Proceedings

of the

5th LONDON SWINE CONFERENCE

Production at the Leading Edge

April 6-7, 2005

London, Ontario

ONTARIO PORK

Ontario Ministry of Agriculture and Food

UNIVERSITY of GUELPH

Proceedings

of the

LONDON SWINE CONFERENCE

Production at the Leading Edge

Edited by
J.M. Murphy

April 6th and 7th, 2005
London, Ontario
www.londonswineconference.ca

Proceedings of the London Swine Conference – Production at the Leading Edge

Additional copies of these Proceedings are available for $25 each.

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ISBN 0-9688770-4-4

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CHAIR'S MESSAGE

Welcome to the 5th London Swine Conference – **"Production at the Leading Edge"**.

With over half the Canadian pig and pork production exported to more than 90 countries around the world, keeping pork production on the leading edge is very important. Canadian pork is recognized for its quality, safeness, uniformity, value, and wholesomeness. Canadian breeding stock and market pigs continue to meet the demands of international customers through the use of superior genetic, health, and production technology. Challenging pork production to be at the leading edge of technology and information helps create an efficient and innovative industry.

To drive this process, the London Swine Conference provides a platform to accelerate the implementation of new technologies in commercial pork production in Ontario. During the two day conference, participants will have the opportunity to exchange and discuss ideas with internationally renowned speakers and innovative industry leaders. Presentations, panel discussions, breakout sessions, and networking provide everyone the opportunity to learn.

This year's theme, **"Production at the Leading Edge"**, features sessions on Keeping Disease Out, Sow Reproductive Efficiencies, Animal Welfare, and The Value Chain. Biosecurity, emergency preparedness, health management, parity segregation, pre-slaughter management, welfare audits, traceability, cleaning, disinfection, 30 pigs per sow per year, and integrated pork production chains are the broad range of topics being discussed by the speakers.

Through the hard work and dedicated effort of volunteers, the support of industry partners, and industry wide participation, the London Swine Conference successfully delivers its objectives. A special thanks to our generous sponsors, who through their financial commitment, support this initiative. Thank you to Ontario Pork, the University of Guelph, and the Ontario Ministry of Agriculture and Food for providing the initial foundation for this conference to become what it is today.

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

Enjoy the Conference!

John Bancroft
Chair, Steering Committee
2005 London Swine Conference

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KEEPING DISEASE OUT

BIOSECURITY: REASONING AND LACK OF REASONS

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ABSTRACT

Biosecurity is a discipline that is difficult to evaluate based on experimental or historic data. Research is used to identify potential mechanisms for transferal and less for prevention. The use of this information needs to be based on a good mechanistic understanding of the management of risk. Mathematically, this risk needs to be understood in a nonlinear fashion. In management, this risk needs to be understood in terms of policy and compliance.

INTRODUCTION

Biosecurity is one of the most important production strategies we need to address. We agree that disease introduction is one of the most important contingencies to address. Yet there are very few aspects of the biosecurity that can be quantified. We have little idea as to the true risk of exposure to its various aspects. Thus we have a ready audience to suggest and purport a long number of different biosecurity procedures. Unfortunately, most biosecurity procedures are untested as to their importance, and even fewer have been tested for farm-level determinants. Some have been tested as to their mechanism and have been shown to be feasible methods of transferal of pathogens.

It has to be emphasized that most biosecurity measures have only been tested as to their plausibility. Furthermore, we have to understand that we mostly speak about intentions of biosecurity and rarely speak about the likelihood of compliance and the relative costs of high compliance levels. Finally, most of the putative biosecurity effects are not linear. Doubling the distance, doubling the down time or doubling the disinfectant dose will never half the risk of introduction. A reasoned approach to biosecurity needs to involve an understanding of mechanisms of risk along with the costs of failure to address biosecurity risks.

THE COSTS OF DISEASE ENTRY

There have been various estimates of the cost of disease entry onto a single farm, into a region or network of farms, or into a country. Devastating is the adjective often used; it is very costly, it is ugly, it is depressing. The costs can be divided into three areas:

- The introduction of a pathogen onto a naïve farm is one of the highest potential costs identified by most farmers. Many of these pathogens result in catastrophic financial losses and compromised welfare for pigs. Some of these welfare concerns can be difficult to address as pig flows are compromised and systems can become quite crowded. We see farm laborer satisfaction declining significantly when there are increased challenges of infectious disease. We see increased antibiotic use, and, overall, we see the cost of production increase and value of output decreased, especially in the short run.

- The introduction of pathogens into a herd also increases the risk for other herds. This can be through various networks, whether it be by delivery, common transport methods or common employees. It can also be by simple geographic proximity, especially with pathogens that are transmitted by air or insects.
- The introduction of pathogens may also result in regulatory effects that will decrease the value of pork within a country or region. This aspect of biosecurity is often underplayed and yet it is a valuable part of any biosecurity system, in that it reduces the likelihood of entry of pathogens into a country, as well as a farm.

THE RISK OF DISEASE ENTRY

Disease introduction continues to be a common event. At the University of Minnesota Disease Eradication Center we are studying in detail the likelihood of transferal of PRRS virus. The risk is significant and appears to be in excess of 10% per year for many sow herds. This agent comes from infected pigs, usually in the first month of infection. Thus the major source of virus comes from nurseries or grow finish groups that go through an outbreak episode. This source of virus is unlikely to be chronically infected pigs, especially sows. We must recognize that the source of pathogens is different than the target of pathogens in swine production. For multiple site production our main concern of entry is the sow herd. Yet the relative number of animals is small in sow herds, and for most pathogens there is a level of immunity that limits pathogen shedding. Thus the source of pathogens is most likely to be nurseries and grow finish sites. If we assume that shedding is a linear function of the weight of animals, grow finish sites far outweigh nurseries as sources of pathogens.

Can we reduce the amount of pathogen shedding? One of the secrets of pseudorabies eradication is that PRV vaccine was used to reduce the likelihood of outbreaks and shedding in infected growing pig herds. Currently, this same effect has been investigated for PRRS virus. Another possibility is the use of filtering to reduce the amount of shedding from the herd. This has not really been studied but should be considered, especially in conjunction with odor control methodologies.

Graphical information systems (GIS) have been used to study proximity and its effect upon likelihood of transmission. GIS is especially useful when it is combined with network analysis, which examines relationships between farms, whether it is the transfer of animals, technicians or trucks. There have been more and more cases where molecular techniques have identified transport as a major biosecurity challenge. A wide range of disinfecting procedures have been examined, with drying appearing to be an essential aspect. The safer alternative is to restrict the size of the network by dedicating trailers to farms.

The previous paragraphs illustrate that there are various mechanisms available for further study of disease transferal mechanisms. How these are integrated into farm policy is important. The general rules of good biosecurity management are to create a comprehensive policy that addresses all concerns in a comprehensive manner. Secondly allow for compliance that is easy and reliable. Thus three major assumptions should be challenged within the swine industry. The first is the question of compliance, that everyone is as interested as herd owners. The second is the mathematical problem of linear thinking. We think that doing something twice as good will result in being twice as safe. The third is that we are able to recognize all major risks.

Linear Thinking

It is evident that there will be no simple answer to biosecurity questions. Yet we need a reasoned approach to the different research aspects that we see in current biosecurity discussions. I think that the biggest lack of reasoning is in the understanding of how to manage exponential risks. Exponential risks are best described in terms of a half-life. Linear thinking suggests that reducing a factor by half also reduces the exposure to risk by half. For almost all of the risk factors that we examine, the effects are not linear and have an exponential relationship. Unfortunately, there are very few of us that can think in exponential terms.

The classic illustration of exponential effects is in paper folding. A normal sheet of paper folded in half and refolded and refolded again is approximately the thickness of your fingernail. If you could fold the paper in half 10 times, it would be the thickness of the width of your hand. At a total of 17 folds it would be as tall as a two-story house; five more folds would make it as high as the Sears Tower. 10 more folds puts it beyond the atmosphere. 20 more folds would bring it to the sun.

If we can take the idea of exponential risk to the discussions we are currently having, many of the discussions will change. Three points need to be emphasized:

- There is no such thing as a zero risk if the mechanism is present. We cannot speak in absolutes, as we are simply reducing the risk by manipulating factors such as distance, cleaning, and disinfection. Questions such as whether aerosol transfer is possible is an inane question if it is shown to travel one meter.
- Doing all steps half decently is much more effective than doing only half of the steps extremely well. We must always be worried about missing a major mechanism of transferal of pathogens, as an uncontrolled mechanism may be the most important.
- We must always be looking for new mechanisms of risk reduction. For instance washing trucks more thoroughly appears to only have a small effect in comparison to a new technology with that separate mechanism. Such an example is drying of the trailers.
- More research has to be done in estimating half-lives of pathogens under different transfer mechanisms. Some of these can be estimated theoretically - dispersion calculations are readily available for aerosol transfer. Survival half-lives under different conditions can also be estimated for many pathogens. Even simple dispersion and turbulence models places that half-life of pathogen concentration at less than 50 meters.

In many ways, the management of exponential risk really follows the adage of working smarter, not harder. Overextending certain effects, such as showering, may have little effect as most of the effect is seen within a short time. Adding time to an already controlled mechanism may do more for the manager than disease transferal. To work smarter does involve further information to model potential intervention effects.

Compliance

It is hard to identify a security system in other types of enterprises that does not have a method to measure and assure compliance. Many businesses with much less inventory at risk use a variety of compliance assurance methods including video cameras, spot inspections, and security officers. Many swine farm owners find such security measures distasteful. It is assumed that the purpose of security compliance measures is to police employees. In fact, in our experience, the real failures in compliance almost inevitably lead to the identification of management faults instead.

If we agree that there is a real cost to biosecurity measures and that there is also a real complexity to its management, it has often been an unfair expectation of employees to understand and comply with all measures. Even more egregious mistakes have been made once and the costs of compliance are borne by the employees. A simple example of compliance management is the placement of time cards. In many farms the time cards are placed after the shower. This places the cost of showering on the employee, and, if the employee is late, showers are curtailed, and biosecurity is assumably compromised.

Cameras, along with time lapse video recorders, are an excellent tool. Such security systems are relatively inexpensive and four cameras along with a time lapse VCR can often be purchased for less than $1000. The major purpose is not to act as a deterrent, as cameras' efficacies are relatively low. Instead, the review of activities illustrates failures and factors leading to its failures. In review of videotapes we have found three major concerns in compliance:

- Foot traffic. Traffic in foyers, through showers and through secondary entryways is higher than expected. Protocols are followed at initial entry, but if secondary entries and exits are allowed, protocols fail. Likewise, weekend compliance is lower.
- Unscheduled and unwelcome visitors. Whether it is livestock trucks, neighbors or even salespersons, traffic will be higher than expected unless gates at the entry to the farm are locked. It is also apparent that locking and unlocking gates is a laborious task for many employees and keys are distributed beyond the original intended audience. Theft is also a problem in many regions, and there have been reports of thieves that collect pigs from numerous farms.
- Supply introduction. Inventories and equipment are kept too low on many farms, so that introduction of supplies and equipment is compromised to allow employees to do their tasks. Whether it be disinfection, special deliveries, or packaging protocols, employees will compromise biosecurity to get their work done.

Identification of biosecurity failures allows for discussion, not punishment. Systematic changes, such as increases in supply inventory, restrictions on entry and exit, and simply adequate time for employees to get their work done. Weekend work is especially problematic as there are often secondary activities for the employee, along with a limited workforce. Unexpected problems, such as disease outbreaks or mechanical difficulties, will result in a choice between neglecting family or biosecurity. It is a position many of us do not appreciate.

CONCLUSIONS

Biosecurity cannot be reviewed in all aspects in a short time. It is a discipline that needs further description and explanation. We will continue to identify potential mechanisms for pathogen movement and control. However, farm level decisions have to be made with the knowledge that the mechanisms do not have a linear effect, and moreover, farm management must take compliance into account. These two aspects are the major challenges in the future.

MONITORING HEALTH

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ABSTRACT

There are many different methods to measure the health status of individual animals or herds. Information gained from monitoring health can be used to make important management decisions such as what vaccines to use or whether or not to depopulate. New technologies are being applied to this field so that better diagnostic tests are being constantly developed and improved, and yet the results of these tests must be interpreted carefully because false negatives and false positive results can occur with all tests. Health monitoring can be expensive, and the cost of monitoring can only be justified if results are acted upon.

INTRODUCTION

Monitoring the health of pigs is carried out in a variety of ways from a simple walk through the barn to determine if all the pigs are eating and looking healthy, to running DNA-based laboratory tests to look for evidence of pathogens. There are limitations to all monitoring techniques and there are costs. How much time and effort is spent in this activity depends on what is done with the information.

This paper will attempt to highlight some of the recent research work performed at the University of Guelph in this area.

TECHNIQUES FOR MONITORING

Visual Inspection

There is a responsibility to inspect animals, at least on a daily basis to ensure that they have access to feed, water, a comfortable environment and that any sick or injured animal is dealt with promptly. This is the minimum level of health monitoring that must be carried out, and there are farms that struggle to achieve this level. One problem is not spending sufficient time to check each pig or not being skilled at identifying a sick animal in an early stage of distress. This work is often hindered by the environment, for example poorly lit pens or covered creep areas. A second issue is the fact that a sick or injured animal is identified and no action is taken. Every farm needs to have a protocol in place to deal with sick or disabled pigs, which likely means being able to move the pig to a well-designed hospital pen for treatment or being able to promptly euthanize the animal. Work is being conducted at Guelph by Dr. Suzanne

Millman to explore sickness behaviour in pigs and hopefully this work will lead to a better understanding of how to design and operate a hospital pen.

In addition to identifying the individual sick animal, visual inspection is a key component of herd health evaluation where one can assess the prevalence of coughing, diarrhea, uneven growth rate, or other conditions. Many farmers use a visual inspection as the main monitoring tool and as long as the animal's health appears to be at a steady state no further action is taken. However this is generally inadequate.

Production Records

Quite clearly it's difficult to improve unless you keep score. With the advent of personal computers and software, such as PigChamp, monitoring performance by means of production record analysis became relatively easy. There have been numerous studies showing the value of this approach (Wilson et al., 1986; Tubbs, 1996). Many of the disease problems that have the greatest economic impact in the swine industry are very subtle, often referred to as sub-clinical diseases. A disease like enzootic pneumonia which seldom causes mortality but can greatly reduce growth rate is a good example. Analysis of production records can be extremely useful in monitoring sub clinical disease in the grower-finisher barn. Tiffany Cottrell, a PhD student in the Department of Population Medicine at Guelph has been analyzing production data collected from August 1995 to March 2004 from six large multi-site production systems in Alberta, Manitoba and Ontario. These data represent over 6 million pigs and provide a good benchmark for the Canadian swine industry. The results of her study are presented in Table 1. These parameters can be used as the basis for determining what is "normal".

Table 1. Batch-level grower-finisher production parameters.

	Mean	Standard Deviation
Average daily feed intake (kg)	1.93	0.25
Average daily gain (kg)	0.78	0.08
Average live exit weight (kg)	111.1	4.0
Average index	108	2.8
Average starting weight (kg)	26.2	3.7
Culls plus deaths/1000 pig-days	0.28	0.38
Days on inventory (days)	126	17.4
Feed cost/pig started ($)	58.46	8.08
Fill-to-fill interval (days)	129	18.3
Gain/kg feed	0.34	0.03
Kg pork sold/m^2/yr	440	68.05
Market price/100 kg ($)	135.7	22.1
Percent mortality	2.76	2.7
Space per pig (m^2)	0.74	0.15

Slaughter Check

Recording disease data at slaughter can be useful in defining herd health status for sub-clinical conditions. The most common diseases monitored in this way include enzootic pneumonia, roundworm infestation, rhinitis and sometimes ileitis and gastric ulcers (Pointon, 1995). One limitation is that lesions can heal over time so that what you see at market may not reflect what happened in the early stages of the grower period. Before the development of reliable laboratory tests this was the most effective method available to monitor high health herds to ensure freedom of Mycoplasma hyopneumoniae (the cause of enzootic pneumonia) and toxigenic strains of Pasteurella multocida (the cause of atrophic rhinitis).

Laboratory Diagnostic Tests

These tests tend to fit into two general categories: firstly those that detect an organism directly, and secondly tests that measure the pig's response to exposure to a pathogen such as antibody production. These tests generally require a biological sample such as blood or other tissues or possibly a fecal sample. All tests can give false or misleading results. In the case of most diseases the pathogen infects the pigs and by the time the clinical signs are quite noticeable the body may have cleared the disease organism, especially in the case of a bacterial infection where antibiotics have been administered so that the submission of tissue to test for the presence of the organism may be fruitless.

On the other hand submission of a serum sample to test for antibodies generally requires a waiting period of at least 2 to 3 weeks from the time of the disease outbreak in order for the antibodies to be produced. In addition there are lots of problems with cross-reactions because of the pig's exposure to other microorganisms that may have similar properties to the pathogen. As a general rule almost all the diagnostic tests that we use in veterinary medicine need to be interpreted with caution. They tend to be more useful in determining the health status of a herd rather than an individual and they tend to be more useful if combined with other information like history of disease in the herd, vaccination programs used, and age of animal.

RESULTS OF THE SENTINEL HERD PROJECT

Beginning in the spring of 2001, we began a project to monitor the disease prevalence of Ontario pig farms. One hundred randomly selected herds were visited on an annual basis for four years. Generally, surveys were filled in, 30 blood samples were collected from sows and 30 blood samples from finisher pigs. Fifteen manure samples from finisher pigs were collected. Sera and fecal samples were processed and placed in –80°C freezers for future analysis. Generally culturing of bacteria was performed on fresh samples whenever possible. In 2003, nursery pigs were included, and nasal, tonsil and rectal swabs were taken. We have tested farms for a variety of diseases that are of economic significance including; swine influenza, atrophic rhinitis, porcine parvorvirus infection, pleuropneumoniea and porcine proliferative enteropathy (PPE or ileitis). And we have tested for microorganisms of public health significance such as *Salmonella, Toxoplasma*, *Yersinia, Campylobacter* and *E. coli*

0157:H7. The most thorough evaluation of pathogens of public health concern was conducted in 2004 and the findings are summarized in Table 2.

Table 2. Prevalence of food-safety pathogens in Ontario grower-finisher farms (2004).

Pathogen	Pigs % (n=800)	Farm % (n=80)
Salmonella	11.4	47.5
Yersinia	13.4	38.8
Campylobacter	100	100
E. coli 0157:H7	0.1	1.2
Toxoplasma	0	0

One of the diseases of significant economic importance that we investigated was porcine proliferative enteropathy. The causative agent is *Lawsonia intracellularis*. This bacteria has been difficult to culture and diagnostic tests have been only recently available. We determined the proportion of herds that were positive to *Lawsonia intracellularis* to be about 70% based on serological testing (Corzo et al., 2005). In addition we evaluated the two tests available- immunoperoxidose monlolayer assay (IPMA) from the University of Minnesota and an indirect immunofluorescence antibody test, (IFAT) from the University of Montreal. Agreement at the individual pig level was poor but we concluded they could be useful if applied at the herd level.

USING HEALTH MONITORING INFORMATION

There is no sense spending a lot of time and money on monitoring if the information is not going to be used. For example, finding the sick pig earlier and treating it, noting a rise in days to market or a drop in market weight and taking action to improve growth rate, detecting an increase in milk-spotted livers at slaughter and starting a deworming program.

In the case of using serological testing to monitor health status, an important application is in the introduction of breeding stock. To safely bring replacement gilts into a herd the ideal situation is to find a gilt supplier with exactly the same disease status as the purchaser. As mentioned earlier most of the diagnostic tests are not very reliable when used on the individual animal so it is possible to test an incoming gilt, receive a negative lab test and introduce her to the herd and still have her bring in disease. It’s more reliable to test the herd of origin.

As a result of the research conducted as part of the Sentinel Herd Project we have a great deal more information regarding prevalence of disease and a better idea of how to test herds for specific diseases. This may become useful if the industry decides to institute some type of control program for a disease like Salmonellosis. The Danish have started a monitoring and eradication program for *Salmonella* (Wegener et al., 2003) but based on the widespread prevalence in Ontario this may not be feasible at present.

CONCLUSIONS

Health monitoring is important in order to maintain or improve productivity and food safety. New technology is making it easier to test for a wide range of pathogens but these tests have limitations. The ultimate goal of health monitoring is to use this knowledge to assist in developing programs to eliminate disease and to design biosecurity programs to prevent disease re-entry.

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EMERGENCY PREPAREDNESS: WHAT IS THE NATURE OF YOUR EMERGENCY

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ABSTRACT

Any outbreak of an Office International des épizooties List A disease, such as classical swine fever or foot and mouth disease has severe consequences for animal welfare as export markets for live animals are immediately closed. In export dependent regions, slaughter facilities may also close or be trapped within eradication zones increasing the farm gate live animal surplus. Time sensitive livestock such as isowean and weaned piglets may be critically affected. Governments of European countries have anticipated welfare slaughter as part of their disease eradication preparedness. The concept of welfare slaughter and the resource implications has not been included in current disease emergency planning documents in Canada. National and regional leadership committed to addressing this issue is urgently required.

INTRODUCTION

In western industrialized countries where stamping-out of Foreign Animal Disease (FAD) has been recently applied, there has been heightened public debate over the extreme costs required to achieve eradication and the ethical issues inherent in the process (ICCPFMD, 2001). The 2001 foot and mouth disease (FMD) epizootic in the United Kingdom gave rise to 3 major forums for public discussion of the disease eradication response in particular and agricultural practices related to producing human food of animal origin in general (Anderson, 2002; Follett, 2002; Curry, 2002).

In considering lessons provided by other countries' FAD eradication experiences, and current livestock marketing practices, the introduction of a FAD into a Canadian export dependent livestock sector (cattle or swine) would result in 3 separate crisis:

1. A small scale crisis related to the control of animals on infected and high-risk farms (stamping-out effort) for which CFIA has the legislative mandate and fiscal resources to address. A recent example is the 2004 Avian Influenza outbreak in British Columbia.
2. An on-farm crisis would develop related to welfare problems consequential to animal movement restrictions put in place by both the stamping-out response and the US border closure, and lastly;
3. A large generalized on-farm financial crisis related to the loss of export market access which in part would be manifested as an acute fall in livestock value (example slaughter cows in Canada subsequent to BSE).

The animal welfare crisis is closely interconnected with the stamping-out effort as the stamping-out and animal welfare operational responses occur concurrently and compete for the same human and carcass disposal resources. In Ontario and Manitoba, the most critical animal welfare problem would be an immediate (within 96 hours) inability to provide housing for thousands of isowean pigs (Bargen and Whiting, 2002). This crisis could also result if a single US state such as Iowa closed its borders to live animal movement. In the scenario of a localized outbreak in an important US market the CFIA emergency (eradication) plans are not triggered as the job of the Agency would be to maintain Canada disease free. Being disease free is of little relevance if your only live animal market is closed. Unlike recent experience with avian influenza in British Columbia, with an introduction of classic swine fever (CSF) or foot-and-mouth disease (FMD) into Canada or a significant trading region in the USA, the agri-emergency and media attention would center on the animal welfare emergency not the disease eradication effort.

DISEASE ERADICATION: DESCRIBING INCURSIONS

In describing the consequences of FAD epizootics, financial impacts are often classified as direct costs or indirect costs. Costs are direct if emergency responders must pay out the cost to achieve the disease control goal such as mandatory cease movement verification and enforcement, compensation for animals ordered destroyed and costs of carcass disposal. Indirect costs are losses incurred by individuals and sectors of the industry consequential to the disease occurrence such as down time on empty farms and loss of export market for meat products and live animals.

Payment of indirect losses (costs) is not essential to the success of the disease eradication goal. A major part of contingency planning is, therefore, anticipating the type and magnitude of direct costs and identifying the corresponding resources required for effective response and impact mitigation.

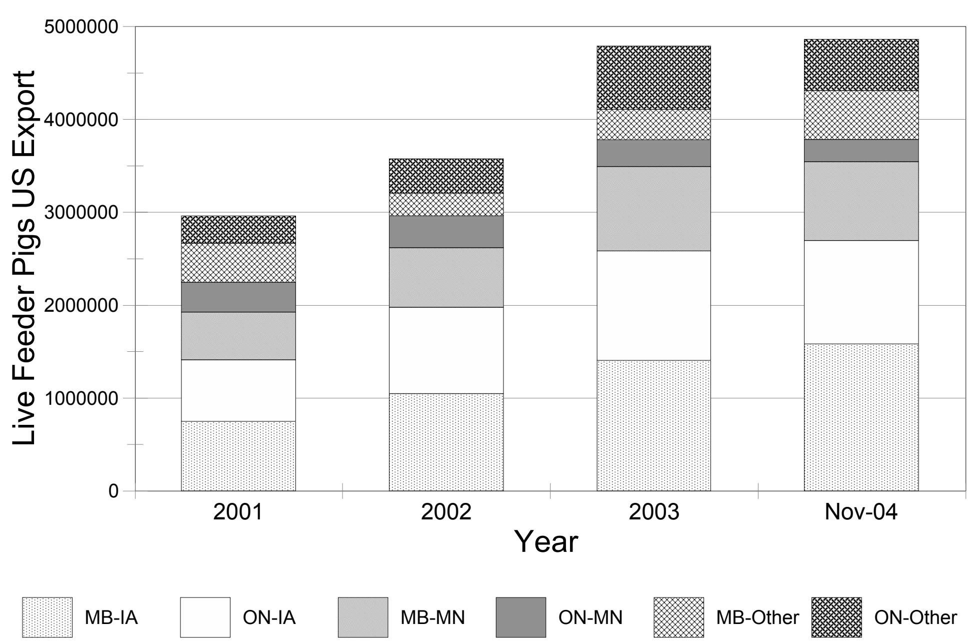
Animal movement restrictions severely disrupt the production systems affected. Animals located in quarantine zones most often cannot be salvaged as food and are strategically killed to relieve overcrowding or otherwise deteriorating animal husbandry conditions which occur on farms placed under movement restriction (EC, 1980; EC, 1985; Seracon, 2002). “Welfare slaughter” is a term used in FAD eradication efforts to describe non-infected animals killed during the operational response. Analysis of previous events indicates the magnitude of welfare slaughter subsequent to an FAD incursion is magnified under certain conditions; a) if the pre-incursion animal production industry is focused on export, b) the incursion is prolonged, c) the affects are in a wide geographic area or d) the incursion involves intensified livestock production (Saatkamp et al., 2000; PC, 2002). Welfare slaughter will also be magnified where a time sensitive livestock commodity such as isowean piglets is affected (Bargen and Whiting, 2002). Welfare slaughter is a direct cost of FAD eradication (Meuwissen et al., 1999; Dijkhuizen et al., 1999; Staatkamp et al., 2000, Sugiura et al., 2001; Wrathall and Mitchell, 2001; Bourn, 2002; Seracon, 2002).

Canadian experts indicated that a FMD incursion into Canada, under the best possible scenario, would result in a prolonged US border closure (Seracon, 2002). In May 2003 Canada identified its first indigenous case of BSE and the US border was closed (Kuehn, 2003). The US identified a dairy cow identified as an individual imported from Canada in December 2003 (Nolen, 2004). An international review panel indicated in January 2004 that Canada and the USA were at equivalent risk for BSE (Kihm et al 2004). It is expected that the border will open for conditional movement of live ruminants on March 7th 2005 (Anonymous, 2005). This re-opening of the US border to Canadian live cattle is quite rapid when compared to similar previous rulemaking in the United States. Classical swine fever was identified on August 8th 2000 in East Anglia and resulted in the infection of 16 farms with the last restricted area lifted in December 2000 (Wrathall and Mitchell, 2001; Sharp et al., 2001). The final rule for the US to recognize East Anglia free of CSF was on October 16th 2003 (USDA, 2003), three full years after the disease was eradicated.

Canada as compared to other industrialized countries is heavily dependent on export of live cattle and swine as well as beef and pork. For the year 2001 the Canadian ratio of meat produced compared to meat consumed domestically was 1.29 for beef and 1.59 for pork (Seracon, 2002). Similar ratios for The US were 0.97 for beef and 1.03 for pork and Australia 3.18 for beef and 1.05 for pork. Feeder pigs are a significant live animal export commodity (Figure 1).

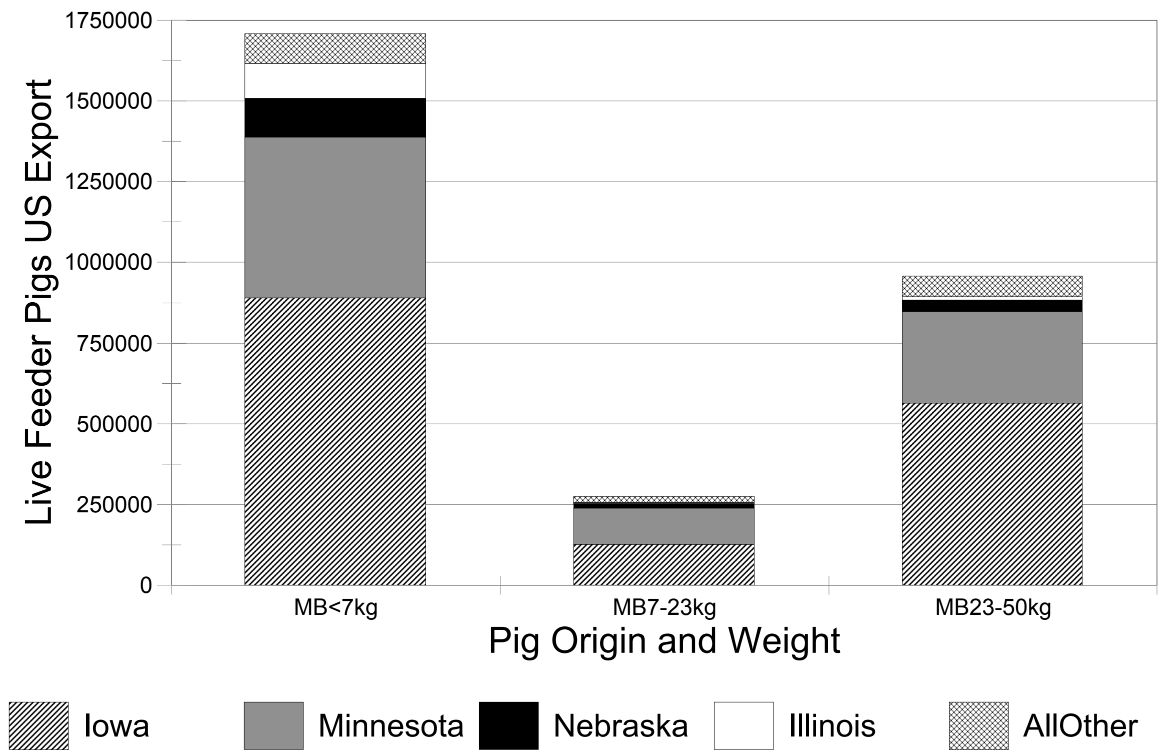
Figure 1. Live swine non-breeding, less than 50 kg exported to the USA from Manitoba and Ontario through November of 2004.

