The second is that virtually all countries with a significant swine industry would be higher than Denmark. Finally, the last one is that the strains of PRRS virus present in that country do not compare in virulence to those we can have in Eastern Canada, and this does make reduction of antibiotic usage more challenging. That being said, the first objective in my mind is to clarify where Canada truly stands, in terms of antibiotic consumption per pig produced, so that we cannot only compare ourselves with other countries, but can also determine if the interventions

that we could make to reduce antibiotic usage are producing results or not. For that, obviously, we need to know what the starting point is, which means that we need accurate and valid data.

In fact, not only do we need to know what the total quantity of antibiotics used per pig is, but we also need to determine what that total is for each specific class of antibiotics, since their relative importance in veterinary or human medicine greatly varies. The Canadian Veterinary Medical Association has produced a document that categorizes the importance of antibiotics on the human side (Agriculture and Agri-Food Canada, 2008). Cephalosporins of third and fourth generations (e.g. ceftiofur) and fluoroquinolones (e.g. enrofloxacin) are category 1 products, which means that they are of the greatest importance, while lincomycin and tylosin, chlortetracycline, and finally salinomycin are category 2, 3 and 4 products respectively. At this time there are no category 1 products that can be used in the feed in Canada in swine.

THE QUEBEC LEGISLATION

Any antibiotic added to the feed, whether used according to the label or not, requires a prescription by a veterinarian in Quebec. The name of the product, dosage, duration, number of animals to be treated and withdrawal period have to be indicated on the prescription. The veterinarian can recommend dosages and duration that are different than what the label of the product indicates, but he/she takes responsibility for that off-label recommendation. So in most cases the withdrawal period will be extended in cases where the dose is greater than what the label says.

EFFORTS TO REDUCE ANTIBIOTIC USAGE AND RESISTANCE

AVIA is the association of Quebec veterinarians working with swine and/or poultry. At the end of 2012, during a regular association meeting focusing on antibiotic usage and resistance, it was decided to form a committee that would address some of the issues related to these two topics. The mandates of that committee had not been precisely determined at the time of writing this document, but the quantification of usage is among the issues that should be addressed. The same is true for the ways that could be considered to make producers and veterinarians aware of the importance antibiotic usage and resistance can have, without creating unnecessary turmoil and attention in terms of public perceptions.

The Faculté de Médecine Vétérinaire of the Université de Montréal has a chair on health and food safety that is responsible for some aspects of the CQA program, and this includes the evaluation of the pharmaco-therapeutic regimen. A full time employee as well as a part time veterinarian are responsible for evaluating the prescriptions of Quebec swine practitioners to see if or not they are in agreement with regulations and guidelines. The chair is funded by the Fédération des Producteurs de Porcs du Québec, which has recently accepted to also partly sponsor a project that will look at quantification of antibiotic usage in Quebec pigs.

Since 1993, Quebec has had a program looking at antimicrobial resistance in food animal pathogens. Last year our ministry of agriculture, fisheries and food produced a document on antibiotic resistance in swine, poultry, dairy and beef cattle (MAPAQ, 2012). This document is interesting since it shows the evolution over the years of the resistance pattern for some of the common swine pathogens detected in veterinary diagnostic laboratories of the province. For example, close to 100% of the porcine strains of *Escherichia coli* were sensitive to ceftiofur in 1994, and the resistance gradually increased and was at 22% of the isolates in 2011.

CONCLUSIONS

As seems to be the case in the rest of North America, antibiotic usage in Quebec swine can be improved. Since antibiotics need to be prescribed by a veterinarian in our province, and since veterinarians have recently opted to put more focus on antibiotic usage and resistance, it will be interesting to see if these efforts will produce the desired results or not in years to come.

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www.mapaq.gouv.qc.ca/antibioresistance

Impact of Influenza A in Pork Production
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Our understanding of the importance of influenza A infection in pig production has evolved rapidly over the past 15 years. Recent detection of novel subtypes of influenza A, such as H3N2, H1N2, and pandemic H1N1 in swine have heightened our awareness of this pathogen as a primary cause of swine disease and significant zoonotic (from animals to people) and reverse-zoonotic (from people to animals) risk. This paper reviews some ways in which influenza A impacts the pig producer and swine veterinarian.

IMPACT #1: PIG HEALTH, WELFARE, AND PRODUCTIVITY

Emergence of ‘triple-reassortant’ H3N2 swine influenza in Ontario in 2005 reminded us that novel strains of influenza, occurring in a naïve population, cause significant clinical signs and loss of productivity. The classic indications of ‘outbreak’ influenza were seen: pigs with fevers and loss of appetite; abortion and other reproductive signs; and growth and efficiency challenges (Olsen et al., 2006). These breaks usually had a defined beginning and end, and thus the economic impact was relatively easy to measure. In 2007 the impact of swine influenza was ranked only second to PRRSv in terms of breeding herd productivity (Holtkamp et al., 2008).

However, the more common situation in Ontario in 2013 is an ‘endemic’ presentation, where the breeding herd is often quite stable, but the nursery and finisher populations may exhibit low-level symptoms of influenza, punctuated by occasional periods where clinical signs become more pronounced. The true impact of influenza is harder to measure in this situation, especially considering that there are almost always co-infections such as PRRSv or *M. hyopneumoniae* that result in complicated respiratory disease.

Some data and opinion on the cost of influenza are available. Donovan (2005) suggested that H1N2 (an uncommon subtype in Canada) resulted in 2.9% more wean-to-finish mortality, as compared to a similar, uninfected pigflow. Other researchers reported on a survey of swine veterinarians in which the reduction in feed efficiency of influenza A-infected pigs was figured at 0.05 (nursery) and 0.04 (finisher), and the combined nursery-finisher mortality was suggested to be 2.5% (Holtkamp et al., 2007).