States receiving large numbers of feeder pigs from both Manitoba and Ontario are Iowa (IA) and Minnesota (MN). During this time period the average cash value for exported feeder pigs was strong (2001-$50.53, 2002-$45.37, 2003-$42.08, 2004-$42.93). There appears to be some slowing in export of feeders from Canada largely by reduced growth in Ontario feeder export market in 2004. Manitoba and Ontario combined account for about 96% of feeder pig exports to the USA.



Partly in response to concerns with border action Stats Canada changed their swine export reporting structure for 2004 to separate feeder pigs previously reported as less than 50 kg into 3 weight cohorts. In previous years all live swine exported less than 50 kg were lumped together in official reports. This weight range of pigs contains both isoweans (4-5 kg) at around 19 days of age and feeder pigs (24-25 kg) at around 60 days of age. These two types of pigs represent very different stages in the production system. Early data for 2004 indicated that the majority of export pigs less than 50 kg are isoweans (Figure 2).

Figure 2. Live Swine Export – Feeder Pigs Jan-Nov 2004 Manitoba Only.
In 2004, Stats Canada started reporting export live swine as 3 weight classes which were previously reported as one group - non-breeding<50kg. In the first 11 months of 2004 Manitoba had exported 3.2 million feeder pigs greatly in excess of the 2.637 million exported in the whole of 2003.



WELFARE ASSURANCE: SCOPE

The proportional cost of animal welfare assurance in comparison to the disease control efforts has been accounted for in financial analysis of previous FAD incursions. However, complete accurate documentation of the financial impacts of FAD incursions is difficult to establish even in retrospect (Saatkamp et al. 2000). In recent incursions of FAD into OIE member countries with stamping-out as the national policy, the scale of welfare slaughter was one half to ten times the cost of eradicating the disease on infected farms (Saatkamp et al., 2000; Dijkhuizen et al., 1999; Sugiura et al., 2001; Wrathall and Mitchell, 2001; Bourn, 2002).

Even in the case of a very moderate size FAD incursion, welfare slaughter operations will exceed the cost for disease control. In Europe for incursions of CSF, if 8 or more herds are infected on the day of identifying the first case, the costs of welfare slaughter are expected to exceed the cost of stamping-out (Saatkamp et al., 2000). In Canada, considering current trading patterns in live animals and animal products, it is estimated that in a small FMD outbreak with 50 infected herds; in the eradication effort 4,200,000 animals would be killed under welfare slaughter programs, while only 10,000 infected animals would be killed (Seracon, 2002). The financial expenditure to control disease would be less than 1% of the overall cost/loss of the incursion.

THE FAERS SYSTEM

The Canadian Food and Agriculture Emergency Response System (FAERS) was developed largely in response to the January 1998 Ontario-Québec ice storm. It is an attempt to describe a foundation for developing contingency plans to potential agriculture disasters; while, assuring such plans are coherent with the *Emergency Preparedness Act, Emergencies Act,* National Support Plan, and the Federal Policy for Emergencies (CFIA, 1999). Provincial departments of agriculture and other agri-food sector stakeholders, Agriculture and Agri-Food Canada (AAFC), and the CFIA have jointly established the FAERS to facilitate federal-provincial-industry collaboration.

For the purpose of FAERS, "an emergency" (agri-food emergency) is defined as "an abnormal situation requiring prompt action beyond normal procedures in order to prevent injury or damage to people, plants, livestock, property, or the environment" (CFIA, 1999). The FAERS is an *all-hazards* crisis management system designed to link the federal, provincial and private sectors to better manage and coordinate response to agriculture and food emergencies. Contamination of the human food supply is included in the manual, as a food borne hazard would constitute a true emergency (human health and welfare threat).

There are five types of Agri-Food crisis situations described in the FAERS manual based on whom the lead agency would be. A FAD incursion is a "mandated emergency" under the FAERS system where the jurisdictional responsibility is clearly with the CFIA as the lead agency. The CFIA component of FAD eradication as described by disease eradication plans (CFIA, 1997; CFIA, 2001) however does not follow the FAERS management principals of a comprehensive bottom-up contingency planning and response system. The CFIA disease eradication strategy documents describe in detail how infected animals and premises will be dealt with. These strategy documents do not consider the consequential impacts of disease presence on the agricultural trade of a region and therefore are not comprehensive crisis management approaches.

In Canada, animal welfare concerns related to a FAD response currently represent a non-mandated disaster (no federal agency has the lead), as the CFIA does not have the legislative responsibility, nor contingency plans in areas other than infected herd eradication. Under the FAERS model, in non-mandated agriculture emergencies, AAFC and the CFIA will jointly determine which of the two organizations will take the lead and which will provide a support function. In general, AAFC is expected to take the lead when the emergency support primarily relates to providing financial compensation to farmers which is a major function of welfare slaughter/market support programs (CFIA, 1999).

THE FADES PLAN

Many provinces are reviewing the Foreign Animal Disease Eradication Support Plans (FADES). These federal-provincial agreements are essentially designed to recruit provincial resources to assist the CFIA in the stamping out of infected herds. These plans have worked well in supply managed commodities where there is little export in live animals or product. In swine production regions which are export dependent the nature and predominant activity of the FAD emergency response will be focused on how to deal with critical overcrowding on uninfected farms, not in stamping out disease.

An additional problem is the current FADES plans may appear to the producers to be comprehensive emergency response plans (and give producers a false sense of security) when in fact they are provincial agreements to support the federal disease eradication effort (Anonymous, 2004).

There is no provision within the FADES initiative to discuss animal welfare slaughter or other consequential effects of dealing with regional animal health crisis (Geale, 2002). During the activation of a FADES plan there will be concurrent demands on provincial and industry resources related to administration of disease control efforts and maintaining animal welfare.

Recent modeling suggests that in a Canadian FMD incursion resulting in the infection of 50 herds, 400 animals would have to be killed under welfare slaughter provisions for each infected animal killed for disease control (Seracon, 2002). Therefore, if a Canadian emergency response to CSF or FMD were to develop as currently proscribed, only part of the management would be planned for, funded and have line responsibilities clearly defined under FADES; that is, the CFIA has committed to deal with the infected and high-risk animals. The current CFIA-FAD infection control commitment could represent less than 1% of the impact of a FMD incursion (Seracon, 2002). The welfare slaughter and consequential market effects of the incursion would be in theory, managed according to the FAERS principal i.e. local authority, municipality/province has first responder obligations.

PREDICTING THE FUTURE

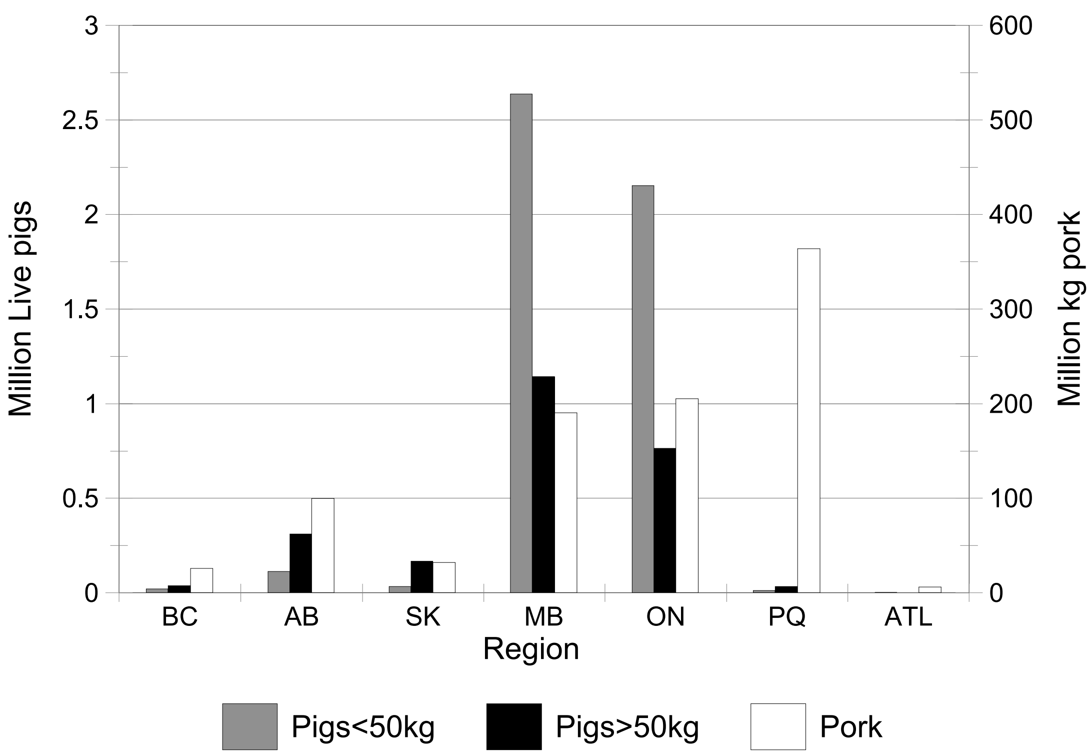
The 1997-98 CSF epizootic in the Netherlands was largely responsible for triggering a re-structuring (compulsory reduction) of the pork production sector in that country. This re-structuring was marked by a significant change in public attitude towards the livestock sector in general and pig production in particular. Livestock farming has fundamentally changed in the Netherlands from a “right” to a licensed activity (Brinkhorst, 2000). It is the explicit intent of the government sponsored re-structuring to decrease the size of the Dutch pork industry.

At present it is unclear how government support of the operational demands of CSF-FMD response and recovery assistance to farmers subsequent to a FAD would be valued and delivered in Canada. For the export dependent beef and pork sectors the lesson provided by Taiwan in failing to eradicate the 1997 FMD incursion is that overall FAD contingency planning should include the worst case scenario of not eradicating the disease and collapse of the industry (Yanc et al., 1999).

Under a real FAD crisis it will be impossible to immediately eradicate FAD from a region and concurrently demonstrate the region is disease free. A significant time period of border closure is inevitable. If costs are federally-provincially shared in response and recovery some regions will be severely affected on a per capita basis. Live pigs and pork products, as an example, vary greatly in their dependence on export markets with the regions of Canada (Figure 3).

Figure 3. Canadian regional volumes of export in pork and live pigs in the year 2003.

Region is indicated on the X-axis. Open bar is pork export in million kg (right axis) Solid bars are live pigs exported in million animals (left axis). Québec (PQ) has a mature pork production chain with predominantly finished product exported where Manitoba (MB) and Ontario (ON) are large exporters of pork products and live pigs. British Columbia (BC) and the Atlantic Region provinces (Atl.) have relatively small export volumes (StatsCan 2004). Regions would differ significantly on a per capita basis in the financial impact of a FAD incursion into Canada or the USA. Pork may be diverted to other international markets as opportunity may arise however; live swine production is contingent on dedicated facilities in the USA. Manitoba and Ontario have similar export volumes of pigs and pork. Manitoba contains only 3.7% of the Canadian population (taxpayers) while Ontario contains 38%, based on the 2001 Census.



CONCLUSIONS

Based on lessons provided by other countries' FAD eradication experiences, introduction of FMD or CSF into Canada would result in 3 separate types of crisis situation.

1. A crisis related to stamping-out disease on infected farms.
2. Animal welfare impacts of disruption to export market access.
3. Fiscal impacts of export market disruption.

The CFIA has the responsibility to deal with infected farms. The federal agricultural minister through AAFC and provincial partnering has traditionally delivered income support to farmers in times of unforeseen financial disaster and would be the apparent lead agency on rural economic stabilization and recovery. Currently there is insufficient Canadian operational infrastructure to rapidly respond to animal welfare concerns inherent in a FAD incursion into North America. There is currently no obvious leadership, legislative framework or pre-authorized funding to meet direct costs that government and industry would incur to assure an effective animal welfare component of FAD response.

Animal welfare assurance is part of the FAD emergency response and manifests as a direct cost. Lack of preparedness to concurrently assure animal welfare and eradicate infected livestock may result in failure to eradicate the FAD. Current national FAD disease eradication strategies only deal with infected farms. It is a gross error to misconstrue these disease eradication plans as effective and comprehensive agri-emergency management programs for CSF and FMD.

There could be a very substantial livestock crisis/disaster in Canada without ever having FAD identified here. Animal disease or other crisis in the USA could trigger international border closure in a time sensitive production system. This situation would not constitute a mandated emergency under the current FAERS agreement and no immediate mandated federal response (CFIA 1999). A FAD limited to a single US State such as Iowa and a single species such as swine would have significant repercussions in live animal markets and farm animal welfare in Canada. Iowa draws feeder pigs from all over the Continental United States in addition to Canada (Shields and Mathews 2003).

Individuals are often unable or unwilling to imagine the potential devastation that could be caused by low frequency catastrophic events and will not take measures to protect against the potential loss (Skees and Barnett 1999). In the insurance field this behaviour is referred to as "cognitive failure" (Meuwissen et al. 2003, Skees and Barnett 1999). Our collective current level of preparedness to respond to the risk to animal welfare posed by the threat of a FAD incursion is similar in nature to "cognitive failure" displayed by individuals in similar circumstances.

I would suggest the important lesson provided from the British and Dutch experiences is that if livestock production systems exist based on public goodwill. That goodwill is predicated on the belief held by the public that farmers are responsible and the national veterinary infrastructure is competent and prepared. If this country were to experience a FMD or CSF incursion there would be massive animal welfare issues generated. In the media coverage of the event and the industry call for free disaster relief, the average citizen would be able to understand the structural issues which should have been identified and avoided as part of responsible emergency preparedness. The response to this reality in the United Kingdom and the Netherlands has been for the public to irrevocably withdraw its support for livestock production.

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ACKNOWLEDGEMENT

Parts of this paper were previously published as Whiting, T.L. 2003. Foreign animal disease outbreaks, the animal welfare implications for Canada: Risks apparent from international experience. Can Vet J. 44:805-815.

MAXIMIZING SOW REPRODUCTIVE EFFICIENCY

PHYSIOLOGICAL LIMITS TO MAXIMIZING SOW PRODUCTIVITY

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ABSTRACT

Major improvements in breeding herd efficiency, as measured by success in meeting critical key performance indicators (KPI) for the breeding herd (body condition and sexual maturity of gilts selected to enter the breeding herd, meeting weekly breeding targets, consistent weaned pig output, and annual replacement rates below 50%), can be achieved by improving sow "fitness", improving efficiency in use of labour and space, and by implementing effective gilt development unit (GDU) programs. It is possible to set ambitious benchmarks for the GDU with available commercial dam-line females (80% gilts selected on the basis of a recorded standing heat within defined time-frames; 100% gilts bred at 2nd or 3rd estrus; 100% gilts bred at target weight of 135 to 150kg; and 85% of gilts bred during a 5-day period). In turn, these will drive excellent levels of performance in the breeding herd. However, these targets can only be achieved by recognizing the key physiological characteristics of contemporary gilt populations, and particularly their exceptional lean growth potential. By controlling body condition (weight rather than "fatness") and relative sexual maturity, producers can maximize first litter performance of gilts and improve their lifetime performance in the breeding herd. Appropriate key performance indicators (KPI) should drive breeding herd management. We suggest that meeting weekly service targets within a short breeding week, and segregated parity management of both the sow and her offspring, will help to achieve the critical KPI of successful breeding herds in the future.

INTRODUCTION: DEFINING "MAXIMAL" SOW PRODUCTIVITY

"Maximal sow productivity" is still usually defined as the number of pigs weaned/sow/year. Alternatively, if the high capitalization costs of the farrowing rooms are to be emphasized, pigs weaned/crate/year may be a more meaningful measure of maximal throughput. However, an industry that is likely to increasingly focus on 1) product quality, and 2) the constraints that welfare and environmental issues will increasingly exert on pork producers, the quality as well as the total number of weaned pigs needs to be considered when determining the best economic returns from the sow breeding farm.

The real or perceived impacts of pork production on the environment are an increasing challenge to the industry. However, these concerns can perhaps be used to advantage if the

Canadian pork industry is willing to rapidly embrace the concept of "environmental nutrition", as something that can be used as a trading advantage in global pork marketing. This approach to measuring the environmental impact of production systems, in addition to more traditional measures of production efficiency and growth performance, challenges us to adopt a totally integrated approach to measuring the relative efficiency of food-animal production. The ultimate measure of efficiency would reflect total production costs + environmental costs/kg of product sold. Environmental costs would include a measure of the land footprint needed for production, recognizing both efficiency of nutrient utilization (land area for feed production, plus land area, or alternative handling costs, of incorporation manure based nutrients and food-animal processing wastes into arable land with zero impact of the environment), and factors like greenhouse gas(GHG) emissions. The implementation of processes for recycling water and using manure digesters for production of "green" energy, represent future economic opportunities for offsetting the costs of pork production. An emphasis on more comprehensive measures of pork production efficiency will probably find more rapid adoption by Canadian production systems, in view of their smaller scale and greater receptivity to technological advances. If such advances in production efficiency can be implemented, and then audited in pork production chains that allow full traceability at retail level, this would allow Canadian pork products to be differentiated from the larger scale, more commodity-based and "less environmentally friendly" production systems, with which we compete in the export market.

There also seems to be a total lack of cost/benefit analysis associated with much of the recent debate about management programs that are claimed to hold the key to increased sow productivity. As discussed later in this conference, if gilts are properly selected and managed, they can; 1) be bred at second or third estrus, 2) achieve 85 to 90% farrowing rates and over 12 pigs born live in their first litter, 3) be bred at a target weight of 135 to 150 kg at <220 days of age, and 4) be retained in the sow herd for an average of 4 parities per gilt entered. All this can be achieved by simply applying good gilt management programs and there appears to be no limitation in terms of the "prolificacy" of most dam-lines in commercial use in the North American swine industry to reaching a target of 30 pigs weaned/sow/year. The prolificacy and lifetime performance of "Danish" sows has recently been given great publicity. However, 1) the cost of adding on 20 to 30 non-productive days (NPD) per gilt bred when breeding is delayed to over 140 days, with little evidence of any great improvement in lifetime performance, and 2) losing the benefit of being able to select gilts on the basis of their early sexual maturity and then manage them for improved first litter size, seems to bring into question the economic reality of adopting these management strategies.

It is also very unclear whether standard measures of sow productivity are being offered for comparison. In some cases the count of gilt NPD can be extremely low and it appears that age at first service is taken as the day the gilt is placed on the breeding farm inventory. In other words, the entry-to-service interval (ESI) is entered as zero days, and the gilt NPD only includes the cost of returns to estrus after first service and gilts that fail to farrow. In other cases, it is often unclear what NPD contribution is included for gilts never bred, but moved to the sow farms and on inventory. Statements that more than 95% of all gilts arriving at the farms are eventually routinely bred, seems to be inconsistent with some of the counts of gilt NPD provided and real-life experience of the high cost of not properly selecting gilts before entry to the breeding herd. In comparison, our estimates of gilt NPD include an ESI that is counted from the day that gilts in a finishing system would, on average, exceed optimum market weight (around 170 days in Canada, and perhaps 185 days in the USA finished pig market), and the count of NPD includes days accumulated by gilts entered but never bred. We would advise producers not to be heavily influenced by the rather unqualified information being provided, until 1) an objective and standardized comparison is possible, and 2) a cost/benefit analysis of adopting these management strategies in the Canadian pork industry is available.

These introductory comments may seem rather “off-topic” given the title of the presentation, but we would argue that the single greatest failure of Canadian pork production industry, and an even greater failure of the larger production systems in the USA, is an inability to deal with avoidable inefficiencies in pork production systems using excellent dam-lines already available. From a Canadian perspective, this results in a failure to capture much of the marginal benefit that is available because of the exceptional genetic potential and high health status of our breeding stock. Most of the improvements discussed below are already attainable and are based on sound information from the R&D community. Indeed most have already found implementation in the top 10% of production systems. Perhaps the most disappointing aspect of these inbuilt inefficiencies is that they largely represent cost/benefit advantages that are captured at the primary production level. Perhaps we should pay more attention to a well-known “truism” of one our great mentors, Frank Aherne, that “you cannot test drive a Lamborghini in a traffic jam”!

Defining Key Performance Indicators (KPIs) of Breeding Herd Performance?

Given the above comments, the key indicators of breeding herd performance need to be carefully defined, and should reflect the most meaningful measures in terms of overall economic performance. Our producers are trying to make money, and should not be encouraged to see a simplistic measure of productivity like maximal numbers of pigs produced, at any cost, as a worthwhile goal. If a production system is not fully integrated, the terms of contracts at each level of the production chain should reflect the value of the pigs produced. Yet, a correct balance between the quality and the number of weaned pigs produced is not always apparent in the contracts agreed. Consequently, this is often not reflected in the priorities given to improving breeding herd performance. In terms of producing a reliable supply of weaned pigs at the critical nursery stage of production, the most important breeding herd KPIs are probably; 1) uniform numbers of pigs weaned per week, 2) the weight and age of the pigs weaned, and 3) the least variation possible in age and weight at weaning. In turn, if properly rewarded, these KPIs determine the key factors that will be the focus of the breeding herd. As has been repeatedly emphasized in the assessment of key determinants of the number of pigs born and weaned per week, the single biggest factor needing attention is meeting breeding targets. The second largest risk factor is farrowing rate. As shown in Table 1, these factors far outweigh the impact of achieving overall increases in the number of pigs born/litter, or variations in pre-weaning mortality. Thus, the primary focus of the breeding herd should be identifying the sows and gilts available on a weekly basis to meet projected breeding targets.

In the “push” concept of breeding herd management discussed later, a focus on establishing a well managed Gilt Development Unit (GDU) is considered to be the best way of ensuring a constant supply of gilts per week, whilst at the same time improving breeding management within the GDU to achieve consistently high farrowing rates. A constant input of high quality gilts into the breeding herd, with increased longevity, in turn stabilizes the parity structure of the breeding herd. This helps in preventing the somewhat erratic contribution that weaned sows are often seen to make to weekly breeding targets. A constant input of select gilts to the breeding herd also prevents the tendency for a reduction in the voluntary culling of sows to achieve weekly breeding targets. All these factors will prevent breeding farms from entering the “death spiral” that is frequently seen in many of our larger production systems (Williams et al., 2005).

Table 1. The relative importance (%) of different components of breeding herd efficiency for achieving a uniform weaned pig flow to the nursery (Foxcroft and Aherne, 2001; see also Dial et al., 2001).

	%
Number of sows served	60
Farrowing rate	30
Number born alive per litter	5
Mortality of pigs born alive	5

As discussed later, implementation of high quality GDU management can also make a considerable contribution to improving farrowing rate and reducing the variability in the age and weight of pigs weaned. However, such “down-stream” benefits can be used as important KPI, but are often not considered when discussing the benefit of changing GDU management practices.

Are such KPI Consistent with the Concept of Hyper-prolific Sows?

There will always be value in producing the maximal number of offspring from our breeding sows, but in an increasingly differentiated pork market, producers must consider the quality, as well of the quantity, of pigs produced. A consistent flow of good quality weaned pigs should be the principle goal, and is not necessarily best served by developing breeding herd strategies that simply focus on the concept that the “hyper-prolific” sow will necessarily meet this need. Indeed, as discussed elsewhere (Foxcroft and Town, 2004), increased prolificacy may well be associated with increased variability in weaned pig quality. Equally parity effects on postnatal growth potential may warrant segregated parity flows into specific nursery/grow finish systems Town et al., 2004; Moore, 2005). Again, the economic advantages of accepting these challenging and achieving much greater efficiencies in nutrient management would be all the more attractive to Canadian producers if such efficiencies provided a market advantage over our competitors.

This review will therefore focus on optimizing the performance of breeding sow units to remove inherent overall inefficiencies and the sources of variability that prevent us from capturing "maximal" economic value at the grow/finish stage of production. A clear understanding of the physiological limits of existing breeding stock helps us to understand both the challenges and opportunities that exist in achieving these goals.

UNDERSTANDING THE PHENOTYPE OF COMMERCIAL DAM-LINE SOWS

What Happened to Half a Pig Per Litter Per Year of Genetic Improvement?

Based on sound estimates of the heritability of all components of litter size in the sow, and continued improvements in the genetic merit of our nucleus sow populations, we should question why the repeated predictions that an increase in litter size of 0.5 pigs per year was achievable has never been realized at production level. There are probably two main explanations for our inability to capture the greater genetic merit of our breeding sows at production level.

1) Lack of appropriate management of contemporary dam-line females. The production systems created in the North America swine industry have tended to focus on a "least cost of production mentality", in which throughput volume is used to offset relatively lower efficiency of production at a biological level. This approach is not surprising, given that much of this philosophy has been directly transferred from the same corporate investors who are dominant in the poultry industry. For many of these integrated systems, the largest risk of becoming less profitable is an inability to maintain maximal flows through their processing plants. As a result, this corporate, processor-oriented approach to pork production seems to favor the availability of pigs for processing over the quality of these pigs; this approach also appears to place less emphasis on increasing efficiency at the primary production level as long as an adequate supply of finished pigs can be contracted for processing. This seems to result in a general attitude of "malaise" at production level that leads breeding herd managers to believe that improvements in efficiency are not a high priority. Even more alarming, this seems to lead to an attitude that it is the pig (dam-line) and not the inefficient management that is responsible for the lower production efficiency! As shown in Table 2, a simple reference to the performance of the average, compared to the top percentage of production in Canada and the USA, immediately denies such a comfortable assumption!

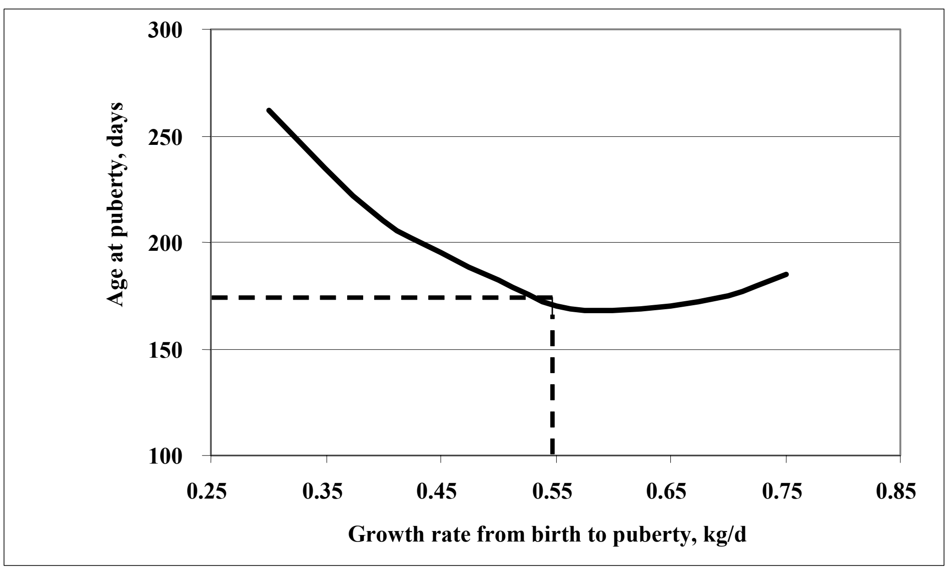
Table 2. Production data taken from the 2002 Breeding Herd Summary for Canada (PigCHAMP, 2002).

Measurement	Mean	Upper 10%	Lower 10%
Average female inventory	1046	2741	240
Annual Replacement Rate (%)	59	33	71
Average parity	2.8	3.8	2.0

2) Changes in lean tissue growth rates in dam-line females. The major changes in the lean growth potential, and associated changes in the overall tissue metabolism of contemporary dam-line sows is not adequately recognized. Compared to selection for reproductive merit, the much greater heritability of growth traits has resulted in improvements in lean growth performance in terminal line pigs that is the very basis of a competitive pork production industry in world meat markets. Inevitably, however, existing dam-lines carry these same traits to a greater or lesser degree. In the major dam-lines used in contemporary pork production in North America, inadequate attention is paid to the changes in basic sow metabolism resulting from this increased potential for lean tissue deposition and an associated lack of fatness in our current dam-lines. Traditional management practices that were established even 20 years ago need to be re-evaluated, if we are to capture the full economic potential of the modern breeding sow and her offspring, in terms of greatly improved nutrient utilization.

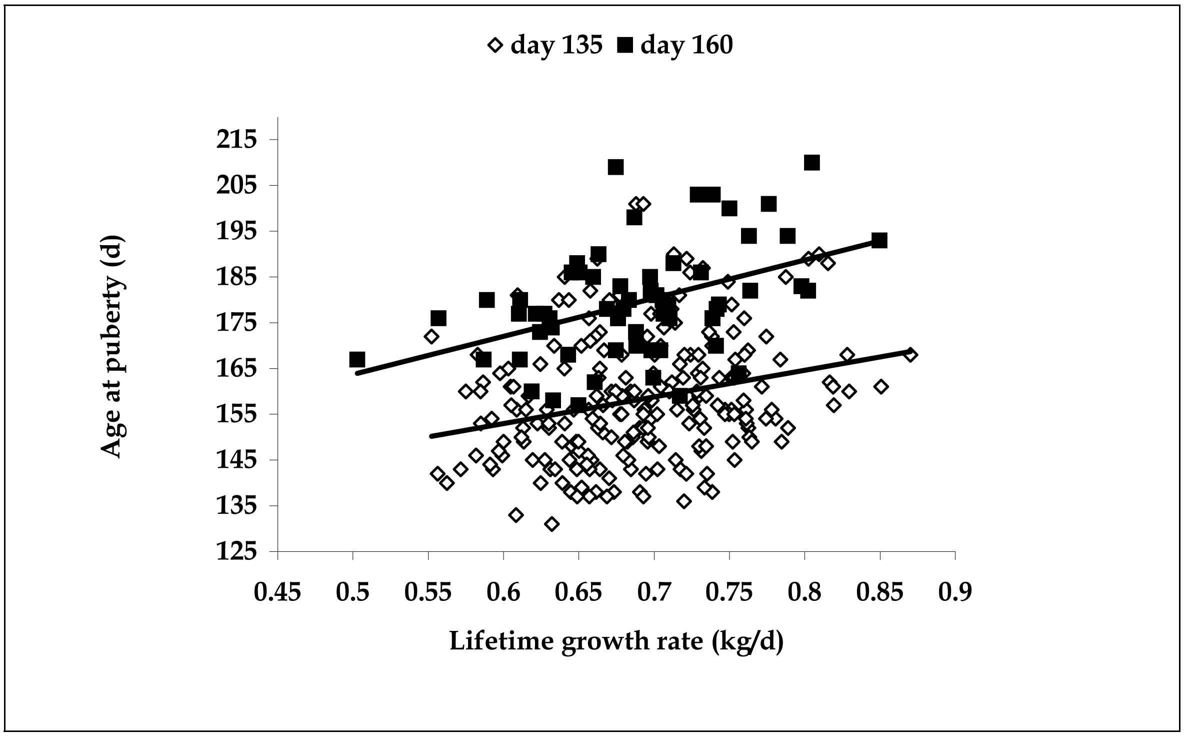
If we look at the relationships between growth and sexual maturation, the earlier data of Beltranena et al. (1991) suggested that only when growth rate was below 0.55 kg/day from birth to onset of boar stimulation at 160 days of age, was there any delay in onset of pubertal estrus (Figure 1).

Figure 1. Relationship between growth rate and age at pubertal estrus in gilts first stimulated with boars at 140 days of age. (After Beltranana et al., 1991). Feed restriction in gilts achieving a lower growth rate was associated with a delay in the onset of puberty.



The more recent data in Figure 2, from a study of Genex grandparent females, and their F1, terminal-line, progeny at the University of Alberta support these conclusions, and the generalization that with unrestricted feeding during the grow/finish phase, it is unlikely that growth rate in commercial dam-line gilts will limit age at the onset of first estrus. Furthermore, the data in Figure 2 emphasize that age at first estrus is very largely dependent on the age at which effective stimulation with boar pheromones and direct boar contact is applied (See Patterson et al., 2002b). Recent comments that pubertal estrus is occurring at older ages in today's commercial dam-lines seems to us to have little substance, unless of course boar stimulation is delayed.

Figure 2. Effect of puberty stimulation in the gilt commencing either at 160 d (Closed squares; ■) or 135 d (Open diamonds; ◊) of age. Both sets of data indicate that the highest growth rates achieved by feeding gilts ad libitum with diets aimed to maximize lean growth potential may result in a delay in the onset of first estrus. (Data from Patterson, 2001).



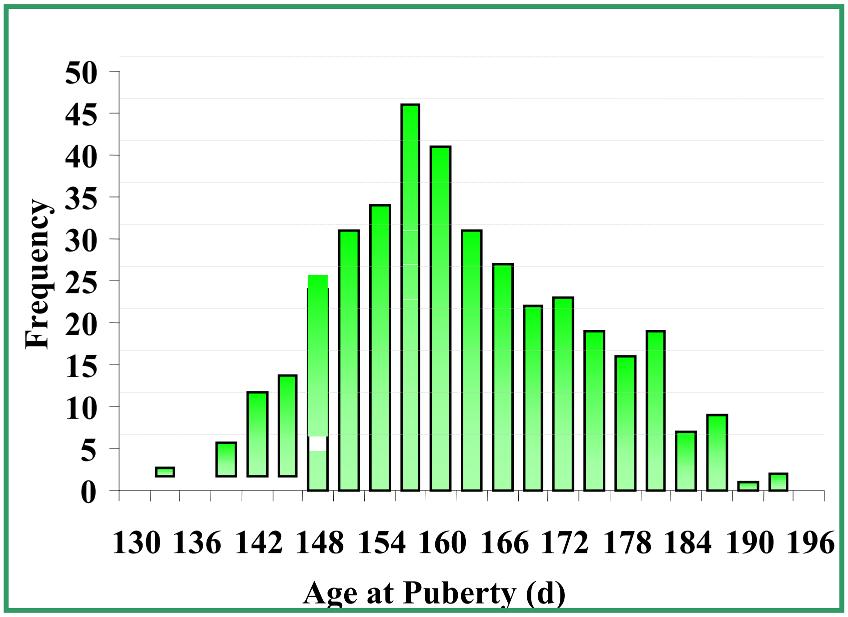
The true distribution of age at first estrus is clearly evident when one re-plots the data in Figure 2 for the F1 gilts that were first exposed to boar contact at 135 days of age, as in Figure 3. Age at pubertal estrus is now seen to be almost normally distributed, with some gilts reaching puberty within days of first boar contact, whilst other gilts may only show pubertal estrus after 50 days of continuous boar contact. However, the data in Figure 3 seem to support the curvilinear "best fit" to the data shown in Figure 1, suggesting a tendency for the highest growth rates to be associated with a marginal delay in pubertal estrus. This may be problematic, in that late maturing and fast growing gilts may become overweight by the time they are bred, and as discussed later, this is one of the major risk factors for poor retention in the breeding herd (Williams et al., 2005).

Finally, to reinforce the view that the growth performance of most commercial dam-line gilts is unlikely to place any constraint on the onset of pubertal estrus, and that pubertal estrus can still be induced at a relatively early age with good boar stimulation, the data in Figure 3 show comparable data from a gilt re-population study conducted in collaboration with the Prairie

Swine Centre Inc., involving PIC Camborough 22 gilts, provided good boar contact from a pen average of 140 days.

These data also serve to demonstrate the total lack of any relationship between growth rate and the population of gilts that did, or did not, have a recorded pubertal estrus within 40 days of commencing boar stimulation.

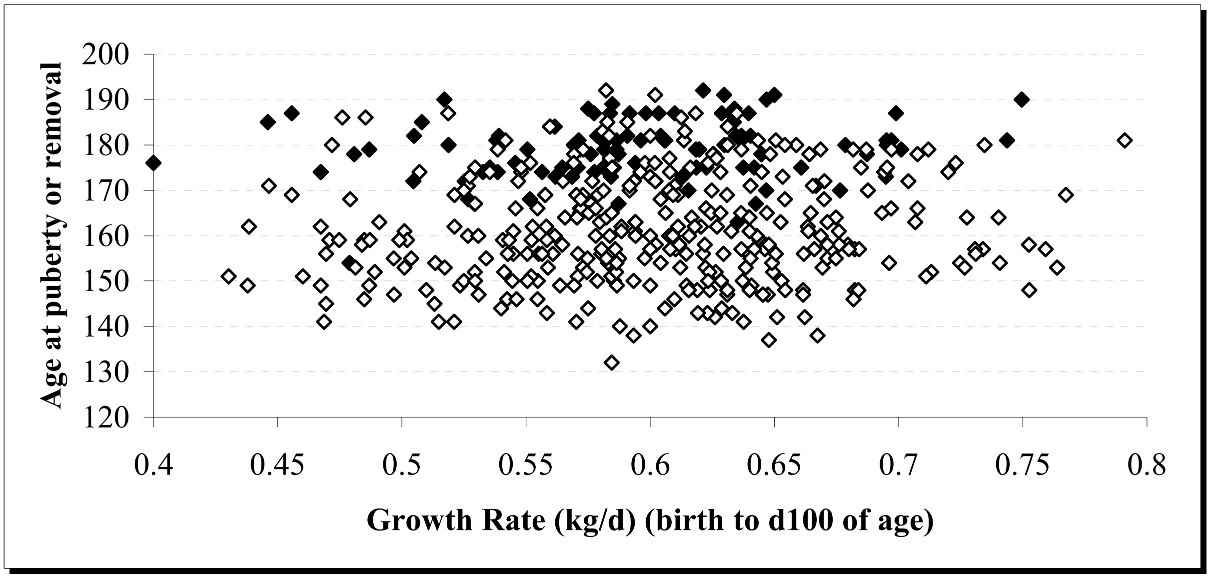
Figure 3. Normal distribution of age at first recorded heat (pubertal estrus) in Genex F1 gilts provided good boar contact from 135 days of age. (Data from Patterson, 2001)



The data presented above and in Figure 4 will hopefully confirm that onset of pubertal estrus has very little association with gilt body weight in gilts grown with unrestricted feed intake. Therefore, in terms of physical maturity, assuming that some arbitrary age will succeed in defining the physical development of gilts at stimulation or breeding is a dangerous assumption. Gilt pool managers seem to ignore the enormous variation in growth rate among groups of gilts, and also the rather uncertain relationship between weight and back-fat. The extremes that were encountered at the time of first recorded estrus in the gilts shown in Figure 3, are shown in Figure 5.

The extremes of sexual maturity and growth rate (boar induced first estrus at around 130 days of age and a growth rate of 0.64 kg/d versus puberty at 189 days of age and a growth rate of 0.80 kg/d) result in first estrus gilts differing in body weight by as much as 73 kg. In terms of gilt conditioning for physical fitness and longevity in the breeding herd, early maturing/slower growing gilts would need to be provided with high energy "fattening" diets to achieve 135 kg body weight and at least 18 mm of back-fat at breeding. In contrast, late maturing/fast growing gilts probably need to be subjected to restricted feeding during development to prevent excessive growth being a cause of lameness and eventual culling. The unavoidable conclusion from these data is that age is not a good measure of weight or fatness, **and the only way to be certain that gilts are at target weight for breeding is to weigh them!**

Figure 4. Relationship between growth rate and age at puberty in response to daily boar stimulation from 140 days of age (open diamonds). Gilts not recorded in estrus by 180 days were designated Non-Responders (closed diamonds). (Prairie Swine Centre and University of Alberta, Swine Technology and Research Centre, unpublished data, 2003).



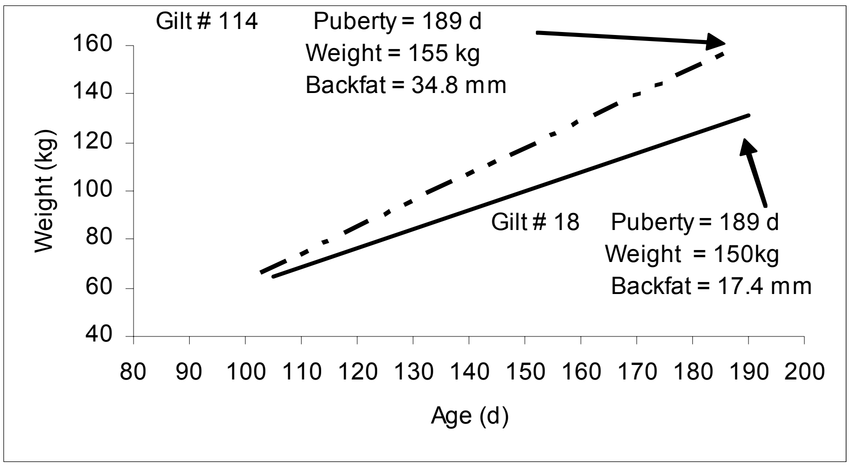
As age at sexual maturity can also vary from 130 to over 200 days, it is impossible to set some arbitrary age and assume that this defines some general level of sexual maturity. Clearly, by starting to assess whether gilts will show a standing heat in response to boar contact at over 200 days, there is little opportunity to determine the relative sexual maturity of individual females. The only benefit from introducing boar contact at such a late stage is the very short period over which pubertal estrus will be observed. However, very efficient boar stimulation programs can involve relatively little labor input per gilt bred, and yet increase the lifetime performance of truly “select” gilts substantially.

The lack of any reliable association between age, and onset of sexual maturity or body weight, implies that these essential benchmarks must be assessed independently in a well-managed GDU and used to allocate gilts to appropriate breeding groups. The aim should be to have gilts as sexually mature as possible before target breeding weight is reached, with the minimal requirement that breeding occurs at least at second estrus. Excluding slower growing gilts may also be cost effective, because, as shown in Figure 6, the number of NPD required to bring these gilts to a target breeding weight can be substantial.

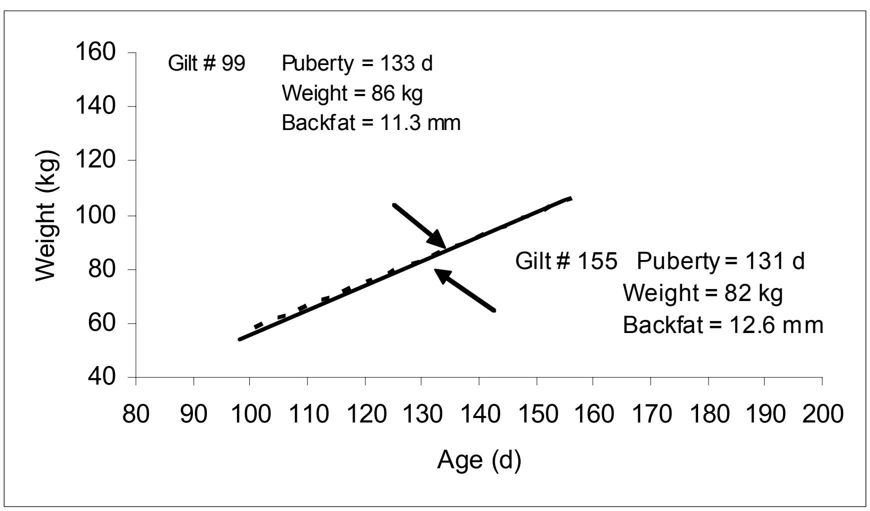
Based on these results, we suggest that a minimum growth rate (> 0.6 kg/day) be achieved at the time of entry to the puberty stimulation phase of GDU management, because 1) excessive NPD to reach target breeding weight results in a lower availability of eligible gilts to breed/pen space/day, and 2) we frequently observe that when gilt breeding targets cannot be met, gilts that are well below the target breeding weight are "pulled forward" and bred anyway. Eventually, these lightweight gilts end up as weaned parity 1 culls and are a major contributor to triggering the "death spiral" that results in excessive annual replacement rates in many breeding herds (see Williams et al., 2005).

Figure 5. An illustration of the extremes of performance within a contemporary group of commercial dam-line gilts provided with direct boar contact from 135 days of age to stimulate onset of first estrus. (Data from Patterson, 2001)

(a)



(b)



Interestingly, the earlier studies of Beltranena et al. (1993) already indicated that the fatness of the gilt was unrelated to the rate of sexual maturity, and this conclusion has also been supported in subsequent experiments. Moreover, in most gilt pools, there is usually a very weak association between weight and measured back-fat, as shown in Figures 7 to 9. Thus, from a management perspective, simply relying on an increase in overall body weight to produce a predictable change in back-fat in all gilts, or to assume that some arbitrary age will be associated with target levels of back-fat in all gilts, is unrealistic.

Consideration of Differences among Dam-Lines (Genotypes)

A question that is frequently asked, and for which the industry has failed to provide adequate data, is the extent the phenotypic relationships described above differ among major commercial dam-lines. Based on recent collaborative studies with two major dam-lines, we conclude that the phenotype of the gilts and first parity sows clearly reflects the extent to which selection for increased lean tissue gain is reflected in these terminal dam-lines. As can be seen in Figure 6, the level of fatness (back-fat measured at the P2 position in both cases) during gilt development tends to be different. Furthermore a maternal weight gain of 50 kg from breeding to farrowing results in a very different response in back-fat gain.

Figure 6. Actual weight and growth rate at 140 days of age shown in relation to the observed and independent age at which pubertal estrus was observed. The number of estrous cycles needed to bring each category of gilt to a target breeding weight of 135 – 150 kg is then indicated. (Prairie Swine Centre, and University of Alberta, Swine Research & Technology Centre, unpublished data 2003).

Growth Rate (kg/d) at 140 d of Age	Weight (kg) at 140 Days of Age	Age at Puberty 160	165	170	175	180	185	190
0.50	70	143	135	138	140	143	145	148
0.55	77	146	137	140	142	145	136	139
0.60	84	146	137	140	143	146	136	139
0.65	91	145	135	138	141	144	148	137
0.70	98	141	145	148	137	141	144	148
0.75	105	136	140	143	147	135	139	143
0.80	112	145	149	136	140	144	148	152
0.85	119	136	140	145	149	153	157	162
0.90	126	144	149	153	158	162	167	171

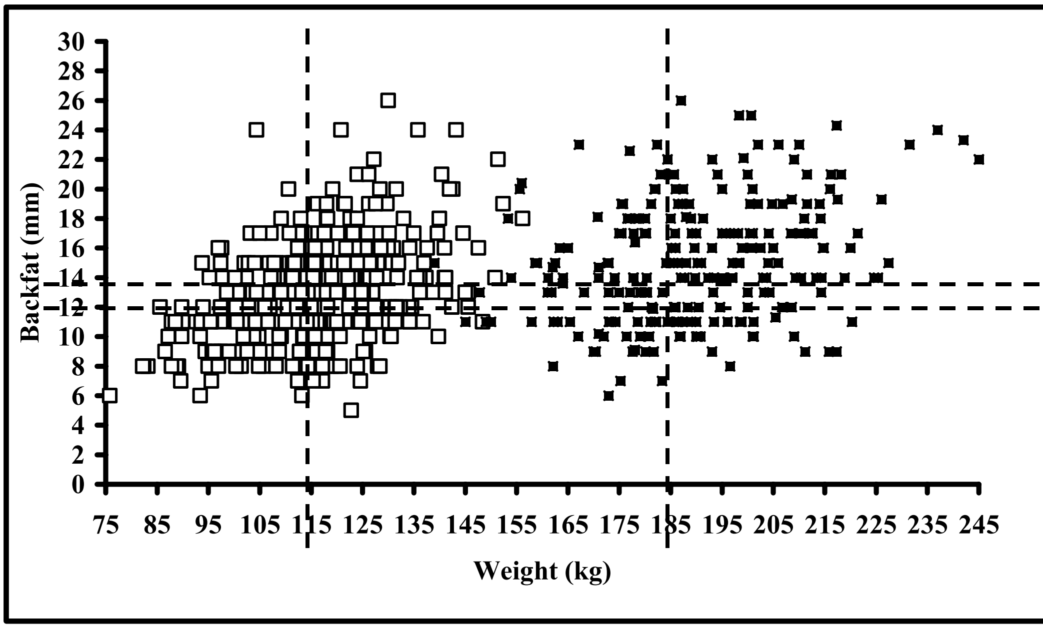
PREDICTED ESTRUS

1st estrus ■ 2nd estrus ▤ 3rd estrus □ 4th estrus ▥ 5th estrus ▩ 6th estrus ▨ 7th estrus ▦

The critical question then becomes, to what extent is this relative leanness of the terminal dam-line likely to affect lifetime productivity of the sow? From existing data, it is hard to suggest that there are any inherent differences in lifetime reproductive performance that can be ascribed to the relative leanness of the sows *per se* (Williams et al., 2005; Figure 8).

Figure 7. **Associated changes in sow body weight and back-fat in (a) Camborough 22 and (b) Genex gilts between breeding and farrowing. Dashed lines indicate average weight and back-fat at each time. (Unpublished data, University of Alberta, 2005)**

(a)



(b)

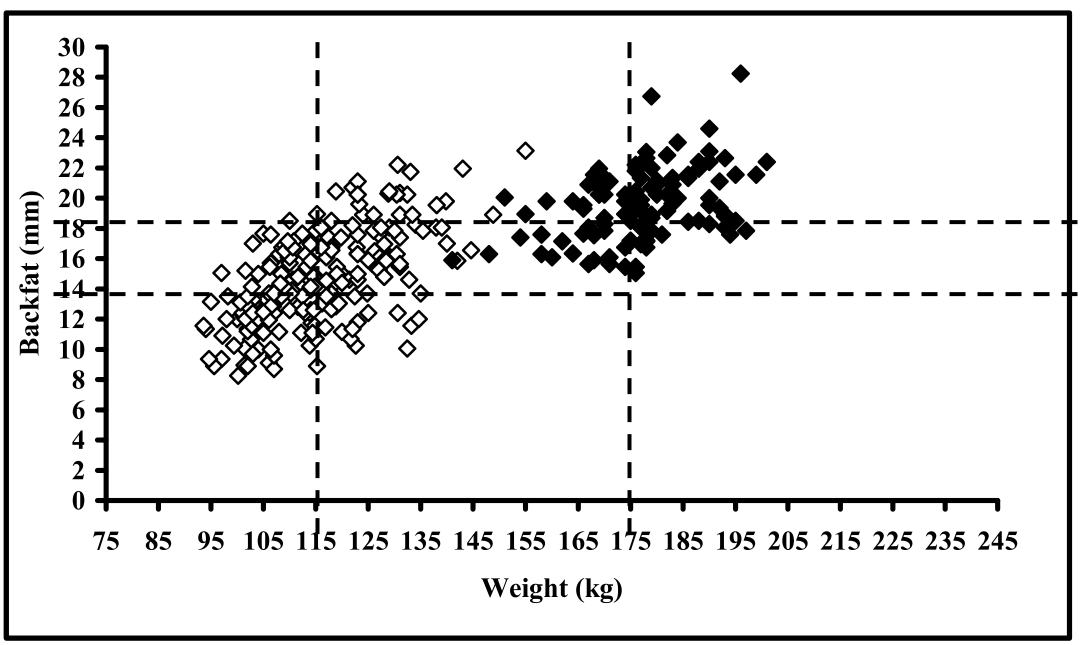
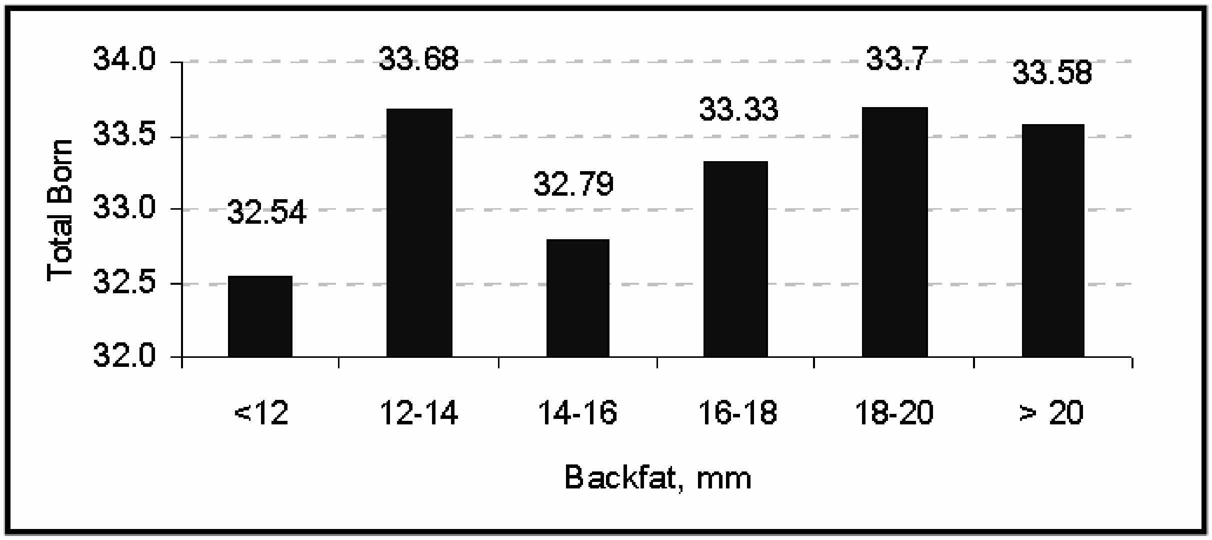


Figure 8. Impact of back-fat at first service on total born through three parities in a large-scale study of Camborough gilts. (Williams et al., 2005)

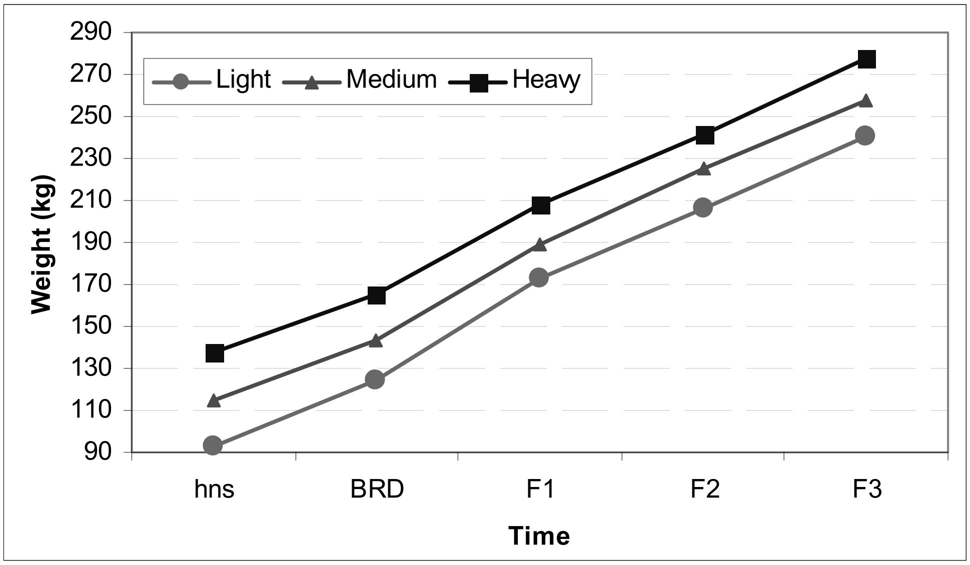


Similar data were reported for the relationship between initial breeding weight and productivity over three parities (Williams et al., 2005). The lack of a consistent relationship between overall sow body weight and back-fat thickness is also seen in data collected over three parities from the gilts shown in Figure 6a. The changes in sow body weight and back-fat over three successive parities, for those sows that were available to record data on each occasion are shown in Figure 8a and 8b, respectively. As can be seen, because gilts were bred by design at third estrus, and the lack of any relationship between body weight and rate of sexual maturity once the critical threshold has been passed, this resulted in a wide range of body weights at breeding and immediately after farrowing their first litter. In general, the pattern of increase in lean body mass over successive parities would meet most conventional targets (Figure 9a), and the changes in measured back-fat were variable and lower than would be suggested as ideal even for the Camborough sow. However, as discussed earlier, the lower than targeted levels of back-fat do not seem to be critical for sow longevity in the breeding herd, or for sow lifetime productivity.

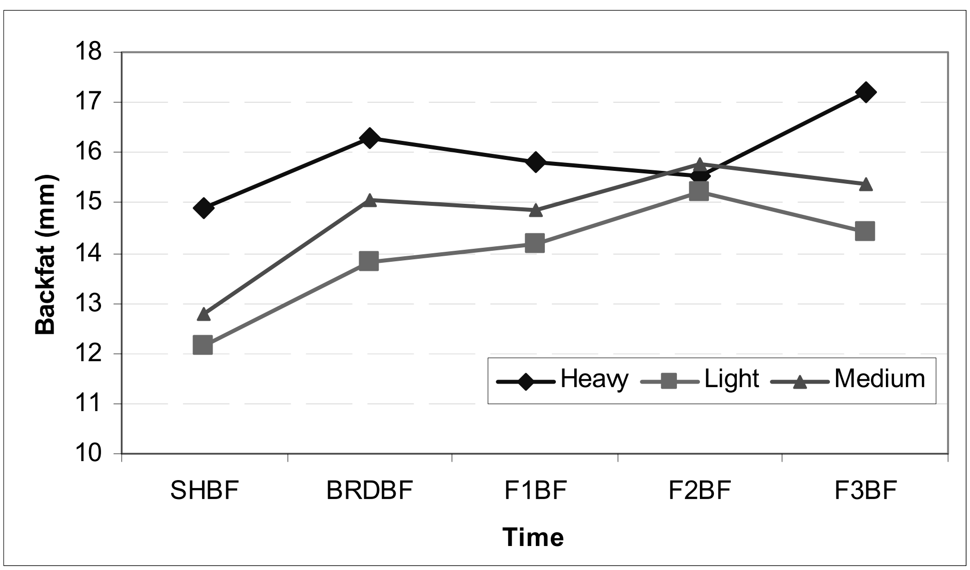
A notable feature of the data shown in Figure 9a is the persistent difference in sow body weight over three parities, despite the fact that management practices in this herd would allow feed intake in gestation to vary with respect to perceived weight and body condition of the sows after breeding. This emphasizes the need to focus on entering gilts into the breeding herd at known and recorded weights, as probably the only reliable way of insuring that lifetime changes in sow weight will be consistent with longevity and good lifetime productivity.

Figure 9. Mean body weights of gilts bred at third estrus, regardless of body weight, with the data representing the body weight (a) and back-fat (b), respectively, for the lowest, the middle and the highest 10% of gilt weights when first recorded as heat-no-serve after introducing direct contact with boars at 140 days of age when first bred.

(a)



(b)



PHYSIOLOGICAL LIMITATIONS TO MAXIMIZING LIFETIME PRODUCTIVITY

As shown in Tables 3 and 4, the performance of contemporary dam-line sows is truly astounding! Their ability to tolerate massive loss of body tissues as a result of experimentally imposed feed restriction at peak lactation, with relatively little effect on many measures of post-weaning fertility, needs to be recognized. Equally, the reality that sows can deposit and mobilize lean tissue, with little impact on fat tissue depots, requires us to accept a new biological paradigm and to manage these sows accordingly.

Table 3. Sow and litter production data for a recent experiment to study the mechanisms mediating effects of tissue catabolism in first parity sows subjected to restricted feed intake from day 14 – 21 of lactation (Restrict) or fed close to appetite until weaning (Controls) on subsequent fertility. (Data are Means ± SEM). (Unpublished data of Vinsky et al., Swine Reproduction-Development Program, University of Alberta, 2004)

Item	Control (n=17)	Restrict (n=17)	P value
Sow data			
Farrow weight (kg)	189.8 ± 12.4	189.1 ± 14.3	0.89
Farrow Backfat (mm)	19.8 ± 3.0	20.5 ± 3.0	0.49
Weight loss (kg)	9.17 ± 6.66	22.35 ± 7.73	<0.0001
Lactation Backfat loss (mm)	1.29 ± 2.51	2.74 ± 2.09	<0.08
Litter data			
Litter Size (piglets)	9.41 ± 0.80	9.47 ± 0.72	0.82
Initial weight per pig (kg)	1.46 ± 0.29	1.36 ± 0.20	0.20
Total weight gain per pig (kg)	5.05 ± 0.53	4.63 ± 0.51	<0.03

Table 4. Embryonic survival and other reproductive characteristics in sows at day 30 of gestation. Data are from the same experiment for which production data are presented in Table 3 and all sows were bred using standard artificial insemination procedures are the same pooled semen after weaning. (Data are Least Square Means ± SEM).