In addition to mortality and feed conversion, influenza increases medication usage in an attempt to control secondary bacterial infections; *H. parasuis*, for example, is known to cause more severe disease following influenza infection (Brockmeier et al, 2010).

Treatment and control options may mitigate some of the impact of influenza. Treatment options are limited to alleviating symptoms; water-soluble ibuprofen, for example, appears promising as a treatment for fever in influenza-infected pigs (Hawkins et al., 2010).

Vaccination against influenza A with commercially available influenza vaccines is often at least partially effective to reduce clinical signs, shedding of virus, and transmission between pigs (Romagosa et al, 2011; Corzo et al., 2012). However, as the genetic diversity of influenza virus increases, cross-protection from one strain to another decreases, so there have been numerous frustrating situations in which commercial vaccines have failed to provide satisfactory benefit

(Rodibaugh, 2008). In recent years many swine veterinarians have used autogenous vaccines to try and provide immune stimulation with a ‘homologous’ influenza subtype; in some cases, the results have been positive (Rodibaugh, 2008).

Some veterinarians believe that we need to take a similar approach to influenza that we have taken with PRRSv. In other words, we need much more information about how influenza spreads from farm to farm, and from pig to pig, so that we can implement effective long-term control and eradication strategies. Eradication of influenza from farms or systems has been reported (St-Hilaire and Derosiers, 2010; Torremorrell et al., 2009).

IMPACT #2: PUBLIC HEALTH

The ability to profitably produce pigs depends not only on the internal factors of the industry itself, but also on the goodwill of the public and regulators to not interfere with normal production practices. This goodwill hit a speed-bump in 2009 when pH1N1 (or ‘swine flu’) caused the public to consider the risk that swine populations potentially pose as a reservoir for influenza A. There are documented cases of influenza transmission from people to pigs (Forgie et al., 2011), and vice versa (Kitikoon et al., 2011). The recent explosion in the detection of novel subtypes and strains of influenza in pigs indicates that the possibility of a novel pandemic strain associated with pigs is real, and is a potential impact that should be avoided if possible.

At this time we do not have clarity on what role, if any, vaccination of pigs ought to play as part of a broad-based public health program for influenza A viruses. Some other actions may be more straightforward. Pig producers and pig veterinarians may choose to receive seasonal influenza A vaccination; strive to stay out of the barn when experiencing flu-like symptoms; restrict unnecessary human visitors from the barn; segregate poultry and wild birds from swine, (knowing the pigs’ ability to become infected with avian subtypes of influenza); use personal protective equipment (PPE; respirator masks and gloves, for example) when in contact with pigs; and work together to implement influenza control programs that limit pig-to-pig and farm-to-farm transmission.

In recent years the pig industry has paid full attention to PRRSv and PCV2 as the biggest animal health threats; because of its importance to animal health and productivity, and human public health, influenza A will deserve our full attention in the future as well.

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Trends and Patterns of Influenza Virus Circulation in Ontario Swine Herds

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ABSTRACT

The ecology of influenza in North American swine populations was stable and dominated by circulation of classical swine H1N1 virus until the 1990s; when a new lineage of H3N2 viruses emerged. This lineage was characterized by a unique combination of internal genes (TRIG cassette) that allowed easy adoption of two genes encoding external proteins, resulting in emergence of different recombinants. This original triple-reassortant H3N2 (rH3N2) virus emerged in Canada in 2005. An event that marked a considerable change in attitudes toward influenza surveillance in Canada was the detection of pandemic H1N1 (pH1N1) in a swine herd in Alberta during the early phase of the 2009 pandemic in people. On one side this resulted in heightened interest towards influenza surveillance in swine by animal and public health authorities, and on the other side, the actual surveillance and testing for influenza decreased. The surveillance that did occur during 2009 and later in different Canadian provinces indicated that diversity of influenza viruses circulating in swine is high (Nfon et al., 2011). As an example, a majority of the H1N1 viruses that circulated in Canadian pigs in 2009 had two external genes originating from the classical swine H1N1 virus, and the TRIG cassette from the trH3N2 viruses. The second most common group of H1N1 viruses was the pandemic H1N1 virus, followed by recombinants between the seasonal H1N1 human influenza and rH3N2 viruses. Similarly, different recombinants of H3N2 viruses have been reported. As an example, Tremblay et al. (2011) reported recombinant H3N2 virus that had all internal genes originating from pH1N1, and HA and NA genes from trH3N2. Similarly, in Ontario turkeys, Berhane et al. (2012) reported different recombinant virus that had combination of genes from the pH1N1 and trH3N2 viruses. Circulation of seven different reassortant viruses between the pH1N1 and endemic influenza viruses was also reported in the US pigs (Ducatez et al., 2011). The interest of public health authorities was sparked again during summer of 2012 when some of these recombinant H3N2 viruses, declared as variant H3N2 (vH3N2) started infecting people who had long-term exposure to swine during pig shows. All this data indicate that influenza is becoming a more complex infection. One of the obvious questions is whether a set of dominant influenza variants will emerge, or the ecology will continue to be dominated by constantly emerging reassortment viruses. This has implications for management of this infection, and monitoring its trends. During this presentation, large scale trends and seasonality of influenza will be discussed, data coming from virological surveillance will also be presented, and results obtained through simulation modeling will also be commented on. The data reported in the scientific literature, as well as the data obtained through the current ongoing Ontario projects will be discussed.

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