Item	Control (n=16)	Restrict (n=17)	P value
Wean-to-estrus interval (days)	5.29 ± 1.26	5.41 ± 1.33	0.79
Ovulation rate	18.25 ± 0.65	18.24 ± 0.63	0.99
Live Embryos	14.43 ± 0.78	12.29 ± 0.76	<0.06
Embryonic Survival to d30 (%)	97.59 ± 6.76 *	77.34 ± 6.56*	<0.04
Number of Males	7.75 ± 0.59	7.53 ± 0.57	0.79
Number of Females	6.50 ± 0.57	4.71 ± 0.56	<0.04
Proportion of male embryos (%)	58.34 ± 4.52*	67.47 ± 4.38*	0.16

* Arcsin transformed data are presented

These results are typical of similar experiments conducted in lactating and weaned sows in our laboratory over the last 10 years and show the extent to which lean tissue is mobilized to meet the demands of milk production during the first lactation, and in comparison, the small and usually non- significant changes in backfat. Compared to earlier reported impacts of the "thin sow syndrome" on subsequent fertility, contemporary first parity weaned sows show very different responses. The relatively minor impact of sow tissue catabolism on the weaning-to-estrus interval, with variable effects on ovulation rate, shows the resilience of these sows from a reproductive perspective. Second parity litter size is usually decreased in sows that are catabolic at weaning due to increased embryonic loss, but within a single estrous cycle, sows subjected to "skip-a-heat" breeding show excellent productivity (Clowes et al., 1994).

Parallel selection for improved lean growth performance and sow fertility seems to have resulted in a fairly characteristic response to lactational catabolism in contemporary dam-lines. The tendency for only a marginal delay in the return to estrus results in inadequate follicular development by the time that ovulation is triggered (Zak et al., 1997a). The associated lack of oocyte maturity and endocrine changes over the peri-estrous period are key contributors to reduced litter size (Zak et al., 1997b). Management strategies for the breeding sow herd must increasingly recognize the changes in lean growth performance in contemporary dam-line sows (see Willis et al., 2003), and the changes to even traditional hormone therapies that would historically be expected to improve weaned sow fertility (for example see Kirkwood et al., 1998; Foxcroft, 2004). Accepting the risk of being considered somewhat heretical, most of our recent experiments with the lactating and weaned sow lead to the conclusion "**that from a fertility and prolificacy perspective, fatness is simply not the key risk factor"!** In contrast, lean tissue mass is a key consideration for correct management of the gilt, and the lactating and weaned sow, and the experimental evidence to support this contention has been clearly established (Clowes, 2003 a,b; Quesnel and Prunier, 2003).

CONCLUSIONS

Implementing an effective gilt pool management strategy will allow producers to meet targets for body condition (weight, back fat) and physiological maturity (age, estrus at breeding) at 1st service, and ultimately reduce annual replacement rates (target for top 30% of breeding herds should be <50%), improve sow "fitness", decrease sow death losses, and increase labor efficiency and space utilization. Furthermore, all these advantages can ultimately be achieved whilst maintaining economic efficiencies of smaller, well managed, breeding herds.

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GETTING TO 30 PIGS WEANED/SOW/YEAR

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THE GOAL

Pork production operations around the world are beginning to set new production targets for achieving 30 weaned pigs/sow/year (PSY). This lofty goal is not easy to attain but should not be considered out of reach. High pig production is a result of a complex series of interrelated factors. Because of substantial advancements made in swine genetics, facilities, and management, some large and small operations have already attained this goal, while others are nearing this target. The foundation required to achieve 30 PSY must begin with the herd genetic potential for total born and pigs born alive. Management of these genetics must focus on born alive and herd management to ensure proper longevity and parity structure. Although herd health must be considered a permissive and limiting factor for PSY, it will not be discussed in this article. Another key requirement for reaching high PSY involves maximizing the output of large numbers of pigs born alive with ensuing low pre-weaning mortality. This is achieved through intensive management during both early and late lactation. High standards for PSY must also focus management on achieving low numbers of non-productive days (NPD) through short wean to service and short entry to first service intervals, low repeat services, few open days before diagnosis and rebreeding or culling, and high farrowing rates to first services. Raising PSY to higher levels will be possible only as a result of proper feeding and nutritional programs for gilts and sows, and through intensive breeding management. Last but not least, as most will agree, the properly trained, dedicated and knowledgeable staff lay the foundation to moving along the pathway to high pig production. This article will discuss these factors and more to explore how it may be possible for "Getting to 30 PSY".

RECORDS FOR TOP DANISH, U.S., AND SPANISH BREEDING HERDS

The actual production figures for an 1180 sow herd farm in Denmark for a 12 month period of time are shown in Table 1 (Jensen, 2004).

Production records from commercial genetic suppliers indicate that certain clients are fast approaching (26) or actually have already achieved or exceeded 30 PSY for periods of up to one year of time (Peet, 2004; Vansickle, 2004). Data from the U.S. and Spain (Caldier, 2002) also indicate that both large and small breeding herds can approach 30 PSY and production figures available and obtained for 2002 to 2004 indicate that production was recorded in the 26 to 28 PSY range.

Table 1. Danish farm production measures for a 1 year period of time (2003).

Item	Measure
Born Alive/litter	14
Stillborn/litter	1.6
Pre-wean mortality	8-10%
Returns to service	4%
Lactation Length	24.5 d
NPD	8-10
Farrow rate	91%
Litters/Sow/Year	2.43
P/S/Y	30-32

However, for perspective, the data available for farms achieving or exceeding 26 PSY are the exception. These data show that the potential for operations within many countries is much higher than current production records, but that these averages are not indicative of current production for any country. The production figures for Denmark are excellent, but are just beginning to approach the targets needed to get to 30 PSY. For example, Danish data for 2003 (NCPD, 2003) indicates that the average production in number of pigs born alive has increased from 11.8 born alive in 2000 to 12.3 in 2003. The number weaned has also increased from 10.4 in 2000 to 10.6 in 2003. These production figures are recorded with lactation lengths averaging 30 days and with litters/sow/year averaging 2.25. The production averages for the 1.1 million sows in Denmark were recorded as 24 PSY. In contrast, for the 6.4 million sows in the U.S., the total numbers of pigs born averaged 11.4 with 10.3 born alive and 9.0 pigs weaned to produce an average of 20.2 PSY (PigCHAMP, 2004). In the U.S. these records result from an average lactation length of 19 days. These data indicate that for both Danish and U.S. pork producers the potential for improvement exists for average and even most top producers.

MODELS FOR 30 PSY

Simulation models for production of pigs produced/sow/year are determined from total sows mated, farrowing rate, farrowing interval (NPD), pigs born alive, and number of pigs weaned. Simulation results for the impact of making a 5% change in factors listed in the current measures are shown on PSY in Table 2.

From these values, it would appear that efforts which concentrate on total pigs born and pigs born alive will have the greatest impact on PSY. Realistically, changing the total pigs born and born alive can be multi-factorial and complex. Influencing litter size or total born starts with ovulation rate, or the number of eggs ovulated. Ovulation rate is a moderately heritable trait and has been selected for, in most existing maternal lines of pigs. In contrast, embryonic survival, uterine capacity, and total pigs born are lowly heritable, but selection even for these traits has been shown to increase the total pigs born and pigs born alive in maternal lines over extended periods of time. Pigs born alive is a trait that some genetic companies are now reporting they are adding into the selection criteria, and although likely to be lowly heritable, it does have the potential to improve performance in certain genetic lines of pigs. However, one clear way to impact born alive can result from attended farrowings, which can increase pigs born alive by 5% or 0.5 pigs at each farrowing. In most cases, farrowing rate can be changed more easily than total born and pigs born alive. Even a modest change of 2.5% in farrowing rate can increase PSY more than 0.5, while a 5% farrowing rate increase can increase PSY by 1.2. Collectively, improving born alive and farrowing rate each by 5% could increase PSY by nearly 2. Other factors evaluated in the simulation model involved changes in lactation length. Increasing or decreasing the length by one day would be expected to impact PSY by 0.2. It was also evident that when a nine day increase in lactation length occurred from a 21 day average to reach a 30 day lactation length, more typical for a European herd, PSY increased by nearly 1.8. For other factors, small changes of 5% in the average pre-weaning mortality would have little impact on advancing PSY (0.11), while changing the pre-weaning mortality average by 10 to 20% to have an average pre-weaning pig mortality of 6 to 8% could increase PSY by 0.3. Changes in the wean to service interval were not highly related to PSY, however, there is evidence to suggest that both pigs born alive and farrowing rate are related to sows that return to service soon after weaning (days 4 to 7). The increased reproductive production from shorter wean to service intervals was not simulated in the present model, but if this was performed under the assumptions of improved production from early returns, as reported by Steverink et al. (1997), a one day change from a 6-day wean to service interval, to a 7-day wean to service interval could be expected to reduce PSY by 0.8, and an 8-day wean to service interval by as much as 1.6 PSY. This decline in production would result from lower pigs born alive and reduced farrowing rates. Therefore, efforts that focus on advancing wean to service intervals toward 4 to 6 days could have significant advantages for improving PSY.

Table 2. **Simulation modeling for the impact of a 5% change in the average production parameter on the change in PSY.**

Parameter	Average	5% of average	Change in PSY
Liveborn (pigs)	10.5	0.53	1.22
Farrow rate (%)	80	2.5	0.67
Lactation length (d)	21	1.05	0.19*
Mortality (%)	8	0.4	0.11
Wean to service (d)	7	0.35	0.07

*assumes farrowing rate and born alive improves.

Using simulation models to test for the impact of multi-factorial changes is also important to determine how and where efforts could and should be expended, and which combinations of efforts are most realistic and effective. In simulation modeling, it becomes clear that the major influence on attaining 30 PSY will be through reaching a target of 13 to 14 pigs born alive, a farrowing rate between 85 to 90%, and a pre-weaning piglet mortality between 5 and 10%. Individual improvements in any of these production measures, alters the impact of the other on the target for 30 PSY, to a more or lesser effect depending upon its importance. For example, at a 90% farrowing rate, changing born alive from 11 to 14 pigs had the greatest impact on PSY, while reducing mortality from 10 to 5% had only minimal effect. When mortality was fixed at 8%, changes in born alive and farrowing rate each had a significant impact on PSY (Table 3).

Table 3. Changes in pigs produced/sow/year after simulation for impact of changes in farrowing rate and born alive with pre-weaning mortality fixed at 8%.

	Born Alive				
Farrowing Rate (%)	10	11	12	13	14
90	21.9	24.1	26.3	28.5	30.7
85	20.7	22.8	24.8	26.9	29.0
80	19.5	21.4	23.4	25.3	27.3

GENETIC IMPACT

A review of the progress made by Danbred for litter size (Peet, 2004b) suggests that in the last 10 years, regardless of the foundation breed, improvements have been made by two total pigs born in the Large White breed and more than three total pigs born/litter in the Landrace breed. The improvement is likely due to genetic improvement, as the improvement is progressive over time. Yet the improvement is also likely a result of improved management, nutrition, housing, and health. Evidence of improvement in PSY as a result of genetic selection is evident in France with reports for increases over time in total pigs born, pigs born alive and numbers of pigs weaned in the French Large White and French Landrace breeds. Yet interestingly, in contrast to the Danish company report, the improvements in the French breeds were greater in the Large White breed compared to the Landrace (Caldier, 2004). Reports from the U.S also indicate similar genetic effects and the National Pork Board's maternal line study showed that significant differences were observed in total born, born alive, and pigs weaned in response to different genetic lines even for animals that were managed under similar conditions (Moeller et al., 2004).

PARITY

Sow parity is related to reproductive performance and for PSY as a result of differences in total pigs born, pigs born alive, farrowing rate, and wean to estrus interval. The reasons for these differences as a result of parity are complex and may be mostly related to body condition and metabolic status. Lower performance is observed in parities 1 and 2 and in later parities (8 to 10) compared to sows in parities 3 to 7 (Koketsu et al., 2003). The production level with respect to parity may become problematic when considering current replacement rates. Early culling of sows prevents the sow and the herd from reaching optimal parity and herd parity structure. This problem can be exacerbated by poor replacement gilt management. High sow failure rates can lead to gilts entering the herd before their optimal period of time. In other cases, lack of fertile gilts at the correct stage may force herds to maintain an older and less productive parity structure. In either case, the potential for PSY is likely to be significantly reduced.

With annual herd culling rates exceeding 50%, prevention of early culling can be an effective management tool to boost herd performance. Most culling occurs due to reproductive failure, and 10% of sows fail to rebreed following weaning, while 20% fail to farrow to the first service. Of these failures, over 40% will return to estrus, while 35% are diagnosed as open without estrus. In both cases, this suggests problems with breeding sows, or failure of sows to conceive or remain pregnant. Other reasons for culling sows involve sows in poor body condition, poor feet and leg structure, and problems at farrowing. Methods that can help alleviate any of the causes for failure can help to stabilize the optimal herd parity structure.

REPLACEMENT GILTS

High culling rates force producers to have gilts available on demand to allow for culling of older or poor performing sows. However, in cases where gilts are not at the correct age or maturation, they may enter the herd at inopportune periods in their development and may be too young and immature or too old and over-conditioned. In either of the cases, sow longevity and reproduction may become compromised. The dilemma has been how should producers develop and manage gilts in order to obtain the correct number needed and also to meet maturation goals for mating, in order to improve herd longevity and reproductive performance.

Although there is no clear cut answer to the gilt management issue, producers who strive for 30 PSY, may need to adopt some new recommendations from those who have neared this target. One such suggestion involves the age at first mating. Controversial data exists and Goss (2003) reports that total pigs born and pigs born alive increases with age at first service peaking at 220 to 240 days before slowly declining. There is evidence to suggest that early puberty and earlier mating may be beneficial. Not surprisingly, gilt retention rates also match increases in backfat at the time of mating. Maximal longevity occurs when first service is achieved when backfat is >23 mm and weight at mating nears 165 kg. Moeller et al. (2004) reported that a line of pigs that expressed early puberty also coincidently had the greatest farrowing rate, total born, born alive, and lifetime productivity. Shukken et al. (1994) also showed that herd life peaked when mating occurred at 200 to 220 days of age. However, slight declines in pigs produced/litter were observed when mating occurred at younger ages, but the total lifetime production was greatest when mating occurred in the younger aged groups. What is interesting, is that several reports indicate no great effect of age at mating or numbers of previous estrus periods (one to four) (Young et al., 1990) or body composition (Rozeboom et al., 1995) at the time of mating. Similarly, a French report (Cozler et al., 1998) suggests that there is no apparent detrimental effect of early mating and early farrowing, although production is slightly reduced in these situations compared to mating and farrowing at more advanced ages. Yet longevity is improved when compared to gilts mated and farrowing at later ages. Jensen (2004) describes a gilt management procedure that is an integral part of their success for attaining 30 PSY. Their report suggests that herd sourcing, combined with 8 weeks allowed for isolation and acclimation, ensures health stability in their system. In this operation, they define the system as one that checks for heat in stalls, and mates gilts at 280 days and 160 kg+ at the time of breeding. Collectively, these reports suggest that inducing early puberty, but waiting until gilts have adequate size and backfat at slightly delayed ages very near 240 days of age, will allow the largest litter sizes with the greatest farrowing rates. Consider longevity though when setting age at service, and remember that in the long term model, parity structure is important for sustained production toward 30 PSY.

BREEDING MANAGEMENT

Recommendations from Danbred (Peet, 2004b) regarding the 30 PSY target also include breeding suggestions for gilts and sows. Jensen (2004) reports that for their farms, they provide gilts continuous boar exposure from entry until one day before expected estrus and then they remove the boar for 1 to 2 hours prior to heat checking. A boar is reported to be added for a "surprise effect" at the time of mating. This is thought to give a better estrus response and reduced insemination time. For weaned sows, continuous boar exposure is also provided for four consecutive days following weaning. Artificial inseminations are performed at 24 hour intervals either in the a.m. or the p.m. Problem sows showing poor standing responses, or sows with excessive backflow are inseminated again 8 to 12 hours later and again 12 hours after that. They also report that they leave the catheter in after AI and a new boar is brought in front of the sows. These procedures are thought to help movement of sperm to the site of fertilization. Interestingly, many U.S. production operations are also closing in on 30 PSY but are accomplishing this with the use of different genetics, and production practices slightly different to those used by the Danish producers. The U.S. producers do not utilize continuous boar contact, but instead supply either once or twice daily boar exposure for estrus detection, and may inseminate based on 12 to 24 h intervals. Since farms can apparently approach the objective of 30 PSY by different routes, the essential elements may involve what they share in common rather than what they do differently.

In either type of production system where production for PSY is above 26, there is little clear evidence to suggest that any or all of the production techniques are critical for high reproductive rates. However, in the same light, there is little information to suggest certain procedures are not beneficial or necessary. It may be surmised that failure to follow the described procedures could prevent attaining production targets or cause production to decline. Unfortunately, there are many uncertainties in understanding the biological limits to 30 PSY. Yet, what we know is that farrowing rate and litter size are most related to the numbers of fertile sperm inseminated and the number and timing of inseminations. Flowers and Esbenshade (1993) reported that the number of inseminations should equal two or more to reach maximal reproductive rates. For timing inseminations, at least one AI must occur within the 24 hour interval before the time of ovulation to maximize litter size and farrowing rates with semen less than 36 h old (Nissen et al., 1997). Rates of reproduction were reduced when AI occurred at an interval >28 hours before ovulation. With multiple inseminations, Watson and Behan (2002) reported that an AI dose must have at least 2 billion sperm cells when inseminating sows at 0 and 24 hours after onset of estrus and using semen <48 hours old. This was compared to the same procedure using 1 billion sperm cells, which resulted in reduced farrowing rates and litter sizes. Most studies indicate that 2 billion cells will not limit reproduction, but fewer cells reduce performance and higher cell numbers provide little or no advantage (Steverink et al., 1997). This may be related to sperm transport and reservoir establishment since these are similar when number of sperm in the AI dose were between 1 to 10 billion inseminated (Baker et al., 1968). Regardless of number of cells, low fertility sperm can cause problems, and in these cases, inseminations must occur even closer to time of ovulation (within 4 hours before ovulation; Waberski et al., 1994) to prevent reduction in reproductive performance.

So, what is known about the benefits or problems involving procedures for providing boar exposure? Interestingly, too much boar contact can reduce the detection of estrus in gilts (Hemsworth and Barnett, 1990) and sows (Knox et al., 2004) and too little can delay onset of estrus (Walton, 1986). But exposure of females to boars at breeding for gilts (Willenburg et al., 2003a) or sows (Knox, 2004) has not been shown to have any clear effect for improving fertility although there have been reports on reproductive hormones and uterine activity (Langendijk et al., 2000; 2003). So what are the most critical components of the boar for maximizing fertility? The method which ensures the most accurate detection for onset of estrus is the first key. Make sure accurate estrus detection is not hampered by over exposure to the boar or too short an interval between last boar exposure. For example, there is a noticeable decline in estrus detection rate but not incidence of ovulation in sows that were detected every 8 hours compared to those detected at 14 hour intervals or more. Yet at the same time, higher detection frequency at 8 to 12 hour intervals allowed slightly improved timings of inseminations and trends for increased farrowing rates and litter sizes when compared to 24 hour detection intervals (Knox et al., 2002). It would appear that increased frequency of estrus detection may have subtle benefits for AI timing, but that this comes with a risk for reduced estrus detection due to refractory behavior to the boar. In this light, boars must be housed away from gilts or sows to allow necessary sensitivity. In many cases this can and should be 2 to 4 hours. It is also clear though that increasing boar stimulation for gilts (Pearce and Paterson, 1992) or weaned sows (Walton, 1986) can advance onset of estrus. At mating, the boar can influence hormone release, but the response is inconsistent. The boar can impact follicle growth (Langendijk et al., 2000), and increases the incidence of ovulation and oxytocin release. Yet the presence of a boar at mating has little effect on fertility. Despite this lack of effect, it is clear the boar will improve standing in gilts and eases the procedure of insemination, and reduces leakage at the time of insemination (Willenburg et al., 2003a). However, if the boar does induce hormone release, is this in fact beneficial to fertility? The answer may lie in studies where exogenous hormones have been added to semen, and in these cases, the additional hormones have been shown to improve sperm retention, and increase movement to the reservoir. Therefore, boar exposure could in fact improve fertility when a risk of low fertility exists (Willenburg et al., 2003b).

NON PRODUCTIVE DAYS (NPD)

Much has been written on the essential measures for reproductive performance, but Peet (2004c) reported that differences in litters/sow/year was the factor most related to NPD. It is nearly impossible to achieve 30 PSY with farrowing rates that are not in excess of 85%, and actually approaching 90%. One of the keys to low numbers of NPD is the number of days a gilt or sow is not lactating or pregnant. This measure is used to determine the farrowing rate and litters/sow/year, for all sows mated in the herd. Open days accumulate from the time interval from gilt entry to first service, from the interval from weaning to service, from the number of days from mating until pregnancy failure occurs and can be diagnosed, and from the time when an open sow is identified and culled. Jensen (2004) reported that in their system, culling occurs for sows that fail to show estrus by 21 days post-weaning, show discharge at first return to estrus post-mating, that return twice following re-breeding, or for those sows that abort.

Entry to service interval for the replacement gilts are determined by the age at selection, and is a function of when the gilts are targeted for breeding. This measured interval is a function of the age at selection, age at puberty, and the number of previous estrus periods prior to targeted breeding. The goals for most U.S. and European operations should be to breed gilts at their second or third estrus, when they are a minimum of 210 days of age and a maximum of 240 days of age. The weight targets at breeding range between 260 and 300 lbs. Despite these goals, few operations meet these expectations for all replacement gilts. U.S. herds average between 25 to 40 entry to first service days (PigCHAMP, 2004), while some herds maintain an entry to first service interval less than 10 days. For sows, an important measure in the calculation for NPD is the variation in wean to service intervals. This interval is frequently delayed in primiparous sows, for sows weaned in the summer, and for sows with short lactations. Other predisposing factors involve poor body condition at weaning, excessive loss of body muscle and fat during lactation, and lack of adequate boar exposure. Techniques used to improve return to estrus can include maximizing boar exposure from time of weaning, minimizing thermal stressors, improving feed intake in lactation, and ensuring lactation lengths occur for more than 17 days.

Another key area for controlling NPD is the frequent determination for reproductive failure at the earliest stages, and employing corrective measures to minimize its impact on litters/sow/year. For example, in average herds, 20% of mated sows will ultimately fail to produce a litter to a service (Koketsu et al., 1997). Approximately 40% of the failures will be classified as conception failures since they will return at regular intervals at 18 to 25 days, or 38 to 46 days following service. Of these reproductive failures, 30% will return at the early interval and 15% at the later period. If all of these animals can be identified in estrus at the first period and rebred, NPD can be minimized, since catching them at the later period adds nearly 20 NPD. Sows that fail to remain pregnant to a re-service should be culled immediately, as this is a clear indicator of inherent infertility. Within the 20% of the females that will not farrow, the next greatest percentage of reproductive failure is composed of those that fail to return to estrus but are diagnosed as non-pregnant by ultrasound. Real-time ultrasound can be used to diagnose sows as early as 24 days following breeding (Miller et al., 2003). However, without detection, these animals may go on to accumulate excessive NPD, and in many cases, sows that are not pregnant, will amass 60 to 80 NPD days each (PigCHAMP, 2004). The reduction of NPD can be controlled using real-time ultrasound and estrus detection, combined with a more aggressive culling policy.

MANAGING SOWS IN GESTATION

Managing the gestating sow herd is an essential component to ensuring maximal farrowing rates and litter sizes. Poor farrowing rates and low litter sizes cause attention to be focused on the management of females in gestation. Some measures that have been reported to impact reproductive performance during gestation involve delayed wean to service interval, short lactation lengths, summer and fall seasons, low and older parities, excessive early gestation feed intake, elevated temperature during early gestation, and incidence of disease. Of the limited evidence available, there are suggestions that a variety of stressors that may occur during gestation could have some impact on pregnancy loss and litter size. Because there is a lack of information involving these stressors on reproductive performance, some general recommendations have been made and adopted. These include ensuring limited feed intake during the first three weeks of gestation, and not moving or grouping sows until 3-4 weeks after mating. Following the critical early gestation period, feeding for optimal body condition can occur during the early to mid gestation period. Feeding the sow can best be accomplished by frequent control of intake amounts and observation for backfat measures (Hughes, 2004). In the Danish system reported by Jensen (2004) sows were fed a fishmeal based top dressing supplement from the time of weaning until breeding. The sows were checked for heat each day for four weeks following breeding, and then real-time ultrasound performed for pregnancy detection before moving sows into group housing where they were fed individually in free access stalls. The fat and thin sows were moved back into individual stalls to control their feed intake to adjust body condition.

MANAGING SOWS AT FARROWING

The goal of 30 PSY is not attainable without ensuring high numbers of pigs born alive. In all production model simulations with farrowing rates at 90%, getting more than 28 PSY was not possible unless 13 to 14 pigs were born alive. This high number of total pigs born will result from a sequential series of events starting with high ovulation rate, followed by high fertilization rate, high embryonic and fetal survival, and then low numbers of stillborn pigs. The greatest opportunity to meet the goal for 30 PSY is through pigs born alive. The reason for this involves the realistic opportunity for most producers to increase their pigs born alive by one for each sow during the year. PigCHAMP (2004) figures indicate that for the top 10% of U.S. herds, the number of total born pigs averages 12.3 with 11.1 born alive and stillborns averaging 0.5. The Danish numbers reported by Jensen (2004) indicate 15.5 total pigs born, 14.0 born alive, and 1.5 pigs born dead. This high number of live born pigs is achieved without farrowing induction, but with assistance at farrowing when necessary. The discrepancy in total pigs born between the top U.S herds and the top Danish farms appears to account for much of the total pig production differences. However, it should not escape notice that the U.S. production figures suggest significantly fewer losses of pigs as stillborns. The exceptional U.S. herds that have achieved 27 to 28 PSY also report 13 to 14 total born pigs and an average of 12 to 13 pigs born alive. Yet even in these herds, there are indications of lower stillborn rates at farrowing. Interestingly, many U.S. producers are not averse to controlled management at farrowing and the use of hormonal induction technology.

CONTROLLING PRE-WEANING MORTALITY AND SOW MANAGEMENT DURING LACTATION

The top 10% of U.S. producers report an average 9.0% pre-weaning mortality, while exceptional producers report 6 to 7% mortality. Comparable numbers are reported by Danish production systems which average 8 to 10% pre-weaning losses (Jensen, 2004). One explanation for the differences in the numbers, not surprisingly, may involve the report that both stillborns and pre-weaning mortality increase with increases in the number of total born pigs. The incidence and causes for piglet losses have been reported (Waddel, 1996). The keys to minimizing these losses must begin with an understanding of why and when these losses occur. In fact, nearly 75% of all piglet losses occur during days 1 to 3 post-farrowing and only 13% of the losses occur during days 4 to 7 with very few occurring over the next two to three weeks. Almost 60% of the pig losses are attributed to injury with 18% of losses due to low viability. With this pig loss information in mind, almost all production operations have made adjustments to remedy these losses. The goal has been to prevent the pigs from becoming weakened, and prevent them from seeking the sow due to lack of milk, until they are hungry and ready to nurse. Jensen (2004) reported that they give all sows oxytocin to stimulate milk let down, and additional doses may be given later if deemed necessary. All pigs are confined to the creep area for one hour post-farrowing and later the 10 smallest pigs are allowed to nurse before the larger remaining pigs are added. In this system, all piglets are provided a milk supplement between days 3 to 10. Many recommendations for U.S. producers have concentrated on methods that improve attended farrowing. This is to ensure technicians are present to assist piglets find the teats, control the placement of heat lamps, allow pigs to find heat mats, and make sure sows are comfortable to prevent excessive up and down movement and repositioning. There are few listed recommendations for U.S. producers to give oxytocin to stimulate milk let down in all sows during the post-farrowing period.

During the mid to late lactation period, Jensen (2004) reports that pigs are provided creep feed starting on day 10. The use of this management tool is also common in U.S. herds, although no general consensus on the practice is reported. In the Danish system, they note that they feed sows three times each day, with feed intake gradually increased from 3 kg provided on the day after farrowing, to 6 kg fed by day 7, and then feed allowance increased 0.3 kg each day as lactation progresses. Daily feed adjustments are made to meet sow appetite. They also report a specific nursing sow management program that involves gilts being weaned at 20 days and then these females are used as foster mothers for the 13 larger five to seven day-old pigs from another mature sow. The gilt will then nurse these pigs for 15 more days before finally being weaned at 32-35 days. This extended nursing period is focused on allowing additional time for the uterus of the gilt to be repaired. The author reports that the extra time improves second parity litter size. In this nursing sow system, the sow that is weaned at 5 to 7 days will nurse the excess newborn pigs from other litters and will typically have an extended lactation length of 3 to 5 days.

PEOPLE

It is beyond the scope and intent of this article to cover the impact of people on production efficiency in the goal of 30 PSY. However, several authors (Jensen, 2004; Peet, 2004b; English, 2003) all agree that training, education, employee attitude and motivation, as well as inclination toward accurate record keeping and review, are essential components toward higher production goals. Management and employees must expend quality efforts toward each of the listed areas discussed in this article. In a report by Messenger (2003) involving a study of two herds, a 5 to 6% increase in PSY was recorded in the year following the implementation of training programs.

Taken as a whole, the targeted goal of 30 PSY only seems possible when all the components of this complex biological system are appreciated, given the appropriate level of attention, and given their correct level of importance in the puzzle.

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PARITY SEGREGATION

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The evolution of the swine industry over the past 20 years has been quite phenomenal. Techniques like segregated early weaning (SEW) and three-site production were not in existence at all 20 years ago, yet they are probably the gold standard of pork production today in North America.

In the beginning, the dream of SEW was disease elimination. But in reality this technique is much more of a disease control technique than a disease elimination technique. The improvement in productivity was probably related to the true application of the all-in, all-out (AIAO) principle, and also the specialization of both staff and site.

Parity segregation aims to take those AIAO and specialization principles one step further to enhance the productivity of the overall system.

DEFINING PARITY SEGREGATION

There are basically two components to parity segregation: sow herd and progeny/offspring.

At the sow herd level, parity segregation is the segregation of gilts and first-parity (P1) sows from the older, second-parity and above (P2+) sows. The segregation of P1 sows can be done any time after a sow weans her first litter, and before she farrows her next and becomes a P2 sow.

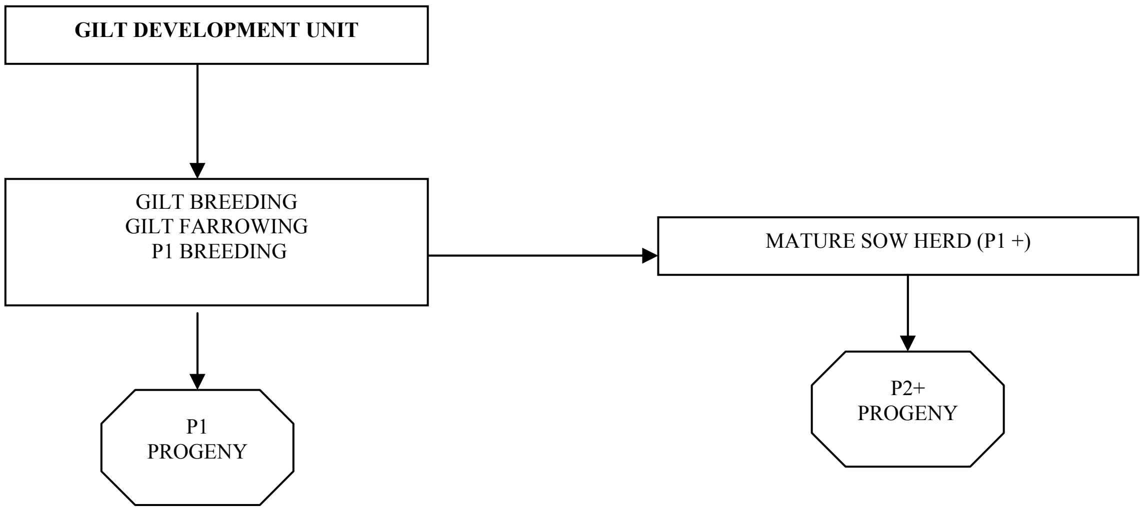
For the progeny of the sow, the goal is to achieve complete segregation between the offspring of the P1 sows and the offspring of all the other parity sows.

As with SEW and multi-site production systems, many options could exist within this general definition based on production goals, production status and problems to be solved.

In consequence, during the implementation of parity segregation, animals could be moved at different times of their cycle and many different scenarios would exist.

Figure 1 summarises the five main components of parity segregation. Within those five main production points, other subcomponents could be added based on needs,. Keep in mind that there may be advantages from using only a part of the total parity segregation system.

Figure 1. Five (5) main components of parity segregation.



In the first system where we developed parity segregation, the steps outlined below were followed:

- Early gilt exposure to the pathogens in the production system;
- Segregation of gilts during the rearing process;
- Gilt breeding and gestation;
- Farrowing of P1 sows and rebreeding;
- Introduction of P1 pregnant sows as replacement animals in the "old sows" breeding herd; and
- Complete flow segregation of the P1 and P2-plus offspring.

WHY PARITY SEGREGATION?

The original driving force for the establishment of parity segregation was a response to all of the problems related to gilt development, introduction, gestation and farrowing.

Based on the lessons learned from three-site technology, it was thought that this concept of segregation could be pushed one step further to enhance gilt development.

Advantages and reasons for parity segregation can be divided into three groups:

Focus on Gilts

Parity segregation will allow pork producers to raise gilts properly – providing them with the right feeding program, the right building and the right amount of space to grow properly.

After gilts have been grown out, it's crucial to focus on their final development. Parity segregation will ease the implementation of programs that support proper backfat deposition on gilts and provide adequate boar exposure. These are critical to final reproductive development of gilts.

Regrouping gilts in one building with dedicated staff will allow for better estrus detection and make specific matings easier.

When all gilts are farrowed in the same barn, a specific lactation diet can be fed to take into account the normal lower feed intake during the first lactation.

And, it's a well-known fact that first-parity sows act completely different at weaning than older sows do. Regrouping the P1 sows will make usage of specific programs and mating patterns easier.

Health Advantages

Gilts can often be a destabilizing factor when they are introduced into a herd. In a designated gilt grower barn, having animals of the same age with a prolonged acclimatization period greatly helps to reduce the risk of destabilization in mature sow herds when P1 gestating sows are introduced. Gilt introduction normally acts as a destabilizing factor on most farms.

With parity segregation, herd health is stabilized, even in older sow herds dealing with porcine reproductive and respiratory syndrome (PRRS) virus.

Health problems related to gilts and their progeny at first farrowing are common. Undoubtedly, gilts and their progeny carry a lower immune status. Therefore, gilts are generally more susceptible to diseases like mastitis-metritis-agalactia (MMA), and their piglets are more prone to scouring.

Regrouping all gilt farrowings in one location makes the implementation of disease-specific prevention programs much easier.

Using parity segregation to control Mycoplasmal pneumonia in progeny from first-parity females has struggled but the problem seems to disappear in progeny from P2 and older sows even without the aid of vaccination.

For example, in one system looking at slaughter check lesions for enzootic pneumonia, a three-fold reduction was seen in the severity of lesions in the progeny of P2 sows vs. P1 sows. In that system, no vaccinations or medications were used on the P2 progeny, and both were provided to the P1 progeny.

Management Advantages

Another advantage to regrouping all gilts on a given farm allows for the development and usage of more specific equipment. For example, producers could use narrower and shorter gestation crates, as well as narrower farrowing crates. Because we know we will have to deal with prolonged wean-to-first-service intervals in P1 females, more space can be provided in the breeding square, or hormonal therapy may be applied more aggressively.

Weaning weights of gilt progeny are normally lighter than those of older sows. This is probably due to lighter birth weights and to lower sow feed intake in lactation. Lower weights at weaning will usually result in lower weight gains in nurseries and finishers.

Keeping P1 litters together allows producers to design a system that builds in the extra space needed to reach optimum market weights while reducing variation within a barn.

Parity segregation can also help achieve consistent throughput. Designing a production system that allows gilt production to be segregated and maximized provides for a consistent supply of quality gilts into the breeding herd, enabling weekly farrowing targets to be met week after week.

BETTER PIGS THROUGH PROGENY SEGREGATION

Assessing the advantages of the offspring in a parity segregation system is not always easy. We have already mentioned some of the health advantages related to PRRS and mycoplasma control. Table 1 describes the differences in production seen between the P1 offspring and the P2 offspring in a given system over a two-year period. In this case, the advantages of the P2 offspring over their P1 counterparts add up to a $2.50 advantage.

Table 1. Production results for P1 and P2 + progeny.

	P1 Offspring	P2+ Offspring
Nursery Mortality (%)	2.96	1.52
Nursery ADG (g/day)	430	465
Nursery Drug Cost (US $)	1.37	0.53
Finisher Mortality (%)	3.8	3.25
Finisher ADG (g/day)	795	820
Finisher Drug Cost (US $)	1.07	0.77

Specifically, offspring segregation has:

- Allowed us to stabilize PRRS in the progeny. Today most nursery batches from the mature sow herd are negative for PRRS at the end of the nursery phase.
- Helped us to stabilize PRRS in the mature sow herds we oversee, where there hasn’t been a PRRS break in the past three years.
- Improved control of mycoplasma. Vaccine is no longer used on the progeny of the P2-plus sow herd, while a strong vaccination program is still needed on the P1 progeny. As described earlier, lesions due to enzootic pneumonia have been reduced three-fold for the P2 progeny at slaughter.

As a caution, the figures for the two progeny groups in Table 1 were obtained from side-by-side comparisons, and do not provide a good basis for results obtained prior to the split of the two groups. However, a retrospective analysis of the records of that enterprise indicates that the results obtained today with P1 offspring are similar to those obtained when the two progeny groups were raised together.

Transportation costs of offspring segregation are not included in the cost structure.

All in all, there still appears to be a real cost of production advantage to using parity segregation on the offspring of P1 and P2-plus sows.

THE GILT AND P1 EXAMPLE

Acclimatization

Usually today there is a good difference in health status between the donor herd and the receiving herd. The greater the difference, the greater is the challenge. In our mind, it is a must that any setback related to health challenges after acclimatization needs to happen before 130 days of age. After that time, we will interfere with sexual development. We are also seeking for an animal on which immunity will be well developed prior to introduction. Depending on the disease, this immunity could need as much as 100 days to develop. In our system, we are using small dedicated finishing barns operated on an all-in, all-out basis. Our replacement gilts are moved into those buildings at around 25 kg of body weight.

Gilt Development

We look at the following:

- Giving them 0.9 square meters per animal in the finishing barn.
- Using a diet that will maximize protein deposition up to 135 days of age then using a diet that will lean more toward backfat deposition. Levels of minerals in those diets are also higher than what would be normally used for growing pigs.
- Focus on light pattern after 150 days of age (16 hours a day).
- All the needed vaccinations (Parvovirus as an example) are done toward the end of their stay in those barns.

Pre-Breeding for Gilts

At an average of 185 days of age or 125 kg of body weight those gilts are moved to our gilt breeding barn. They are placed in pens of 10 equipped with a self-feeder. Boar exposure is performed upon arrival with direct contact with vasectomized boars. Heat detection is performed twice a day and as soon as they are detected in heat gilts are moved to the breeding area. At time of movement they are individually weighed to assess if they will be mated at the subsequent heat or if we will skip one.

In the breeding area they are crated but in crates equipped with a self-feeder. They will remain fed at libitum until mating time. All incoming gilts that would not have shown estrus within 28 days post arrival will be automatically culled.

Gilt Breeding

Because previous estrus date had been recorded, we know when the next one should happen. Boar exposure starts 3 days prior to this date. Estrus is detected twice a day in an attempt to detect onset of estrus. First mating is done 12 hours after detection and then every 12 hours until she stands.

Immediately after the last insemination, gilts are moved to gestation. At that time they are weighed again and probed for backfat. We are using 3 different feeding regimes based on those results. This feeding regime is kept the same for the first 100 days of gestation. We are using smaller gestation crates.

Gilt Farrowing

Around 80 days of gestation, gilts are moved to our gilt farrowing barn. Specific pre-farrowing vaccination programs are used. At around 95 days of gestation, diet is increased by one kg per day.

At the proper time, they are moved to the farrowing crates. We are using smaller farrowing crates and also a specific, more dense lactation diet. Gilts are induced at 115 days of gestation (instead of 114 for mature sows).

After 6 days of lactation, if needed, milk replacer is provided in the farrowing crate for the piglets. We are also routinely removing one or two piglets two days prior to the expected weaning date.

P1 Breeding

At weaning, all P1 sows receive Regumate for 5 days. This treatment starts the day of weaning. They are crated, fed ad lib using individual self feeders and kept on the same lactation diet. There is no boar exposure while they are on Regumate.

When Regumate is stopped, boar exposure starts. They are mated 12 hours after onset of estrus and inseminated every 12 hours until they stand.

Animals that have not shown estrus within 20 days post Regumate treatment (25 days post weaning) are injected once with PG600. If they are not in heat within 10 days post PG600 injection, they are culled.

RISKS RELATED TO PARITY SEGREGATION

We have mentioned many advantages related to parity segregation, but as with any strategy, there are also risks and pitfalls related to the application.

First, parity segregation reduces the flexibility in a system. After the implementation of parity segregation and the use of P1 females as replacement animals for the older sow herd unit, the system becomes much more of a continuous-flow system and animals need to be moved on a regular basis. This reduces flexibility, mainly in the face of a disease outbreak.

The other danger of parity segregation is related to the biosecurity risk posed by making use of isolation units at each sow farm much more difficult to implement. However, if off-site gilt acclimatization is done well and the cooling-off phase properly set, this phase could easily become the isolation period for each group of animals.

Parity segregation in a system under expansion is more difficult to apply. When establishing a new herd, due to the fact that replacements will be brought in as P1s, we need to plan replacement matings at the same time that we are doing matings for herd establishment. This will increase the number of gilts needed and the space needed for the production of those animals.

Exposure to pathogens is also critical. Our goal is to expose animals to herd pathogens early to enhance herd health stabilization. If for some reason proper pathogen exposure does not occur, there is the possibility of introducing naive animals and placing the receiving herd at risk of infection.

Parity segregation increases the number of movements for animals, adding to transportation costs and increasing the risk of contamination.

Location also needs to be taken into consideration. The scientific community does not agree on proper separation distances between gilts, P1s and their offspring and the rest of the system. We recommend a minimum separation of two miles. Each pyramid should also have a dedicated transportation fleet.

With replacements being produced in a common location, a disease break at the site could potentially transfer problems to every production location.

CONCLUSIONS

We are still in the infancy of understanding all the pros and cons regarding parity segregation. However, the results obtained so far make this breeding/reproduction strategy attractive, and we expect to learn much more about its benefits within the next few years.

ANIMAL WELFARE

ANIMAL WELFARE GROUPS – WHO'S WHO AND WHAT'S WHAT

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ABSTRACT

In any society, the way animals are treated by people reflects a common morality. In the last three decades the purchase and consumption of food in western societies has become a method for the individual to express ideas, identity and moral convictions. The assignment of ideological values to food and food choices has facilitated expression of consumer concern related to some aspects of agriculture, biotechnology, methods of production and animal welfare. Many consumers of animal products such as meat, milk, eggs and fish are concerned about how animals are treated in production, slaughter and transport. Non-consumers of products of livestock production also have a voice in the societal discussion around sustainable agriculture and a healthy planet. Both consumer and non-consumer opinions have the potential to be reflected in and change public policy in well functioning democracies. New social cause activist groups have emerged often focused on a single animal welfare issue. The motivation for membership in such groups is often not collective material benefit but an individual expressive reward realized by solidaristic interaction with like minded or prestigious people within the group.

INTRODUCTION

Consulting the public in developing government policy is in part a response to a trend for non-profit or special interest groups in pluralist democratic societies to challenge government policies post hoc. Science as the pre-eminent underpinning support of good public policy has come under challenge from public opinion which often contains a component of fear or moral outrage.

Media has been instrumental in feeding and is a beneficiary of public concern over perceived food safety risks, "unnatural" farming practices, animal welfare questions and possible environmental dangers of agriculture practices. The expectation for government to respect "moral and ethical" concerns of the public is well established. The articulation of the moral connotations of food purchase, consumption and production and the political positioning and lobbying of those convictions has become a significant growth industry in Europe and to a increasing extent in North America. In addition social cause activist groups (SCAG's) have identified that fear and moral outrage can be profit centers for a thriving business model. This paper will explore current parameters and evolutionary trends in the commercialization of public policy consultation and specifically the development of the animal welfare focus.

MORALIZATION: GOVERNMENT INVOLVEMENT IN LIVESTOCK PRODUCTION

Government decisions in the areas of food safety and farming practices are increasingly affected by widely divergent views of the general public (Thiermann, 2000). As food consumption and inter alia food production practices have taken on moral importance and are no longer the lone purvey of individual choice, there is increasing pressure if not justification in democratic societies for regulatory intervention in livestock production. Regulatory intervention should express and reflect the will of the people.

In some social circles the act of eating has progressed from being a source of nutrition and sensory pleasure to being a social marker, an aesthetic experience, a source of meaning and a metaphor, and often a declaration of moral entity (Rozin, 1996). "Moral (Ethical) Vegetarians" claim to be mindful of both short and long-term consequences of individual choice and although personal health is recognized as a partial motivator for a vegan choice there is a much broader commitment to vegetarianism as a way of life (Fox, 2000). Moral vegetarians view meat avoidance as a moral imperative and are upset by others who participate in meat consumption. This is in stark contrast to health or religious motivated vegetarians who are generally neutral to the food choices of other people (Rozin et al., 1997).

Recent study of adolescent vegetarianism identified a largely female phenomenon characterised by meat avoidance, weight loss behaviours and a high concern with body appearance (Worsley and Skrzypiec, 1997; 1998). Teenage vegetarians are more likely to be Caucasian, from a higher socio-economic stratum, practice various weight control strategies and also have an increased concern for the environment, animal welfare, and gender equality compared to non-vegetarian peers (Perry et al., 2001; Janda and Trocchia, 2001). Vegetarianism among teenage women is different from traditional western culture vegetarianism, which has primarily a nutritional or religious basis. The prevalence of vegetarianism (those who do not consume red meat) in one South Australia study is 8-10% for teenage women and 1-2% for teenage men (Worsley and Skrzypiec, 1998). The prevalence of vegetarian tendencies however was 32-37% for teenage women. Teenage vegetarians believe that meat production is morally wrong for animal welfare reasons and harms the environment.

Moral vegetarianism may be seen as an extreme example of a general trend in public opinion of farming practices. Current public concern regarding farming is frequently based on a mix of animal welfare, human health and environmental quality concerns (Fessler et al., 2003) and is in fact a manifestation of a philosophy of life (Lindeman and Sirelius, 2001; Fox, 2000). This gender related, anti-meat focus should be of concern to livestock producers as women may have a disproportionate future influence in food purchasing patterns for families, as is currently the case.

Moralization is a process that works at both individual and cultural levels and involves the acquisition of moral qualities by objects or activities that previously were morally neutral. Moralization is the process where a preference is converted into a value (Rozin et al., 1997). When behaviour becomes moralized the individual will seek multiple justifications for the relevant conviction. In the anti-factory-farm movement a combination of justification arguments including the destruction of the family farm, environmental concerns, animal welfare concerns and revulsion at “un-natural” husbandry practices are evoked in rationalizing and articulating an anti-intensive farming world view (Rowan et al., 1999).

Moralization is a gradual conversion of individual preference into societal values. A critical difference between preferences and values is that values are much more likely to be transmitted within the family environment and values are subject to institutional and legal support (Rosin et al., 1997). Bill C-22, the amendment to the Canadian Criminal Code regarding the protection of animals is clearly the result of a process of moralization and of regulatory response to that moralized cultural consensus (Anonymous, 1998).

THE SOCIAL CAUSE ACTIVIST GROUP (SCAG) AND DEMOSCLEROSIS

The number of interest groups engaging in political lobbying has increased dramatically since 1970. It is estimated that the number of interest groups doubled in the United States from 1955 to 1970; doubled again from 1970 to 1990 and reached 20,000 identified interest groups in 1995 (Rauch, 1999). Such groups are often given to expressions of moral outrage over single often new-value issues (Schweikhardt and Browne, 2001). The motivation for membership in such groups is often not collective material benefit but an individual expressive reward realized by solidaristic interaction with like minded or prestigious people within the group.

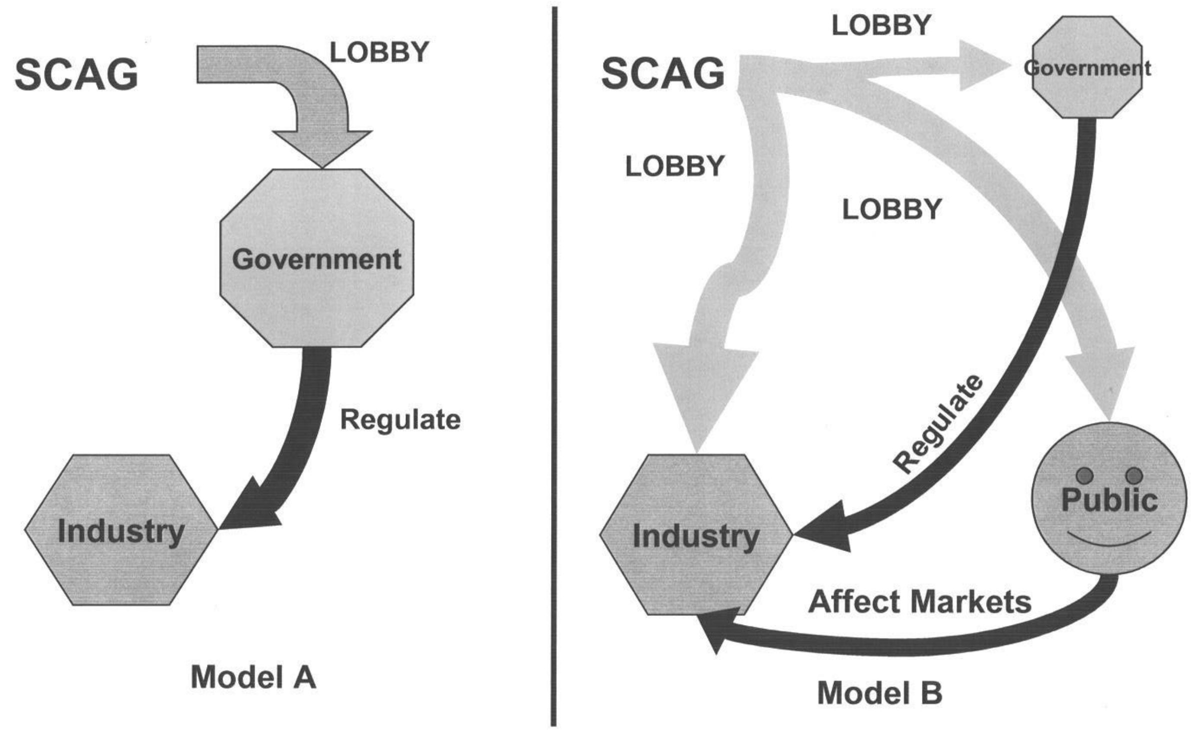
Demosclerosis is a term coined in the United States to describe an increasing inefficiency within government to clearly identify the public good and protect that public good in policy development (Rauch, 1994; 1999). If as often suggested, an astute democratically elected administration identifies which way the mob is going and then positions itself as the leader; it has become increasingly difficult to clearly identify the consensus of the electorate on many issues of social conscience. In the operation of government, so many conflicting consumer and public interests groups vie for political consideration that effective decision making is prevented.

In the recent past, SCAGs have emerged which no longer rely on traditional legislative means to achieve their political ends. Instead of lobbying primarily for better laws or better enforcement of laws, they have focused on the marketing chain and affecting consumer choice or generating fear in the manufacturer that consumer choice may be affected (Figure 1). The increasing effectiveness of SCAG food directed campaigns in part result from 3 converging forces in food production in North America; congestion in legislative channels, rising affluence of the consumer allows for preference for products with specific attributes and the concentration of the consumer food markets make targeting far easier (Schweikhardt and Browne, 2001).

As an example; in 1999 Greenpeace sent an innocuous fax to Gerber with the simple request for information related to whether the company had taken steps to avoid the use of genetically modified (GM) ingredients in baby food. Within days Gerber announced it would limit the use of GM ingredients in baby food. This in one aspect was an astonishing announcement considering Gerber is owned by Novartis a major developer of GM seeds (Schweikhardt and Browne, 2001). Greenpeace was able to accomplish in hours what one could only estimate would take years for the government regulatory process to accomplish if there was a scientific or human health basis for regulating GM content of food.

Figure 1. Organizational models for Social Cause Activist Group (SCAG) targeting of campaign message.

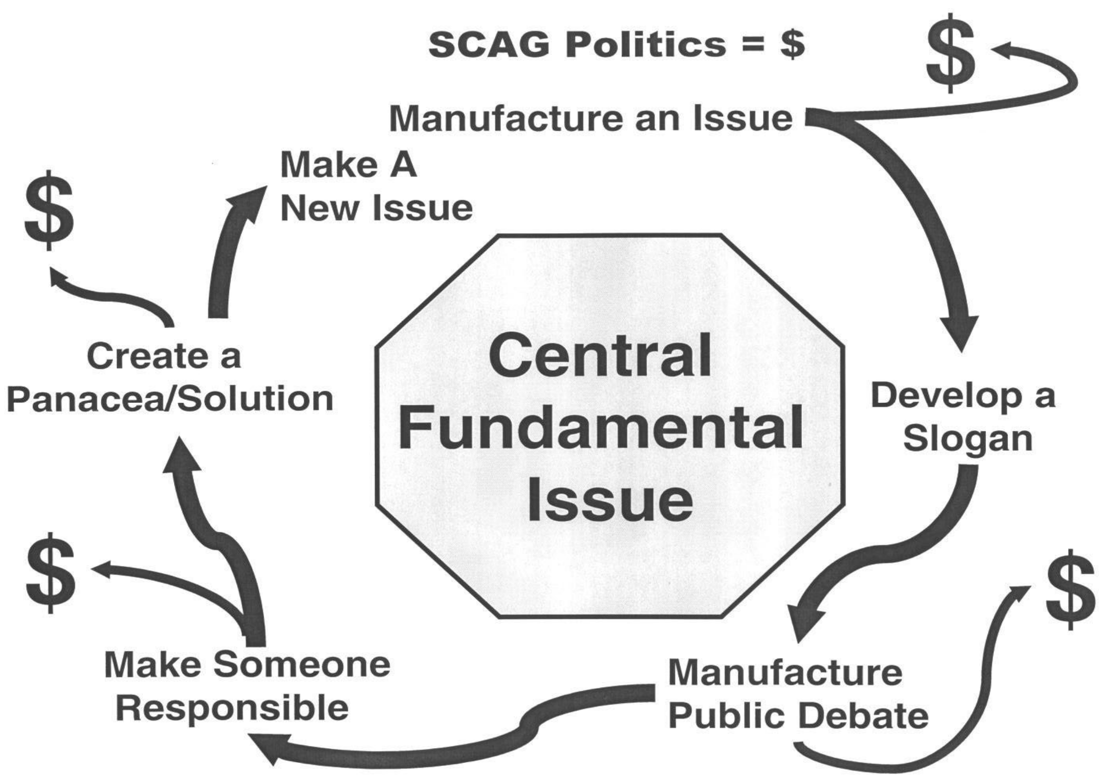
Model A is the traditional Greenpeace type environmental protection campaign which predominated in the 1970's and was directed toward government and regulators to improve environmental protection regulations. Current SCAG activities are better described by Model B where the message is simultaneously directed to governments, the general public and directly to the industry where there is a perceived vulnerability such as the Gerber Company and baby food (see text). Other examples of this approach are the polystyrene clamshell controversy well described by Svoboda and the regulation of primate research facilities in "The Monkey Wars" (Blum, 1985).



Similarly in part due to Greenpeace anti-GM potato campaign, McCain's announced in November 1999 that it would not purchase GM potatoes. The GM potatoes in question are arguably not inherently evil as their presence would have avoided the great Irish potato famine had they been available in 1845. Harrison McCain defended the decision by indicating; "*We are in the business of giving our customers what they want, not what we think they should have"* (Gray, 2000).

Social cause activist groups are usually non-profit organizations which derive financial support from the voluntary contributions of members. As memberships to the group must be sold to raise funds, then marketing of the group message (product) is most important. In the development and maintenance of these interest groups, as funds are raised they must be spent to maintain "non-profit" status and this requires a continuous series of campaigns (Figure 2). A successful SCAG campaign has two components; firstly, it actually must accomplish at least some of the goals identified in the campaign which was originally promised; secondly, the campaign product must provide the SCAG with considerable increase in profile and/or increase income from voluntary contributions.

Figure 2. Operational model for Social Cause Activist Group (SCAG) targeting of campaign message for fund raising and enhancing visibility.
The central issue is chosen for simplicity of messaging. Campaigns must also have a target such as an influential player in the food industry (eg. Gerber, McDonald's). The primary lesson from the P*e*TA success story is a campaign must have unambiguous and achievable objectives. The campaign will usually focus on one small aspect of an overall production system which has been targeted. The central fundamental issue must be easy to understand for the target audience to be able to believe they have an honest and valid opinion on the issue. The issues most likely to be capitalized are those that can be portrayed as unnatural, horrendous or brutal and the result of human greed or lack of caring (dehumanizing). Each step in the iteration of a campaign provides the opportunity for the SCAG to generate profile and income for its operations ($ in figure). Often these campaigns do result in changes in practices of the system targeted. Future targets in livestock production will be the issues which can be made to fit the P*e*TA five-step process (Mealey, 2002).



People for the Ethical Treatment of Animals (P*e*TA) is a non-profit SCAG that has an excellent template for success (Table 1) with 2002 annual contributions at slightly under 24 million (P*e*TA, 2002) and a proven track record for achieving results.

An example of a successful SCAG environmental campaign is the "Ronald McToxic Campaign" originating with the Citizens Clearinghouse for Hazardous Waste (CCHW) in the early 1980's (Svoboda 1995a; 1995b). The campaign targeted a single goal, that of forcing McDonalds to eliminate the use of polystyrene packaging within the fast food chain. By 1989 school children, the backbone of McDonald's customer base had been recruited as part of the "Kids Against Polystyrene" movement and Burger King had switched to paperboard containers. A more holistic goal or campaign target such as decreasing the overall disposable packaging is not in the best interest of the SCAG. A topic such as "minimizing packaging waste" does not meet the standard of an unambiguous and achievable objective in the business model for a successful SCAG campaign (P*e*TA Step 1 of 5, Table1).

Table 1. The lessons for corporations to be taken from examining PeTA's career to date include the following five-step process (Mealey, 2002).

1. Campaign must have unambiguous and achievable objectives
2. Utilize a range of tactics, and never underestimate the Internet
3. Segment your target audience into defined targets
   a. "Cruelty to Go" (Target: house-spouse, weakness guilt for purchase of fast food)
   b. "Meat Stinks" (Target: Vegan leaning Teens)
   c. "Don't be a Milk Sucker" (Target: Young Teens message milk causes acne)
   d. "McUnhappy Meals" (Target: Direct to children <10 years old)
4. Organize campaign strategy to maximize the domino effect (minimum cage size for laying hens in McDonalds supply chain triggers slightly larger minimum cage size in Burger King supply chain)
5. Keep the pressure constant

The outcome of the McToxic campaign can be viewed as a success. McDonald's Corporation completely reviewed its environmental strategy and was able to initiate remarkable decrease in packaging used, primarily by source reduction. In the 1970's an average meal of Big Mac, fries and a shake required 46 grams of packaging, in 1995 it required 25 grams, a 46% reduction (Svoboda, 1995a). The CCHW went on to become a very solvent SCAG with a 1990 budget of $689,908.00 (Svoboda, 1995a) and changing its name to Center for Health, Environment and Justice (CHEJ) reflecting a new mandate to deliver a broader line of products (www.chej.org/). Many US based non profit organizations (MADD, P*e*TA) post the annual financial statement, IRS Form 990, Return of Organization Exempt from Tax Income on their website; the CHEJ does not.

For food safety reasons, fast food must be packaged and held in a manner that will keep food warm and sanitary. As it turns out, the actual polystyrene clamshell debate is irrelevant on an environmental basis. In comparative environmental cost analyses, which are quite complex, comparing polystyrene which is a recyclable petrochemical product with non-recyclable wax paperboard which contributes to deforestation, the polystyrene is probably a slight overall environmental advantage (Svoboda, 1995a). In North America, due to concern for the environment, specifically CFC's and ozone depletion, McDonald's limits use of polystyrene packaging. Due to concern for the environment in the United Kingdom with an emphasis on concern for deforestation, McDonald's has used polystyrene in preference to wax paperboard packaging. The environmental concern argument can be used to support either anti-paperboard (save the trees) or anti-polystyrene (save the ozone) political agenda. McDonalds UK has recently piloted a new clamshell material made from limestone and starch which is fully bio-degradable and responds to both arguments (EarthShell, www.earthshell.com/).

A similar SCAG single issue animal welfare example is provided by the "Monkey Wars", the campaign to regulate primate research facilities in the USA (Blum, 1995). Early on in the debate scientists confused the public campaign with an interest in improving the welfare of primates used in medical research. It became clear that improving primate welfare was not to be the focus of the debate. The debate would be focused on regulating the minimal cage size for animals. "Improving the welfare of animals" is too fuzzy a premise to base an effective SCAG campaign around. It is not an unambiguous and achievable objective. The focus on regulating minimal cage size does meet the specificity criteria and had the added benefit that retooling a facility for new standard cage size was about the most expensive capital investment a research facility could imagine. The goal of regulated minimal cage size was achieved, and many facilities abandoned primate research for financial reasons as the cost of re-caging was just too high. It is undetermined whether the general welfare of primates used in medical research in the United States has actually improved subsequent to the regulatory changes (Blum, 1995).

A current active campaign in livestock production is one to eliminate the use of sow gestation stalls by regulatory prohibition in Australia (www.animal-lib.org.au/docs/sowstall.shtml), and Manitoba (Quit Stalling, www.quitstalling.ca/). It is possible that this unambiguous and achievable objective could be reached and the actual overall welfare of sows in pork production not be improved. Assessing the welfare of gestating sows is a multifactor issue plagued by considerable uncertainty as the scientific assessment of many potential alternate systems is lacking (Bracke et al., 2002a; 2002b). Regulatory actions affecting structural standards with high capital investment such as housing can be predicted to have severe financial implications for the producer (Penny and Guise, 2000).

If the logic of SCAG business management is followed, the organization must spend money to generate moral outrage and harness moral outrage to collect more money. One campaign success is needed to fuel the next campaign. It is possible that some campaigns are either poorly thought out or pure lost leaders for the organization that is, they raise visibility but do not generate income. The April 2004 P*e*TA poster campaign which shows a young woman on one side, a "smiling" pig on the other, and a slogan: Neither of us is meat; is a reference to the case of alleged serial killer Robert Pickton on charges he killed 15 women on his farm in Port Coquitlam, B.C. (CTV, 2004). It is hard to imagine that this campaign could have been designed to recruit yet uncommitted but sympathetic citizens.

Many discussions on animal welfare regulation have focused on the lack of objective science to clearly demonstrate that one method of production is superior to another method. The focus on the science basis for animal welfare standards may in fact be missing the yet unresolved point.

Regulation, that is law compelling certain human behaviour and prohibiting others, is not based purely on science but on a need to protect human welfare. Science is one of the major tools used to measure the potential for human injury if free enterprise or other forces were to run amok. The major question to be answered in the next few years is:

> *Are people significantly injured by the way animals are raised to provide food for human consumption?*

If the answer to that question is yes, people are injured by the presence of production systems that they consider inhumane, and the magnitude of that injury due to the presence of those systems is a non-trivial injury, then governments will be compelled to draft regulatory frameworks that protect the public from that harm.

Well funded and well organized SCAGs can produce effective and convincing rhetoric. There is evidence that the general public will believe a "negative-spin" story originating with a special interest group over an accurate and balanced story from an unbiased source (Hayes et al., 2002). As in all social movements there is a range of proponents within the animal welfare community from the law abiding to those committed to violent direct action. In the near future those who strongly believe that there are serious moral concerns related to animal welfare will be frustrated working through the legislative channels. Anti-intensive livestock farming has had some success with initiating regulatory intervention in the area of environmental protection, where there is some possible link to human injury. This success is unlikely to be repeated in the area of pure animal welfare. One only has to look to the recent extreme slow movement of Bill C-22 the proposed amendment to Criminal Code cruelty of animals' provisions, for an example of how the legislative process is inadequate or at best extremely slow to address rational concerned debate on the issue of animal welfare.

BIO-TERRORISM

If an individual (or SCAG) truly believes for example that sows are better dead than in gestation stalls and chickens are better dead than in cage-layer confinement then the logical course of direct action is clear. Any social cause activist group that claims in it's literature a desire to "To inflict economic damage to those who profit from the misery and exploitation of animals" (ALF, 2004) should not be treated as trivial considering the previous range of targets (ALF, 2002). Bio-terrorism and the threat of purposeful introduction of foreign animal disease is a real risk for our livestock industries.

CONCLUSIONS

There are a variety of possible policy options that could be pursued to deal with the farm animal welfare issue. All policy decisions are derived from moralization of the issue at hand; that is the electorate come to believe that the public good is served by government intervention.

Bennett outlined three policy options to achieve a balance between the production of livestock products and farm animal welfare that would represent the wants of society (Bennett, 1997a):

1. Use market mechanisms along with government intervention to supply information primarily via a registered method of production label program, to verify animal welfare and alternatives to standard production products that would allow people to make informed choices about what they consume. Bennett previously argued that the Consumer is in fact unable to make a free choice at the checkout counter when the decision in individual purchase is confounded by simultaneous competing concerns (Bennett, 1995; 1996). If animal welfare is a public good, and welfare policy is restricted to the market forces, vegans are disenfranchised as they are prevented from democratic participation in policies that are limited to the marketplace. The WTO has clearly indicated that this sort of method of production labeling is not supported in international trade negotiations (Hobbs et al., 2002; Kerr, 1999).
2. Government could regulate the production of livestock products through legislation or codes of practice to ensure that the wants of all citizens who are concerned with animal well-being are considered. Regulation has at least two regressive costs for society. Firstly, the cost of licensing a large farm is the same as a small farm and cost of new programs works against survival of small operations. Secondly if food costs increase incrementally due to new regulations, the future cost of food represents a greater proportion of income for poor people than for the wealthy representing an unfair burden of public policy.
3. Government could tax producers who cause the poor welfare and/or subsidize those producing goods that are thought to result in good animal welfare. (Bennett, 1997a). For example, if a tax or subsidy were applied to egg production so that free range eggs were of equal or lower price than standard production eggs, fewer “cage eggs” might be sold or produced (Bennett, 1997a).

Ultimately, Bennett (1997b) argued that legislation enforcing minimum standards combined with subsidy payments as incentives would be the best policy approach. This author is working from the European model which has a long history of government support to animal agriculture.

Future market forces may play an increasing role as demonstrated by the Freedom Food success in the UK (Appleby and Hughes, 1997). Supermarkets and large single desk buyers such as McDonalds can influence how farm animals are treated. One UK chain has adopted the RSPCA’s “Freedom Food” label and markets standard production and free range eggs at the same price despite the decreased profit to the store and producer (Appleby and Hughes, 1997). In Canada, the development and increasing market share of cost focused retailers such as Wal*Mart in the past five years would argue against the potential impact of method of production labeling programs on the majority of consumer choice decisions. The CFIA has recently initiated a consultative process intended to develop a verifiable system for method of production labeling in Canada (CFIA, 2005).

In a democratic society, the public expects to have its opinions count. The public in considering the complex processes in agriculture and food processing are likely to approach political questions posed, using significantly different parameters than current regulatory structures are prepared to include. Considering societal trends; it may be prudent if decision makers in livestock production methods were to take into consideration or at minimum acknowledge factors other than science in a long term vision of sustainable and ethically supportable agricultural production systems.

Over time, consumers will probably express a clear opinion on genetically modified products and technology such as food irradiation as critical scientific assessment has been made and is possible in these areas. The same consumers likely will conclude that some forms of livestock production although scientifically defendable are unnecessary or not reflective of societal values and those citizens will support regulatory intervention to address those concerns. As regulatory bodies currently claim a sound science base for decision making, more discussion is needed on how society will make decisions in the face of scientific uncertainty in food production or in the case of animal welfare, in the face of moral conviction. In highly contentious issues there will be some science on both sides of the argument and the final policy decision will be based on ethics (Weaver and Morris, 2004).

If the statement made by the late Harrison McCain in relation to GM potatoes *"We are in the business of giving our customers what they want....."* is representative of food processing industries, it is unlikely that significant science or ethically based leadership in animal welfare or similar issues in food production will originate in that quadrant.

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ON-FARM WELFARE AUDITS - WHAT YOU SHOULD KNOW

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ABSTRACT

The creation and application of animal welfare audits involves a wide range of questions that must be answered before an efficient mechanism can be created. We are currently limited by inadequate information, a consistent lack of cooperation between constituencies, and an over inflated expectation of the potential effects of audits.

INTRODUCTION

In many disciplines there is a saying that administrators should not be trusted if they actually want the job. Likewise, I think that anyone who actually welcomes welfare audits should be questioned. Welfare audits are the result of a dysfunctional relationship between animal agriculture and the general public. They reflect the argument that farm level decisions and decision makers cannot be trusted. If we accept this lack of trust, and invariably a lack of understanding, there is a place for audits, though audits may not be the best method to address the problem.

Welfare audits are problematic in many different aspects. We have problems in definition of the elements of welfare, measurement of those elements and measurement of processes that lead to unsatisfactory welfare in animals. In application, it is fraught with personal bias, and it is conflicted by many different agendas.

We must come to the issue of welfare measurement with an understanding that our measures can only be partial, that all parties bring inherent biases, and that good communication methods are required to bring efficiencies to the process. In addition, all must admit that there are real needs for improvement in the welfare of farmed animals. It must also be recognized that all improvements are made under the restriction of limited resources. Particularly when we speak of welfare policy, where regulatory aspects are considered, we must view welfare considerations in terms of the allocation of limited resources. It really does become an economic question, though it is difficult for many parties to admit to this.

With all these points, it is absurd for any person to stand up and claim to have an answer to all questions concerning welfare audits. It takes a community to ask the correct questions and define the correct route to solving the considerable challenges in animal agriculture. What producers should know is whether the correct questions are being asked. Below are 10 questions that I would like to ask before creating an audit program.

TEN QUESTIONS

So Howzitgoing, Eh?

One of the first challenges in coming to a consensus on measuring and evaluating welfare is in having a group that respects each other. Too often I have seen farm owners portrayed as profit maximizing ogres, animal activists portrayed as anarchistic zealots, and veterinarians as unprofessional and pliable puppets of animal agriculture. Yet, the most frustrating aspect of some of these consensus models is self-aggrandizement by scientists. Science has been portrayed as allowing for an absolute truth, yet most scientists have a narrow view of welfare through a specific discipline.

So Who are the Experts in Welfare?

The experts in welfare have to be defined as those who are involved in the care of animals and the day-to-day allocation of limited resources. Farmers, stockpersons, caregivers, whatever the terms, are the experts we should give to the discussion. Yet, too often, these are the people that are kept outside of the discussions. We need to personify the decisions and the decision-makers to allow a recognition that intentional and expert care giving is the aim of endeavors on the farm. There needs to be an argument that empowerment of caregivers is a central requirement of welfare improvement.

Are Audits the Best Way to Improve Welfare of Animals?

We must agree that audits have limited capability in improving the welfare of farmed animals. Audits are designed to identify and punish bad apples. They are not designed to change the average. Any welfare improvement program thus needs to address concerns about ignorance and apathy. There are areas of genuine lack of information and further research is needed. There is a need for further education of producers and methods for inducing producers who are apathetic. Programs such as SWAP (Swine Welfare Assurance Program) (National Pork Board, 2005) are designed for self assessment and education and meet a real need outside of an audit program.

Audits are almost always done where there is some level of distrust between parties involved. Demand for audits has come from animal activists and meat retailers. The reason for demanding audits differs between these two parties. Animal activists argue that the majority of farmers cannot be trusted and are unethical. Their purpose for audits is to illustrate systemic deficiencies and induce wholesale change. For meat retailers, there is a desire to avoid surprises and, in some cases, differentiate their product.

Are Audits the Best Way to Improve the Level of Trust?

I don't think that this question has been thoroughly addressed by our community. Certifying animal welfare must be more than simply examining animals, facilities and processes. In my discussions with people concerned about animal care, the main question is whether there is intentional care. The criticisms of animal agriculture almost always use the words "corporate" or "industrial" as a descriptor of farms and are an attempt to portray a lack of intentional care. The real response to that distrust cannot simply be audits. The professionalism and care given by stockpersons must be given as much emphasis as audits.

So What Do We Measure if We Do Audits?

There is considerable controversy and no straightforward answers. The measures can be divided into five areas: the pigs, historic performance records, the caregivers, contingencies, and production processes. There are absolutely stunning differences in the estimates of relative importance of components. These differences should lead to real questioning of the utility of welfare audits. Prioritizing measures is a very important step as it should reflect the priorities of the community. In addition, it has to be recognized that there are limited resources available for welfare audits and that there will be a bias towards simpler measures. These are measures that are repeatable between auditors and can be performed in a short period.

In the discussions I have seen three major biases. The first is to rely on experimental studies to critique processes such as castration and gestation stalls. We then are not auditing the welfare of animals but the application of the results of experimental studies. There are numerous potential failures in scientific studies. There are differences in genotype, environment and management that limit the representativeness of studies. We are also limited by the breadth of issues studied. For instance, if pain is a concern, is castration the most painful condition for pigs? It can be argued that lameness should be much more of a concern than castration, and yet lameness has had little study.

The second bias is towards culpability. I have seen too many arguments of whether disease is a welfare concern. Many critics are much more interested in controlling the direct interaction of pigs and people. Thus, again, there is more interest in castration then lameness. Likewise, contingencies such as alarm systems are often underemphasized.

The third bias is against production records. Admittedly, animal productivity is not linearly correlated to animal welfare. Yet deviations in productivity, particularly in mortality and morbidity, are excellent measures of potential failures. It is interesting that human welfare measures often emphasize the mortality and morbidity records of different communities. Second to that, basic health procedures such as vaccination and prenatal care are also emphasized. We see little of these discussions of animal welfare.

Can the Audit Results be Served in a Cafeteria Style?

The obvious answer is no. The National Council of Chain Restaurants (NCCR) and the Food Marketing Institute (FMI) argues that the results of audits can be given as a database to its members, as they do in their Animal Welfare Audit Program (SES, Inc, 2005). This will allow buyers to define differing welfare priorities, as required. This avoids the whole controversy of prioritizing aspects of the audit. It also balkanizes our efforts to improve the welfare of pigs. Furthermore, it is difficult to imagine its application as it requires good segregation of product within the processing plant. This is especially difficult to achieve for ground meat products. It also results in an unstable relationship between retailers and producers.

Who Should Administer the Audits?

There are really two choices in this area. The first is to create an audit that can be administered by almost anyone. The aim is to have simple measures, usually biased towards process verification, and a simple pass fail system. Thus the audit is limited by the skills of the auditor. The opposite is a professional and educated auditor that can recognize more complex conditions. The Professional Animal Auditor Certification Organization Inc. (PAACO) is currently organizing a professional body of auditors to address the latter requirement (JAVMA News, 2004). It is made up of animal scientists and veterinarians in the United States, and involves training and certifying auditors.

Who Should Design the Audits?

In theory it should be a body reflecting all constituencies. In reality, so far, it has been single constituencies. We need to have buy-in for the forms to allow utility and also stability. As long as there is a power-play between constituencies and their audit forms, the producer is at risk. In addition, audit forms must be designed with good statistical methods to evaluate sample size and the repeatability of welfare measures. Finally, audits must be pretested to ensure that they can be done efficiently.

So What About Gestation Stalls?

No discussion on animal welfare can be complete without a discussion on gestation stalls. The justifiable use of gestation stalls cannot be comprehended by many members of society. Conversely, animal welfare audits cannot simply focus on facility and other process measures to reflect the care of animals, and stalls cannot be a central measure of an animal welfare audit. There is evidently a need for further education of the public of the requirements and alternatives for gestation sow housing. Given that, decisions on animal care are often based on aesthetic evaluation, and this is an aspect that will be difficult to address in the future.

Where Will it End?

Many producers express a real unease, arguing that we are on a slippery slope towards loss of control and overregulation. They are worried about academics, administrators, government officials and bureaucrats embracing assurance programs that have no real endpoint. That concern is justified, yet assurance programs do have a real place as animal agriculture has lost a strong link with the general society. The building up of relationships, so that pork producers can be trusted, should be the long-term goal, with audits being, at best, just part of the answer.

CONCLUSIONS

Audit creation is a complex and demanding exercise. If done incorrectly it will open up a Pandora's Box for pig farmers. The simple answer to that question on what you should know is that you need to be at the table. A poorly designed and administered welfare audit can do more damage than good, both for pig farmers and pigs.

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PRACTICAL APPROACHES TO ENSURE ANIMAL WELFARE ON FARMS

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ABSTRACT

Although animal welfare can be defined in terms of animals' feelings, determining how this is manifested on farms relies on professional judgement. Various guidelines, both general and specific have been developed that provide direction on ensuring good animal welfare on farms. To achieve this, managers must demonstrate that they place a high value on animal welfare through their practices. These include training programs for staff and high standards for animal care. Operations should be internally assessed using the Code of Practice, as well as externally using industry developed tools. Certain areas such as handling, treatment and euthanasia require specific attention. Issues such as handling facilities, space requirements and gestation housing should be part of long term planning.

INTRODUCTION

Our ethical obligation to the animals we raise relates to the balance of positive and negative experiences or feelings that they have. This is what is important to the animals, and that is how animal welfare has been defined (Duncan, 1996). Because of the difficulty assessing these feelings, we use a variety of behavioral, physiological and clinical measures to assess welfare in animal research. Transferring general knowledge and research findings to the farm involves professional judgement by researchers, veterinarians and consultants, and producers themselves. One of the most widely quoted set of welfare criteria resulting from such professional opinion is known as The Five Freedoms (Farm Animal Welfare Council, 1992):

1. Freedom from thirst, hunger and malnutrition.
2. Freedom from discomfort.
3. Freedom from pain, injury and disease.
4. Freedom to express normal behaviour.
5. Freedom from fear and distress.

Professional judgement, using research findings whenever possible, has been used in the development of numerous welfare documents specific to pig production, including the Code of Practice (AAFC, 1993). Tools to assess the welfare of pigs on farms, such as the proposed Swine Animal Care Assessment program of the Canadian Pork Council, are based on these welfare documents. The question we are addressing in this presentation is the application of these welfare principles to the care of pigs on our farms.

ATTITUDE

Based on her extensive experience within the animal industries, Grandin (2000) states unequivocally that the single most important factor that determines how animals are treated is the attitude of the manager. This attitude should flow throughout the organization, and is evident to all staff through the allocation of resources (time and money), and the standards set for animal care. Without leadership by management, animal welfare becomes dependent upon the personal standards of individual stockpersons, who receive no reward for their efforts in this area.

Hemsworth and Coleman (1998) have emphasized the importance of developing the attitude of the stockpersons toward animal welfare. Training of staff should include not only the technical aspects of caring for animals, but the importance of good care to animal welfare, productivity and job satisfaction. Communicating the importance of good animal care goes beyond the initial training period. Animal welfare should be mentioned in staff meetings, continuing education seminars, and throughout the work environment. The use of signs throughout the barn, reinforcing good handling practices, is a means of communicating the importance of animal care.

The attitude of the manager is evident in how the farm is operated. If staff receives training in animal care, if standards are established and enforced, if money is spent on appropriate facilities and repairs, then the staff will realize that management cares. If these practices are not evident, then staff will assume the opposite.

ASSESSMENT

The first step to improvement is assessment. A good starting point for any farm is to examine its practices against recognized standards. The Code of Practice (AAFC, 1993) contains a wealth of information and suggestions on achieving high levels of animal welfare on pig farms. As with any such document, the Code of Practice has fallen out of date in some areas, or is either not definitive enough or too specific in others, but it remains a valuable source of advice. Managers should engage in a process of comparing their operation to the recommendations of the Code of Practice. Where differences are found, the decision to change or retain those practices should be based on what is best for the animals' welfare. Farms that have done this have usually identified a number of practices that could be improved on their operations.

Both the Canadian Pork Council and the National Pork Board (U.S.) have developed tools to assess animal care on pig farms. These tools are designed to identify problems on farms and to encourage producers to address them. Over a period of time, with repeated assessments, the standard of animal care should improve on all farms, and the poorest producers will realize their status relative to the rest of the industry. Although these assessments are voluntary, it is anticipated that major customers may require them in future. Canadian Pork Council's Swine Animal Care Assessment may become part of the Canadian Quality Assurance program, which has a high level of uptake by the industry and its customers.

An important part of assessment is the day-to-day inspection of pigs and facilities. The daily routine of each stockperson must include identification of animal care problems such as illness, injury, lack of feed, and broken equipment. It must also be stressed that these problems are to be attended to immediately if it will alleviate suffering, or by the end of the day it they pose a risk to animal welfare. Problems should not be allowed to accumulate until an annual 'fix-up' day.

CRITICAL POINTS

There are a number of critical points that deserve special attention. These include situations in which suffering is already present or likely to occur if care is not taken. Animal handling represents one such critical activity. At the very least, we should be eliminating use of the electric prod on farms, including the loading area. Not only do the behavioural reactions of the pigs do so, but their physiological responses also indicate that use of the prod is painful and extremely aversive to pigs. Every stockperson should be trained on handling animals with the goal of eliminating the prod in mind. All handling situations should be examined to determine how to reduce the inclination to use the prod. The movement of pigs through all handling facilities, including scales, crowd pens, alleyways and loading ramps, should be observed by supervisory staff to identify problems and offer direction to the stockpersons. In particularly difficult situations a consultant should be brought in to provide advice on handling and facility improvements. The Banff Pork Seminar recently recognized the importance of such expert advice by granting their Innovators award to consultants in this area.

Sick and injured animals must be promptly identified and a course of action initiated. Regular, normally daily, inspection of every animal should be standard practice on all animal farms. The more intensive the situation, as is typical on pig farms, the more frequent inspection should be. A decision tree should be established to determine the appropriate course of action. Suffering due to sickness or injury that can be alleviated by treatment should be attended to promptly. If suffering cannot be alleviated, or once recovered the animal is unfit for human consumption, or if transporting to a slaughter plant would impose additional suffering, then the animal should be euthanized. Several of the 'FAC' groups and provincial pork producer organizations, including OFAC (Ontario Farm Animal Council) and Ontario Pork have developed guidelines for assessment, decision making, and on-farm euthanasia. Every pork producer should obtain copies of these and include them in their staff training and management protocols. Failure to, or delay in, euthanizing animals is a major and avoidable source of animal suffering on farms. All stockpersons should be trained to identify animals requiring euthanasia and be prepared to administer it promptly.

LONG TERM PLANNING

It is often said that good stockmanship is the key to animal welfare. Although I agree that stockmanship is critical, it is my opinion that this statement has been used to deflect valid criticism of management systems and facilities. A good handler can greatly reduce the stress on a pig moving through a poorly designed loading ramp; but, a well-designed ramp is essential to trouble free handling. It is evident that packing plants realize that they will only achieve acceptable standards of animal welfare in their handling areas by providing well designed facilities and appropriate training to the staff that use them. Producers must realize that the same applies to their facilities. A new loadout may be costly to design and build, and so must be considered part of a long term plan for improving welfare on the farm. We should also recognize that although excellent designs exist for the high throughput facilities required in packing plants, less expensive facilities that accommodate fewer pigs are needed for farms. Such designs are not as readily available.

Space allowance represents an area of compromise on many farms. Although producers would generally concede that crowding to the point that growth rate is depressed reflects poor animal welfare, the practice remains common as it reduces the cost of production and additional space is often not readily available. The situation is compounded by the fact that preferred slaughter weights are increasing, and many farms produce more pigs than they were originally designed for. Producers need to realistically assess their space needs for nursery and finishing pigs and plan for additional space or reduced animal throughput.

Perhaps the most controversial welfare issue in North American pig production is that of gestation housing for sows. In recent presentations I have identified what I believe to be the main welfare criteria for these animals. These are: freedom of movement; freedom from aggression; control over individual feed intake; environmental enrichment; and, sufficient postural space for comfort and safety. Perhaps the issue of gestation housing best reflects my earlier comments on the importance of management system as well as stockmanship. If freedom of movement is seen as the most important contributor to sow welfare, then stall housing, regardless of the skill of the stockperson, is unacceptable. Similarly, if protection from aggression is critical to good welfare, then all group housing systems would be unacceptable regardless of the care given. In this presentation, I will defer to the Code of Practice (AAFC, 1993), which states “we recommend that producers give serious consideration to alternatives or modifications to the current dry sow stall systems when renovating, expanding, or building.” Long term planning, by both individual producers and the industry as a whole, is required to address this welfare issue.

CONCLUSIONS

Ensuring a high standard of animal welfare on a farm requires a firm resolve on the part of management that is communicated to the stockpersons through training and supervision, and is reflected in facility design and repair. A process of both internal and external assessment is necessary to identify shortcomings and measure progress. Several critical welfare concerns need continuous attention, including handling, identification and treatment of sick and injured animals, and timely euthanasia. Producers should include consideration of handling facilities, increased space requirements, and alternative gestation housing in their long range plans.

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THE VALUE CHAIN

GLOBAL PERSPECTIVE ON INTEGRATED PORK PRODUCTION

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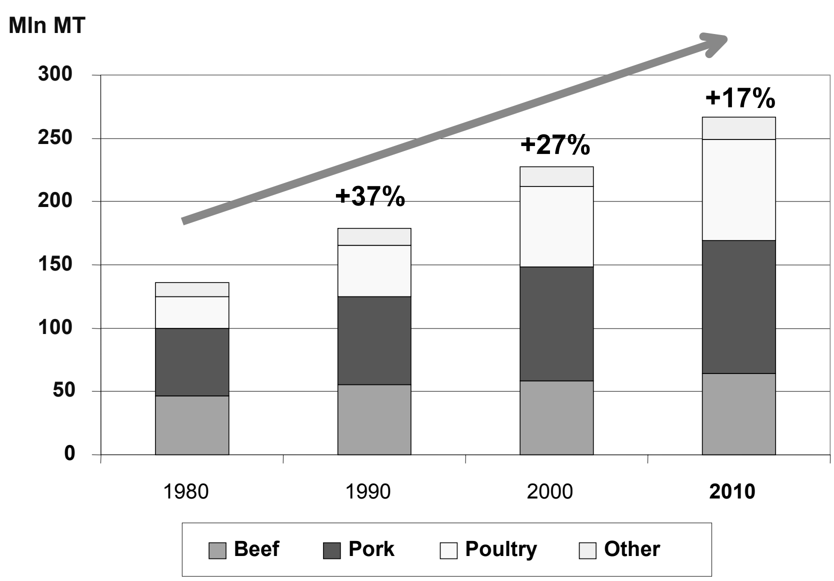
ABSTRACT

Total Quality Management through the whole production chain is the only way to fulfil the demands of consumers and to offer them safe, nutritious and attractive meat products for a fair price. Food safety and a customer oriented supply chain are the issues now and for the future.

The world's population has increased during the last decades and will increase further during this century. Due to this fact and increased meat consumption per person, global consumption of meat will rise. Over the last 40 years, global pork production has increased by a factor of 3.5, from 24.7 million tons in 1961 to 86.6 million tons in 2002. Figure 1 shows the world market demand for meat including pork.

Figure 1. The world market demand for meat (Rabo N.D. Mulder, Projection Fapri 2001, FAO).



PRODUCTION AREA

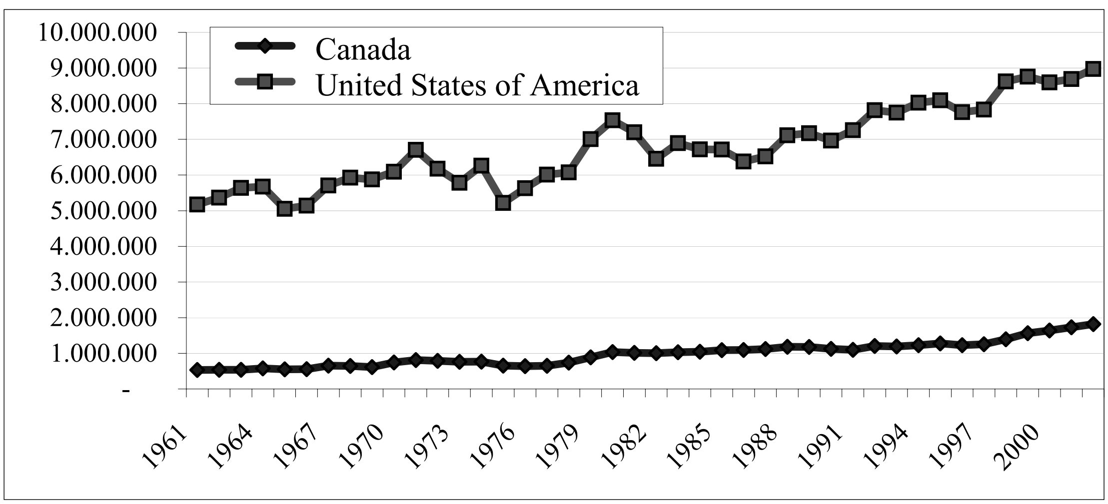
The main production areas for pork are East Asia, North America and Europe. In eastern Asia there is a shortage of land and feedstuffs for animal production. Japan is a major importer of pork. China however contains nearly 50 % of the world pig population. As China continues to increase pork production, more than 50 % of the world pork production in the future will occur in this country. Table 1 shows pork production per country.

Table 1. Pork production per country in 2003 (million tons).

Country	Pork Production
China	43.46
USA	8.93
Germany	4.12
Spain	3.20
Brazil	2.60
France	2.35
Poland	2.20
Canada	1.91
Vietnam	1.80
Denmark	1.76

In the USA and Canada, pork production has increased during the last decade. (Figure 2).

Figure 2. Development of pig meat production in the USA and Canada across 40 years (tons/year, Source FAO).



The USA has changed from an importing country to a pork exporting country. Export of pork is 4 times more profitable than the export of grains. In South America, especially Brazil, the production circumstances are favourable - feedstuffs are available, labour is cheap and there is enough land available for manure. Animal production is developing rapidly in this part of the world. Several changes have also occurred in Europe. The EU, for example, has expanded. This means an increase in the EU member state population by about 110 million people. The surface of the EU will increase by about 33 % but the area of fertile agricultural land will only be enlarged by 55 percent. The Eastern European countries have relatively cheap labour and land prices are also relatively low.

Tables 2 and 3 show the amount of imported and exported pork in 1990, 2000 and 2002. It can be concluded from these tables that the biggest increase in pork export has occurred in North America and Brazil.

Table 2. Import of pork per country (x 1000 ton carcass weight, Source GIRA 2002).

	1990	2000	2002
Japan	497	847	962
US	483	745	842
Russia	489	486	817
CEEC	201	227	303
Mexico	-	185	291
S. Korea	-	182	173
China	-	149	141

Table 3. Export of pork per country (x 1000 ton carcass weight, Source GIRA 2002)

	1990	2000	2002
EU	807	1321	1163
Canada	380	886	1079
US	109	600	735
Brazil	-	155	522
CEEC	323	266	323
China	443	59	188

The West European market is characterized by:
- Change from production oriented to market oriented
- Critical consumers with wishes concerning production methods
- Large market consisting of consumers with a relatively high income
- High production costs compared to other areas.

COST PRICE

Western Europe has approximately 3.2 million swine operations. In total, 110 desks buy pork for 170,000 selling points in order to serve 160 million consumers. The pig operations in Western Europe are mostly privately owned. The number of farms decreases while the number of pigs per farm increases. Differences in cost price between EU countries are relatively small. The difference in cost price between farms in a country is much bigger than cost price differences between countries. For several years now, the use of meat and bone meal, meat meal, feather meal, poultry meal, hoof meal and blood meal for feeding to pigs has been prohibited, although feeding of fish meal is allowed.

Table 4 gives a comparison of cost prices per kg slaughter weight between countries on different continents.

Table 4. Cost price in euro per kg slaughter weight (source Rabobank, 2004).

Country	Cost price
Brazil	0.99
Canada	1.13
USA	1.15
Poland	1.18
Netherlands	1.30
China	1.35

Table 4 shows that production costs of pork in Eastern Europe, the USA and Canada are 10% lower than in Western Europe. The cost price in Brazil is 25 % lower. However, welfare and environmental issues will increase production costs in these countries in the future.

MARKET

Markets are changing from production to market oriented, which means that we are moving more and more towards a consumer oriented production. This means that we should be aware of the wishes of the consumer concerning products and production practices. Because there is a variety of consumers and therefore in products, different supply chains should be built. The consumer expects attractive, nutritious and safe food from environmentally responsible and sustainable sources for a fair price. The keys for the successful future of pork production are:

- Food safety
- Quality assurance and transparency
- Sustainability in production
- Variety of products which are easy to prepare

In pork, for example, the following production chains have been developed:

- The "*Welfare chain*" was developed for the production of bacon for the English market. This chain includes, for example, group housing of sows.
- The "*Greenline chain*" delivers products for the retail and food service. In this chain no antimicrobial growth promoters are used in diets for finishing pigs.
- The "*Organic chain*" is a niche market and follows the international regulations for organic production.
- The "*Global pork chain*" is the basis for products for the food industry.

These supply chains are differentiated and continuously innovated by market demands. Additional demands in the supply chain have an effect on the cost price of the meat. Therefore economic simulation models for pigs and poultry are used as tools by the supply chain manager to calculate different "what-if" scenarios. For all the mentioned concepts, there are guidelines formulated. Farmers that want to join a certain concept have to adhere to the guidelines and standards and are audited by an independent company.

SUPPLY CHAIN

In order to fulfil the market demands, several companies have developed supply chains in which breeding, feeding, husbandry and processing are related. Optimization of the supply chain and specialization of the processing plants are used for further improvement of the product quality for bacon, industry, retail and food service. This means that breeding companies develop different breeding lines in order to fulfil the requirements of the production chains.

In Europe, pork is mainly consumed in a processed form, especially in the UK, Germany and Italy. The share of fresh prepacked meat purchases is also growing steadily. The percentage of fresh prepacked meat increased in the Netherlands from 42% in 1990 to 82% in 2004. The supermarket share in retail meat purchases keeps growing from 61% in 1990 in the Netherlands to 82% in 2004. The importance of prepacking, processing, fresh products and supply chain management will increase in the future. In order to differentiate in the EU from non-EU pork producers we have to stay close to the consumer and focus on the aforementioned aspects.

The five basic items which may affect the supply chain are:

- Food safety
- Quality
- Production circumstances
- Cost price
- Information

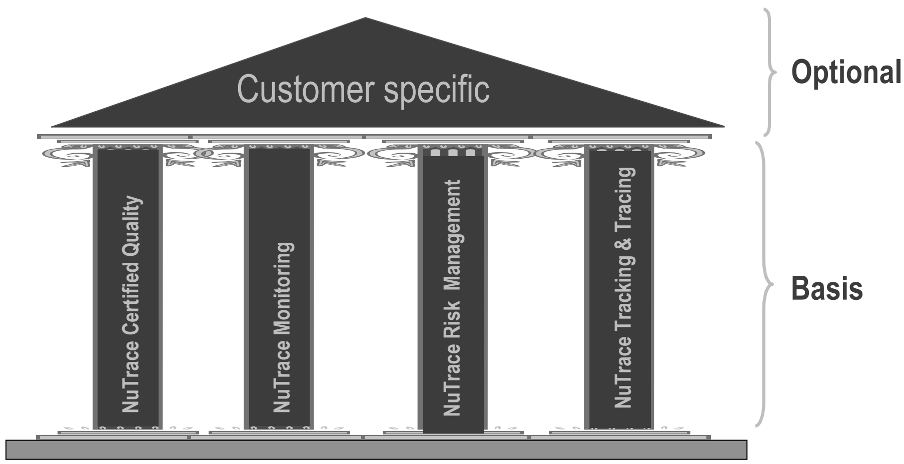
FOOD SAFETY

Food safety is a priority in all parts of the production chain nowadays. The first essential step in a food safety program is a good risk analysis (actual and perceived risk) which consists of risk assessment, risk management and risk communication. EU legislation demands livestock to be free of forbidden substances and imposes self control measures at the producer level. EU legislation on control of zoonoses is the basis for monitoring and control of salmonella in the pork production chain. At the Dutch national level, a salmonella surveillance programme has also started. This surveillance is based on examination of blood samples taken every 4 months on all pig farms.

In order to guarantee the consumer that the products are safe, four key characteristics in the Nutreco quality program NuTrace® (Figure 3) are defined:

- Development of food quality assurance programs (certified quality).
- Development of tracking and tracing systems.
- Effective risk management and preparedness.
- Monitoring the whole food value chain.

Figure 3. Nutrace®, based on four pillars.



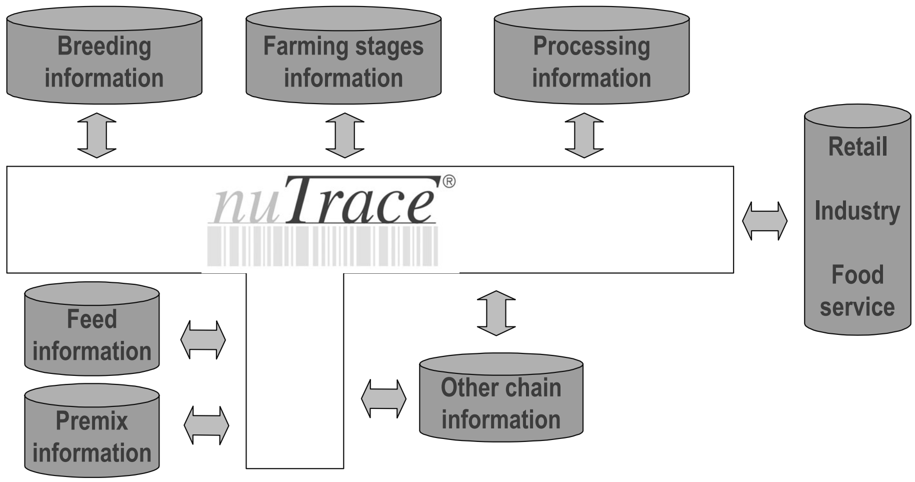
QUALITY SYSTEMS

The food quality assurance program fits with the specifications of the Global Food Safety Initiative. This initiative was launched by a group of international retailers and is a market oriented approach to assure food safety. However, in several countries, national requirements are involved as well. For this purpose not only a good relationship with customers is needed but also intensive communication with non-government organizations, governmental organizations and politicians is necessary.

TRACKING AND TRACING

Tracking and tracing through the whole chain and also to the suppliers is necessary in order to state the guarantees. Therefore NuTrace® tracking and tracing was developed which contains information concerning the product and the production process regarding, for example: breeding, farming, feeding, delivering, processing and packing (Figure 4). This means that the NuTrace® tracking and tracing system contains all the integrated information from feed raw materials through to processed products all in one database. This makes it possible to trace back within a few minutes from meat to, for example, the feed ingredients used to produce that meat. NuTrace® starts with traceability, evolves into transparency and leads to trust.

Figure 4. Nutrace®, Tracking & Tracing.



An example of a new technology that has been installed to track and trace meat products during processing is the DOT code system. The DOT code is put on the hams, backs, bellies and shoulders of the carcass by an advanced robot. Also the boxes with the smaller meat cuts can contain this code. In this way the customer has not only access to information of the product but also to the production process like breeding, feeding, health inspection and classification. This is the way to completely transparent production. A comprehensive administrative system which allows tracking and tracing of batches of products and product inputs at the press of a button is fast and accurate.

RISK MANAGEMENT

In order to build confidence with customers and to react in an adequate and accurate way, effective risk management policies and procedures are necessary.

INTERNAL AND EXTERNAL MONITORING

Monitoring all parts of the chain is essential. Suppliers are audited and raw materials checked rigorously at company laboratories. The traffic light procedure for suppliers is used. Only suppliers with a green light are allowed to deliver their products to Nutreco companies. Suppliers with a red light are not allowed to deliver and those with a yellow light have to be double checked. All the results of the monitoring procedure are communicated to the supplier. Detection methods for rapid and accurate indication of the presence of contaminants or undesired micro-organisms are developed. An example is the Calux analysis for rapid dioxin analysis.

TRACEABILITY OPTIONS FOR THE CANADIAN PORK INDUSTRY

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ABSTRACT

This paper will attempt to demonstrate the current status and direction of traceability systems in the pork production industry in Canada, with particular emphasis on what it will mean for Canadian pork producers. Traceability by definition is the ability to trace pork through the production chain. Traceability gives the production chain transparency, and transparency allows customers to understand and trust the product they are buying. Making sure that people continue to buy pork is the bottom line for all of us.

CURRENT STATUS

The current status of traceability in Canada's pork production system is outlined in Table 1.

Table 1. Current status of traceability in pork production in Canada.

	Feed Manufacture	On Farm Feeding and Production			Move Animals	Slaughter and Primal Cuts	Value Added Processing	Sell Product
Location	Feed mill	Farm 1 Grand-parents	Farm 2 Parents	Farm 3 Finishing	Transport	Packer	Processor	Retail
Technology	Business records	Ear tags	Business records	Business records	Tattoo	Bar code	Bar code	Bar code
Precision	Farm level	Animal level	Farm level	Farm level	Farm level	Multiple farms	Packer level	Packer level
Unit	Feed batch	Single animal	Groups of animals	Groups of animals	Group tattoo	Daily cut room output	Box ID	Box ID
Oversight	CFIA*	CQA**	CQA	CQA	CFIA	CFIA	CFIA	CFIA
Bottleneck	No animal movement database					Farm identity lost	Farm and/or packer identity may be lost	

* CFIA – Canadian Food Inspection Agency
** CQA – Canadian Quality Assurance (CQA^{TM}) Program

The current traceability status has some key deficiencies that leave significant risk for all stakeholders in the industry. The two major risk areas are:

Foreign Animal Disease Control Options

A foreign animal disease (FAD) has the potential to devastate the industry; outbreaks in the UK and Holland have cost the industry and public millions of dollars. The Foot and Mouth Disease outbreak in Taiwan devastated their pork industry. Risk of this magnitude affects everyone. Risk mitigation involves investment in and compliance with biosecurity measures, along with a plan for a rapid and efficient containment and eradication of the disease. Containment requires early detection and knowledge of the movement of infected animals. Currently the knowledge of animal movement in Canada is limited.

The major consequence of not knowing animal movements is that Canada cannot be zoned quickly. In the case of a foreign animal disease, the whole country may be considered infected until it can be demonstrated the disease is localized to a region. The more quickly the disease can be shown to be limited to a region, the more quickly international trade can resume with unaffected zones within Canada. Knowing animal movements is fundamental to being able to zone Canada in the event of a foreign animal disease outbreak.

An effective traceability system in Canada is essential to mitigating risk associated with an infectious disease that can disrupt international trade of Canadian pork.

Food Safety

A crisis associated with contaminated pork leads to an immediate need to identify the source of the contamination, as well as finding all other potentially contaminated product. A recall of contaminated pork is expensive both in terms of dollars lost but also in loss of brand confidence and competitiveness to other proteins in the marketplace. Minimizing the extent of the recall and finding contaminated product quickly is the optimal response to a crisis. Currently in Canada, maintaining product identity beyond the cutting room is difficult, although initiatives are underway to address this deficiency. Beyond the cooler, finding the farm of origin for pork products is currently difficult.

Even when the farm of origin is known, pigs in Canada often change farms multiple times from birth to market. Effectively finding the source of contamination requires knowledge of what farms pigs have resided on. Currently there is no systematic information of pig movements in Canada. An effective traceability system would help reduce exposure to the two risk areas, and thus the Canadian industry through the Canadian Pork Council is exploring options into a traceability system in Canada.

TRACEABILITY NEEDS

The current traceability needs in Canada as compiled by the CFIA and industry stakeholders are summarized in Table 2.

Table 2. Traceability needs in Canada's pork industry.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Occurrence of an outbreak of	FAD	Indigenous disease	Emerging disease	Food borne disease in humans	Poisoning issue
Point of detection	➢ Exported live animals or animal products ➢ Slaughter ➢ Sow unit ➢ Grow-finisher units	➢ Exported live animals or animal products ➢ Slaughter ➢ Sow unit ➢ Grow-finisher units	➢ Exported live animals or animal products ➢ Slaughter ➢ Sow unit ➢ Grow-finisher units	➢ Exported animal products ➢ Post slaughter	➢ Exported live animals or animal products ➢ Slaughter
Most probable chase (contacts and time)	Trace all contact last 3-4 weeks	Trace from first possible introduction to expression of disease through life span of afflicted animal	Previous 1 to 2 sites (evolves to scenario 1 or 2)	Trace to slaughter plant and then to the finishing barns that contributed to the product in question	Having confirmed slaughter plant trace to finishing barns, growers and farrowing barns as nature of poison/residue dictates
Most probable contacts of interest	➢ Animals ➢ Transport vehicles ➢ People/fomites ➢ Area	➢ Animals	➢ Animals	➢ Animals ➢ Transport vehicles	➢ Animals ➢ Area
Most probable transmission (horizontal, vertical, common source)	➢ Horizontal ➢ Common source	➢ Horizontal ➢ Common source	➢ Horizontal ➢ Common source	➢ Horizontal ➢ Common source	➢ Common source
Most probable chase (single animal or group)	Group	Group	Group	Group	Group
Most likely unit of interest for the chase	Herd (or group)	Herd (or group)	Herd (or group)	Herd (or group)	Herd (or group)

To address the traceability needs of the industry the following information is needed:

- A standard definition of farm, location or premise where pigs are housed, and
  - When and how many pigs left a premise?
  - When and where did they go to?
  - Who moved them?

To get this information, we need a premise database, a movement database including transportation information, and in some cases, an identification on the pig to link it back to a premises where it lived earlier.

Significant research is being expended in Canada to answer the above questions, but some information has already been generated. The first and most critical piece of information was the definition of swine premise.

Premise Definition

The premise needs to have a common definition across Canada that can be standardized into a database. Often database costs for accuracy maintenance are greater than initially creating the database. Ideally the maintenance costs can be minimized or shared with other stakeholders. The definition of premises for traceability purposes so far has been as follows

> *'A swine premise is a contiguous land location, based on provincial land title records, including all structures housing pig(s) and other livestock.'*

In this case, a premises is a land location based on legal deeds, that are kept up to date in municipal databases. Land title records are kept accurate for tax purposes, and like death are clearly defined.

Animal Movements

Animal movements between premises need to be recorded for traceability purposes. Some countries require herd books that log all movements to or from the premises. In some cases these movements are registered in a central database, in others the information remains on farm. Farm business records are essential, but it takes time in the event of a crisis to go to each farm to examine movement records. A central database is useful during a crisis as animal movements can be retrieved quickly, assuming the movement database is up to date. In an animal disease outbreak, response time is critical. A central database needs to be secure and guided by tight disclosure policies.

Transportation Information

In the case of an infectious disease, the transporter can be a source of contamination. Capturing the transporter information is certainly of value. A simple method may be to record the license plate of the trailers hauling the animals, alternatively a transportation log may be used. Again, this information may remain with the farms, the transporters, or in a central database.

Animal Identification

Some countries and commodities require a permanent identification for all animals. This gives the option to link a premises to an identification and thus be able to trace each animal to a premise. Identification without a movement log or identification registry would require a tag or identification for each premise. An evaluation of practical means for identification of pigs is underway. While a permanent ID of each animal is logical for the cattle industry, it is impractical for the poultry industry. Pork production is midway between these two commodities, and in some cases pigs will need to be identified, but in other cases, traceability can likely be achieved without identification of each pig.

Pigs going to slaughter in Canada currently have a permanent identification which is read on the slaughter line. This ID (slap tattoo) is used to reconcile shipments for payment purposes. This identification method could be used for traceability purposes if each tattoo was linked to a specific premises. This would require standardization of tattoos across the country, but would easily allow for traceability back to the last premises for market pigs in Canada.

Traceability from Pork and Pork Products

Perhaps the most effective way to traceback pork, from cut room or beyond to the farm of origin when the animal identification is lost, is through the use of DNA. Maple Leaf Foods have pioneered a system in Canada to trace back pork to the premises where the pig was born. Identigen Genetic Testing Services have successfully piloted a system in Canada. DNA analysis offers an ability to correctly identify a pig from any tissue even from fully cooked product. Advances in technology are making this process increasingly affordable. Figure 1 indicates DNA traceback options currently available.

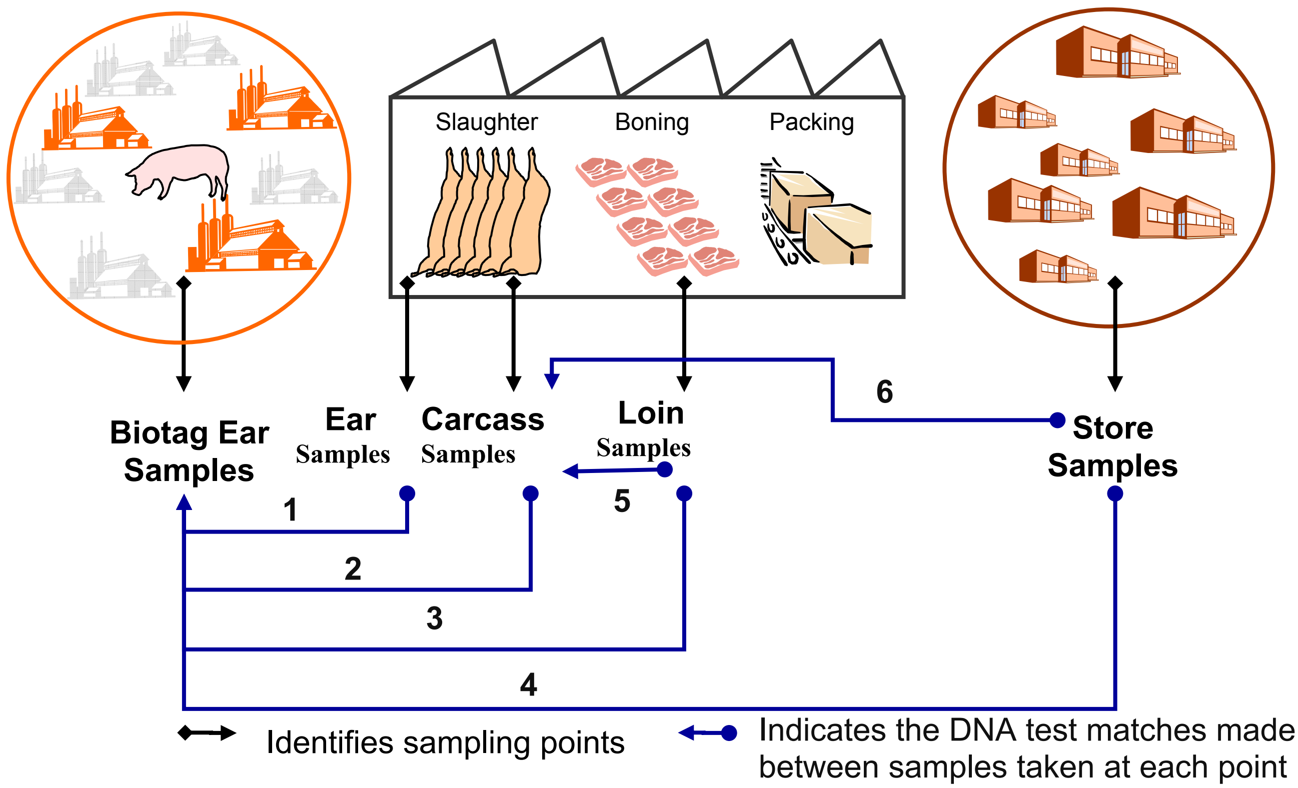
DNA traceability offers matching animal and pork cuts which has benefits beyond crisis management. Currently it is difficult to match the genetics to optimal pork quality. DNA matching allows finding the parentage of pork that is judged superior by consumers and retailers. This offers a significant new genetic selection tool for the industry.

EXAMPLE - HOW TRACEABILITY COULD WORK IN CANADA

Scenario Number 1 (from Table 2) - Foreign Animal Disease Outbreak

Assume a fictitious foreign animal disease outbreak was diagnosed in a barn identified as premise 60329. Baby pigs started dying in large numbers showing signs of central nervous disease and a Pseudorabies diagnosis was made. A question of immediate concern to answer was where has the disease spread? This requires knowing where pigs from premise 60329 have been moved within a specified time interval. This question can be answered through a forward tracing of pig movements starting at least 3 weeks prior to the initial diagnosis.

Figure 1. DNA sampling and traceback options for commercial pork production.



Forward Tracing Movement of Pigs

Figure 2 shows a sample output of a trace forward analysis for premise 60329 – this is an example data set from a prototype traceability system. It returned all the downstream contact premises where the pigs went over a set time interval.

Farm 60329 shipped pigs to premises 60313, 60314, and 60315, and each of those shipped to other farms as shown in Figure 2. This information would guide CFIA personnel to focus on investigating 9 farms in the case of a disease outbreak, as opposed to having to investigate **all** farms in the region.

A more complete examination of the records can yield specific contact information (Figure 3) making date of shipment, destination, number of animals, and license plate readily available. Clearly information such as this is powerful, and access to it would require clear disclosure policies, but the traceback indicates that the pigs did not move outside of a certain region, allowing for a zoning process to begin to be defined.

At the same time, a trace-backward analysis (Figure 4) from premise 60329 would indicate that no animals came into the herd in the time in question.

In the case of infectious disease, vehicles remain sources of infection for subsequent loads of pigs. It is crucial to be able to track vehicle movements and a traceability system can provide such a vehicle trace for this simulated outbreak (Figure 5).

Figure 2. FAD premises trace forward summary.

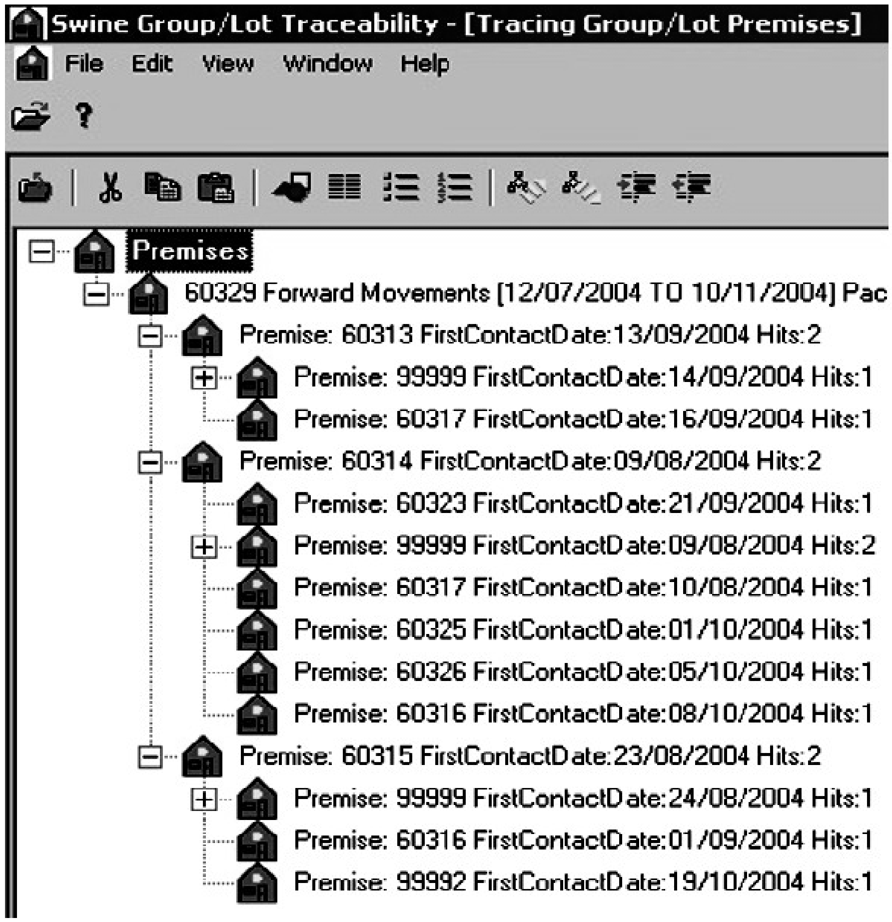


Figure 3. FAD premises trace forward detail.

Date	Data Source	Status	From	To	QShipped	QReceived	Plate#	Prov
30/09/2004	Shipped	Reconciled	60329	60313	73	0	G 5Z	MB
30/09/2004	Received	Reconciled	60329	60313	73	73	G Z	MB
04/10/2004	Shipped	Not Reconciled	60329	60314	92	0	G Z	MB
02/09/2004	Shipped	Reconciled	60329	60315	89	0	G Z	MB
02/09/2004	Received	Reconciled	60329	60315	89	89	G Z	MB
06/09/2004	Shipped	Reconciled	60329	60315	88	0	G Z	MB
06/09/2004	Received	Reconciled	60329	60315	88	88	G Z	MB
09/09/2004	Shipped	Reconciled	60329	60315	88	0	G Z	MB
09/09/2004	Received	Reconciled	60329	60315	88	88	G Z	MB
09/08/2004	Shipped	Reconciled	60329	60314	78	0	G Z	MB
09/08/2004	Received	Reconciled	60329	60314	78	78	G Z	MB
12/08/2004	Shipped	Reconciled	60329	60314	86	0	G 6Z	MB
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13/09/2004	Shipped	Reconciled	60329	60313	66	0	G 5Z	MB
13/09/2004	Received	Reconciled	60329	60313	66	66	G 5Z	MB
16/08/2004	Shipped	Reconciled	60329	60314	75	0	G Z	MB
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18/10/2004	Received	Reconciled	60329	60314	65	65	G 6Z	MB
21/10/2004	Shipped	Reconciled	60329	60314	74	0	G 6Z	MB
21/10/2004	Received	Reconciled	60329	60314	74	74	G Z	MB
20/09/2004	Shipped	Reconciled	60329	60313	71	0	G Z	MB

Figure 4. FAD trace back.

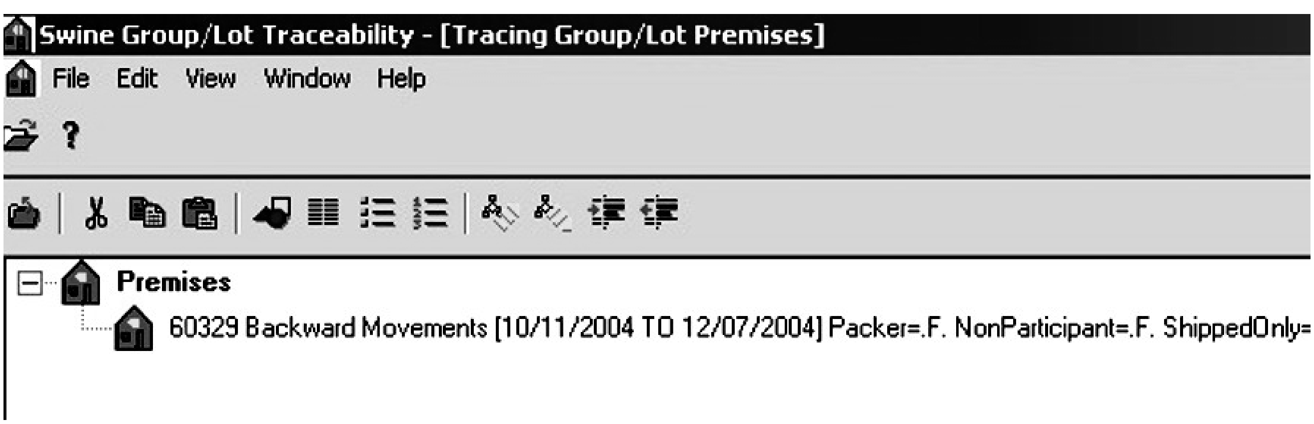
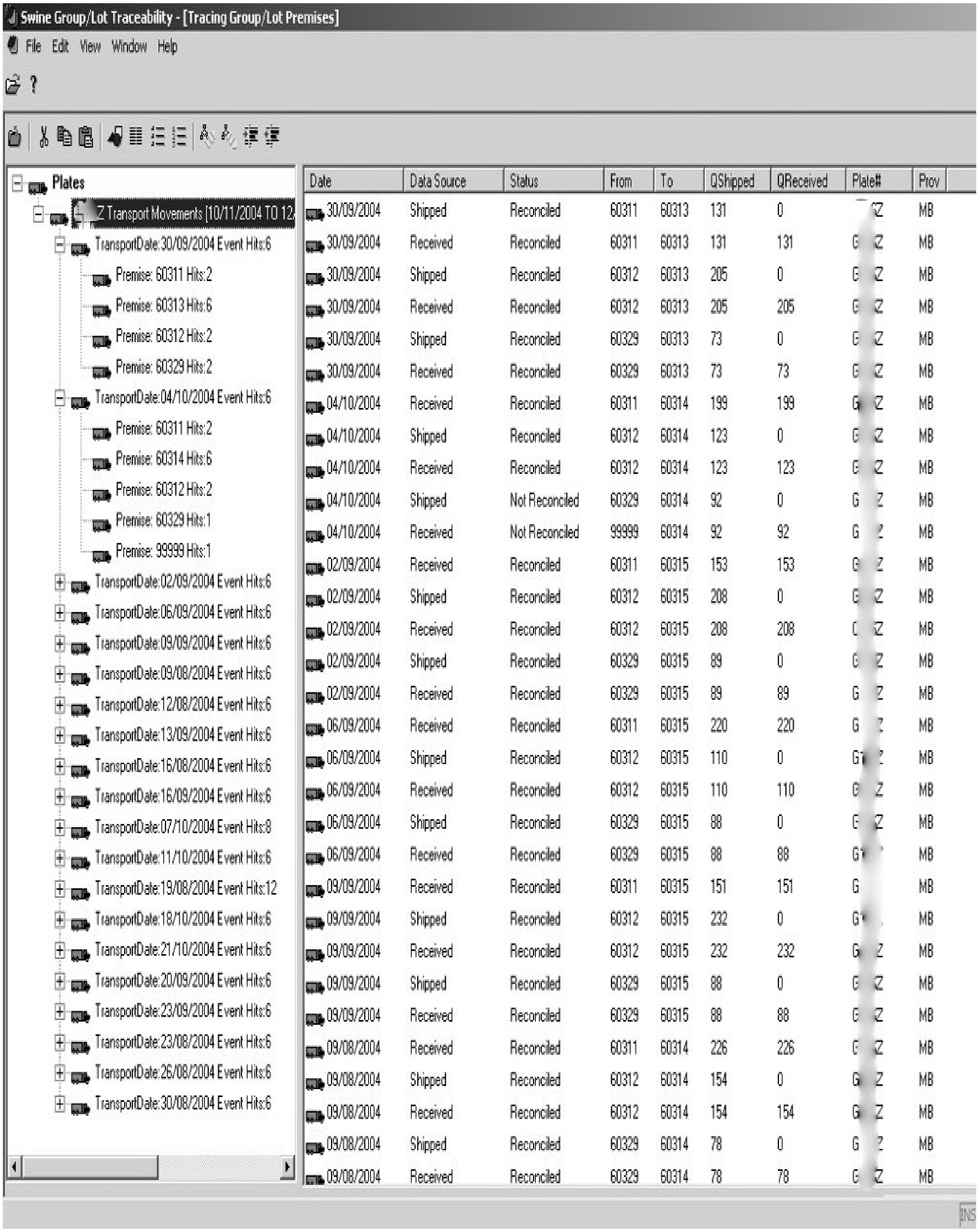


Figure 5. FAD transportation tracking.



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30/09/2004	Received	Reconciled	60312	60313	205	205	[illegible]	MB
30/09/2004	Shipped	Reconciled	60329	60313	73	0	[illegible]	MB
30/09/2004	Received	Reconciled	60329	60313	73	73	[illegible]	MB
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04/10/2004	Received	Not Reconciled	99999	60314	92	92	[illegible]	MB
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MANAGEMENT OF PIGS IN THE PORK PRODUCTION CHAIN

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ABSTRACT

The pork industry has the objective to produce high quality lean pork products. The pig's genetic potential for lean growth and the environment both affect the pig's rate of growth, carcass composition and feed efficiency. Exposure to disease or other stressors reduces carcass muscle growth to a greater extent than fat tissue growth such that at the same feed intake, stressed pigs have decreased carcass lean percentages. Variation in the growth of pigs is in conflict with the pork processors demand to produce pork products which are uniform in both weight and composition. Farms with higher levels of stressors present and large litter sizes with greater numbers of light birth weight pigs will have greater variation in pig growth. Cost effective methods to reduce variation in pig growth should be evaluated. A stochastic model has been developed which allows for the optimization of marketing strategy, Paylean use and barn turn-over. Future models will predict the amount and form of nutrients excreted by pigs and evaluate for specific producers, the most profitable, sustainable nutrient management plan relative to both the pork production and cropping systems. These models currently evaluate the use of alternative diets to reduce the excretion of N and P. In the future they may predict the relative production of other compounds and compounds released as gases.

INTRODUCTION

The goal of the pork industry is to provide high quality pork products to the consumer at the lowest possible cost. Pork processors sell numerous highly trimmed pork products and receive premiums for products that meet specific weight, quality, trim and compositional standards. This has resulted in the development of "value–based" marketing systems in which a premium or discount is received for each pig based on predicted lean content and carcass weight. To remain profitable pork producers must consider a number of alternative genetics, management and marketing decisions to strive to produce pigs with the optimal predicted lean content and carcass weight.

While many criteria (e.g. feed cost/pig or lb of pork) can be used, the ultimate objective is to maximize the daily returns to the facility (pig space-investment) above daily feed and variable costs. A model may take into account optimal pig growth performance, carcass characteristics, nutrient requirements, packer grids, prices of ingredients, replacement animals (feeder pigs), current meat prices, fixed and variable facility costs all being optimized simultaneously.

Economic modeling has become more complex given the current environmental regulations. Producers not only have to try to maximize their profit/pig space/day but also need to balance that with environmental regulations. The new phosphorus based standards go into effect in the US in 2006. The swine manure by-products will need to be land applied on a phosphorus basis depending on phosphorus soil tests and planned crop removals. Traditional manure applications will need to be spread over 2 to 4 times more land base depending on soil and manure phosphorus levels, drastically increasing nutrient management costs. This requires the modeling of the amount, composition and cost benefits of the nutrient excretion and resultant manure applications.

The objectives of this paper are: (1) to review some of the key factors affecting pig performance, (2) to discuss the interactions between pig to pig variation in growth, marketing and scheduling on profitability, and (3) to explore the future use of ractopamine (Paylean™) and (4) the future of pork production systems analyses.

GENETIC POTENTIAL FOR LEAN GROWTH

Swine growth models require estimates of the protein accretion potential, partitioning of energy and daily energy intakes for each genetic source–sex population. The relative differences in feed intake, feed efficiency and nutrient requirements of barrows and gilts also differ amongst different genetic populations (Schinckel, 1994). Genetic selection for increased carcass leanness and, more recently, increased carcass lean growth rate has resulted in pigs with increased protein accretion rates, increased partitioning of energy to carcass lean growth from fat tissue growth and reduced feed intakes (Schinckel and de Lange, 1996).

ENVIRONMENTAL LIMITATIONS ON PIG GROWTH

Substantial differences in performance exist between different environments and health management strategies. Environmental stressors including pathogen exposure, social stress, and less than optimal stocking density limit growth, such that pigs managed under commercial conditions do not express their maximum potential protein accretion even when allowed ad libitum access to nutrient dense diets (Holck et al., 1998; Schinckel et al., 2003a).

Genetic populations with different genetic potentials for lean growth and fat accretion are different physiologically. From a modeling perspective, lean, low feed intake pigs are expected to be more sensitive to any environmental stressor that reduces feed intake. In addition, selection for increased carcass lean growth and decreased fat tissue growth has likely resulted in changes in immune response (Spurlock, 1997; Spurlock et al., 2003).

EFFECT OF HEALTH STATUS ON PIG GROWTH

In a past experiment, pigs with minimal disease via segregated early weaning (SEW), which were fed a series of non-limiting diets and reared in pens of three pigs (2.23 m^2/pig), achieved

104 kg at 136 days of age and 120 kg at 151 days of age (Schinckel and de Lange, 1996). Pigs raised on the original commercial farm, conventionally weaned with all-in, all-out (AIAO) production, required 184 days to attain 104 kg live weight.

Research conducted in two health status environments, medicated early weaning and continuous flow (CF) commercial conditions, indicated that disease status affects lean growth to a greater extent than fat growth (Williams et al., 1997). The pigs reared via continuous flow management averaged over three diets (.75, .90, and 1.05% lysine) consumed less feed from 27 to 112 kg (2.43 vs. 2.69 kg/d), grew slower (743 vs. 947 g/d), had poorer feed efficiency (.307 vs. .352), and lower muscle growth (263 vs. 342 g/d). At 112 kg, the conventional health status pigs had greater backfat depth (29.8 vs. 26 mm) and smaller loin muscle area (32.1 vs. 36.7 cm^2) than the high health pigs. The visceral organ weight to carcass muscle weight was substantially greater for the conventional health status pigs (57% vs. 49.7%).

GENERAL ENVIRONMENTAL EFFECTS ON PIG GROWTH

The compositional growth of the same genetic population of pigs has been evaluated on two US commercial production units (Schinckel et al., 2002). Pigs reared on farm 1 were reared via AIAO management with 1 week age groups. Pigs on farm 2 were reared in two week groups and were not maintained as a group. Pigs of different age groups were present in the nursery and finish at the same time. The barrows from farm 2 required 6.3 more days to achieve 115 kg body weight (BW) (194.2 vs. 187.9 d, $p<.01$), had .97 cm greater backfat (3.22 vs. 2.25 cm, $p<.01$) and smaller loin muscle area (37.5 vs. 42.4 cm^2, $p<.01$). Gilts on farm 2 required 11.6 additional days (200.5 vs. 188.9, $p<.01$) to achieve 115 kg BW, had .57 cm greater backfat (2.42 vs. 1.85 cm, $p<.01$) and 2.6 cm^2 smaller loin muscle area (42.0 vs. 45.5 cm^2, $p<.01$). The predicted protein accretion rates were 20 g/d lower for farm 2 and predicted daily lipid accretion rates were higher than farm 1.

In a nutrition trial (Carroll et al., 1999), lean gilts sired by lean European sires on the same Landrace by Large White-Duroc dams were reared in the west and east wing of a grow-finish facility. In the west wing, the lean gilts grew faster (934 vs. 798 g/d ADG) and had higher daily feed intakes (2.42 vs. 2.24 kg/d), but were leaner (13.7 vs. 15.8 mm backfat) and had larger loin eye areas (49.1 vs. 47.7 cm^2). The ventilation of the east wing did not provide the air quality of the west wing. In this project, few animals were treated for signs of infectious disease. The results of this trial suggest that the environmental stressors (air quality) reduce muscle growth to a greater extent than fat growth, such that at lower feed intakes percent lean is reduced.

GENETIC BY ENVIRONMENTAL INTERACTION TRIALS

To document and quantify genetic by environmental interactions, three genetic by environmental trials were conducted (Schinckel et al., 2003a). In each trial, two or three genetic populations of pigs (288 to 320 pigs per trial) were reared under two health status environments. Significant genetic by environmental interactions were found for average daily gain, daily feed intake, days to 112 kg live weight, death loss, feed efficiency and predicted percent lean. These results indicate that the increased performance produced by changes in health status differs amongst genetic populations. To make correct decisions concerning any environmental change (health status, air quality, pen density, etc.), the pork producer must have information concerning the expected response of their specific population of pigs to the specific environmental change.

FARM-GENETIC POPULATION NUTRIENT REQUIREMENTS

Because the environment limits pig growth, farm-production system specific essential amino acid: energy ratio and available P to calorie ratio requirements need to be estimated (Schinckel and de Lange, 1996; Schinckel et al., 1998; Tokach and de Lange, 2001). The three alternate methods to set target nutrient requirements are (1) conduct full scale nutrition experiments, (2) develop farm specific compositional growth curves using serial ultrasound and, (3) to utilize mean predicted lean growth rates over the grow finish period (Schinckel et al., 1996).

MODELING VARIATION IN BODY WEIGHT GROWTH FROM BIRTH TO MARKET WEIGHT

Several researchers have realized that variation in growth rates amongst pigs has a cost and should be reduced when cost effective means can be identified (Deen, 1999; King, 1999; Le Dividich, 1999; Dewey et al., 2001; Patience et al., 2004; Tokach, 2004). Some of the variation in body weight growth is caused by differences in birth weight (Foxcroft and Town, 2004). Increasing the birth weight of the lightest 20% of the pigs could substantially increase subsequent BW's and potentially reduce variation in BW (Schinckel et al., 2004). Increasing the birth weight of the heaviest pigs will result in only small increases in subsequent BW's (Figure 1). One reason for this curvilinear relationship is the fact that ADG increases rapidly as BW increases. Heavier pigs at the same age are able to grow faster than average pigs, achieve even greater BW at the same age than average pigs, and thus increasingly grow at faster rates (Figures 2 and 3).

One alternative is to have a separate production system, including nutrition, health program, and facility management for the lightest pigs at weaning. The reduced variation observed in the remaining 80% of the pigs will improve utilization of the larger grow-finish facilities. This reduced variation could result in more precise phase feeding, use of ractopamine, and marketing at specific target weights.

The modeling of the mean and variance of subsequent BW's from birth to market weight is complex because of the curvilinear relationships between birth weight and subsequent BW. Statistical analyses, which assume or only account for linear relationships amongst the serial BW's, would likely not reproduce the actual relationships and variation amongst the serial BW's.

Figure 1. **Relationship of body weight to age for five percentile groups of pigs based on birth weight.**

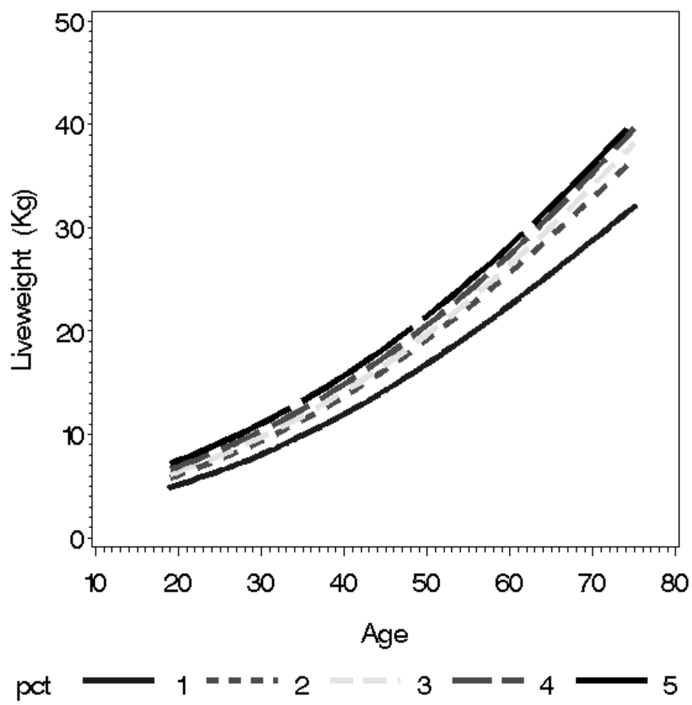


Figure 2. **Relationship of ADG to age for five percentile groups of pigs based on birth weight.**

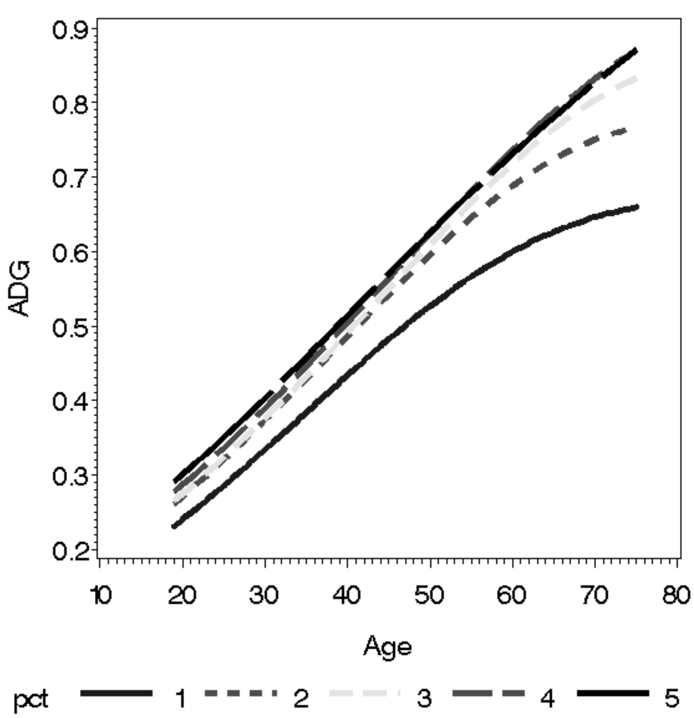
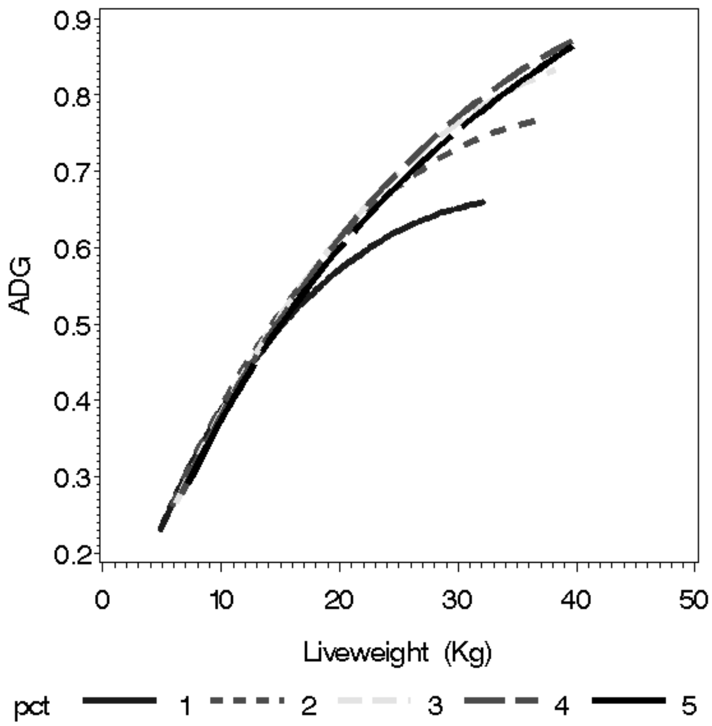


Figure 3. **Relationship of ADG to live weight for five percentile groups of pigs based on birth weight.**



Health status impacts the amount of variation in BW at each age and the days to reach a specific target BW (Tables 1 and 2). The day of age to reach specific target weights was predicted for the five fastest gaining and five slowest gaining percentiles of gilts in each environment (Table 2). The difference in age predicted to achieve 120 kg between the fastest and slowest growing gilts increased to 61 days in the CF environment and 53 days in the SEW environment. This difference grew to 62 days for the AIAO system and 104 days for the CF pigs to reach 130 kg, making it impractical to market CF pigs at 130 kg BW.

The increased variation in days required to achieve specific market weights has an economic cost as most pork processors discount pigs below their specified target market weight. The economic evaluation of rearing pigs under AIAO or CF management must include both the impact of the differences in the mean performance and differences in the variation in growth.

DEVELOPMENT OF A STOCHASTIC MODEL FOR EVALUATING MARKETING ALTERNATIVES

Pork processors have the objective to market lean pork products which are uniform in weight and composition and receive premium pricing for their product. The evaluation of alternative management and marketing strategies, requires knowledge of the between pig variation in BW and carcass composition.

Table 1. Means and standard deviations for live weight, kg.

	All-in, all-out				Continuous flow			
Age	N	Mean	SD	CV	N	Mean	SD	CV
49	96	28.88	2.34	11.2	96	20.74	2.26	10.9
70	96	36.85	3.76	10.2	96	36.72	3.18	8.7
104	96	67.28	5.34	7.9	96	67.88	5.32	7.8
132	96	93.00	7.99	8.6	96	90.05	8.10	9.0
153	96	115.14	8.52	7.4	96	106.08	9.05	8.5
174	42	120.29	9.03	7.5	96	113.65	9.96	8.8

Schinckel et al., 2002

Table 2. Overall means and means for the pigs of the fastest and slowest five percentile groups for predicted age to achieve specific body weight.

	All-in, all-out: Age				Continuous flow: Age			
Target body weight, kg	Mean	Upper 5	Lower 5	SD	Mean	Upper 5	Lower 5	SD
100	138.1	121.0	159.8	8.4	144.4	123.2	159.8	10.9
110	149.5	130.4	175.2	9.7	160.9	134.4	180.0	16.5
120	161.5	139.4	192.4	11.3	177.4	146.4	207.4	19.3
130	174.2	149.2	211.8	13.4	199.3	154.8	258.9	22.9

Schinckel et al., 2002

The random effects produced by mixed model nonlinear equations could be used to evaluate the growth of individual pigs or specific groups of pigs. Farm-specific BW, empty body composition, and carcass composition can be predicted from serial live BW and real-time measurements. Data from a Purdue University research trial were used as the example data set. High-lean gain gilts (N=96) were reared via AIAO procedures.

The stochastic model predicts daily BW growth, empty body protein accretion, and empty body lipid accretion for each individual pig. For this reason, the stochastic model can be used to predict the BW and carcass composition of groups of barrows and gilts marketed at different ages. The marketing strategy that maximizes the daily return for the grow-finish facility above daily feed costs can be identified. Stochastic models can be used to develop optimal sorting and marketing strategies and to evaluate the costs and returns of specific management decisions that affect variation.

The predicted standard deviation (SD) for carcass weight, fat-free lean mass, total carcass fat tissue mass, and all carcass measurements increased as the age at marketing increased (Table 3). Variables associated with carcass fat mass or backfat thickness increased more rapidly than measures associated with lean mass including longissimus muscle area or optical probe muscle depth.

Table 3. Means and standard deviations for live BW and carcass measurements at alternative marketing ages[a].

	146 d		160		174	
Item	Mean	SD	Mean	SD	Mean	SD
Age						
Live BW, kg	107.4	8.1	119.4	9.1	130.8	9.9
Hot carcass wt, kg	80.6	6.8	90.8	7.7	95.6	8.4
Fat-free lean, kg	42.2	3.7	46.3	4.1	50.0	4.5
Percent fat-free lean	52.5	3.2	51.0	3.2	49.9	3.3
Total carcass fat, kg	24.3	3.8	27.9	4.7	31.6	5.5
Fat thickness, 10th rib, mm	20.9	2.7	22.3	3.3	23.8	3.8
10th rib longissimus area, cm^2	10.8	2.8	43.4	3.1	46.3	3.5
Optical probe fat depth, mm	20.3	2.4	21.2	2.8	22.3	3.2
Optical probe muscle depth, mm	52.2	2.7	54.0	3.0	55.8	3.1

[a]Mean and standard deviations were predicted by simulating 1000 pigs with the means, variances, and relationships predicted by an original sample of 96 gilts.

Four alternative marketing strategies were evaluated. The first strategy was to market all pigs at 160 days of age with a mean BW of 119.4 kg. The second strategy was to market all pigs above 113.8 kg BW at 146 days (21.2%; mean = 118.6 kg) and 160 days (53.5%; mean = 119.9 kg) of age and all remaining pigs (25.3%; mean = 118.8 kg) at 174 days of age. The third strategy was to market pigs above 112.3 kg at 146 days (25.8%; mean = 117.6 kg) and 160 days (53.0%; mean = 118.9 kg) of age and all remaining pigs at 181 days of age (21.2%; mean = 122.6 kg). The fourth strategy resulted in pigs above 116.4 kg being marketed on a weekly basis (13.0, 21.9, 28.8, 19.6, and 9.6% with mean BW's of 120.9, 119.8, 119.6, 120.1, and 120.0 kg, at 146, 153, 160, 167, and 174 days of age) with the remaining pigs (7.1%; mean = 116.6 kg) marketed at 181 days of age.

The three multi-day marketing strategies reduced the SD for BW and carcass weight (Table 4). The SD of carcass fat-free lean and fat mass were reduced to a lesser extent. This is due to the fact that each carcass component mass has two sources of variation: variation in carcass weight and variation in the carcass percentage of the specified carcass component. The weekly marketing strategy resulted in further reductions of the SD for BW and carcass weight in comparison to the two 3-time marketing strategies. However, the weekly marketing strategy had little impact to further reduce the SD of any carcass component or measurement. The multi-day marketing strategies resulted in BW, carcass weight, and to a lesser extent, carcass component mass to not be normally distributed.

Table 4. Means and standard deviations for live weight and carcass measurements with alternative marketing strategies.[a]

	160 d		146, 160, 174		146, 160, 181		146-181 weekly	
Item	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Live BW	119.4	9.1	119.3	4.3	119.4	4.7	119.4	3.0
Carcass weight	90.8	7.7	90.6	3.8	90.6	4.1	90.8	2.7
Fat-free lean, kg	46.3	4.1	46.3	3.3	46.3	3.4	46.4	3.2
Percent fat-free lean	51.0	3.2	51.1	3.1	51.1	3.1	51.0	3.0
Total carcass fat, kg	27.9	4.7	27.8	3.6	27.8	3.6	27.8	3.5
Fat thickness 10th rib, mm	22.3	3.3	22.2	2.8	22.2	2.8	22.1	2.8
10th rib longissimus area, cm^2	43.4	3.1	43.3	2.6	43.3	2.6	43.3	2.5
Optical probe fat depth, mm	21.2	2.8	21.1	2.5	21.1	2.5	21.1	2.5
Optical probe muscle depth, mm	54.0	3.0	54.0	2.8	54.0	2.8	54.1	2.8

[a]Strategies included: 1) all pigs marketed at 160 days of age; 2) pigs above 113.8 kg marketed at 146 and 160 days and the remaining pigs at 174 days of age; 3) pigs above 112.3 kg marketed at 146 and 160 days and the remaining at 181 d; and 4) weekly marketing of pigs above 116.4 kg from 146 to 174 days with marketing of the remaining pigs at 181 days of age. Data based on simulation of 1000 pigs.

The predicted age at 110 kg was normally distributed ($P > 0.10$) for the AIAO gilts. Predicted age to 110 kg was not normally distributed for the CF gilts ($P < 0.02$). Pigs reared under CF management have been previously found to have a greater than expected percentage of slow growing pigs (Patrick et al., 1993).

USE OF A STOCHASTIC MODEL TO OPTIMIZE MARKETING AND BARN CLOSE OUT TIMES

A bio-economic model was developed based on a stochastic growth model (Li et al., 2003a, b, c; Schinckel et al., 2003b), which incorporated the economic optimization principles of livestock replacement, swine growth under limited dietary lysine intake, and growth response to Paylean (Schinckel et al., 2003c). This stochastic model was used to derive the optimal production and marketing decisions for grow-finish swine production.

The objective function of the model was set as maximizing daily return for a 1000-head grow-finish barn managed all-in/ all-out. Model parameters were estimated for modern high lean genetic populations. The return was optimized under 10-year average prices and costs. The optimal management was derived for four payment schemes, simulating producers with various marketing channels and market structures. They were: (1) carcass payment with discounts on underweight and overweight carcasses; (2) carcass merit payment system adopted from Hormel's Carcass Value Program; (3) lean to fat price ratio of 2:1; and (4) lean to fat price ratio of 4:1. The carcass weight discount grid for payment schemes 1, 3 and 4 were also adopted from Hormel's Carcass Value Program. Payment scheme 3 simulated the producers under limited coordination with packers, while payment scheme 4 reflected vertically integrated producers, which capture the full benefit of the increase in carcass value. The model optimized the return for 50-day-old feeder pigs to market.

Pigs were marketed by semi-truck with a capacity of 170 head. Thus, the 1000 pigs were marketed in six truckloads. One or more truckloads can be marketed on the same day. Pigs were marketed when the number of pigs heavier than the sort weight (also a variable to be optimized in the model) exceeded one truckload, except that pigs can be marketed in the last batch regardless of the weights.

It was optimal to market the pigs in three batches under payment schemes 2, 3 and 4, while under payment scheme 1 pigs were marketed as 4 batches (Table 5). The optimal marketing age for the last batches ranged from 162 to 166 days of age, with the earliest age associated with scheme 4. The marketing day for the first batch was in a close range of day 153 to 155 across marketing schemes. For batches other than the last one, the number of pigs to be marketed was 170 head (i.e. one truckload). Thus, there were always multiple truckloads for the last batch.

The optimal return/day/barn ranged from \$230 to \$302 under the assumed average economic conditions (Table 5). Because the SEW gilts are relatively lean, the returns were higher with higher lean to fat price ratios. Numbers of underweight carcasses were calculated to be from 41 to 75 head, with the highest number associated with scheme 4 and lowest number with scheme 1. The numbers of overweight carcasses ranged from 42 to 92 head with the highest number belonging to payment scheme 1 and lowest to scheme 4. The amount of sort loss received were $938, $1327, $774, $929 under payment schemes 1 to 4, respectively.

Table 5. Predicted optimal return and management for SEW gilts with control diets (1000 head/barn).

Payment system	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Return, $/barn-day	230.19	258.45	287.06	301.81
%lysine in diet 1	0.80	0.83	0.82	0.82
%lysine in diet 2	0.74	0.76	0.75	0.75
%lysine in diet 3	0.64	0.67	0.67	0.67
Diet 2 start day	114	115	114	117
Diet 3 start day	128	130	129	131
Marketing age for 1st batch, d	155	153	153	153
Marketing age for 2nd batch, d	161	159	159	159
Marketing age for 3rd batch, d	165	163	164	162
Marketing age for 4th batch, d	166	-	-	-
Avg. slaughter age, day	163.1	160.6	161.3	160.0
Sort weight, lbs	271	268	268	268
Under-weight carcasses, head	41	68	59	75
Sort loss from under-weight, $/barn	299.14	708.24	432.54	600.03
Over-weight carcass, head	92	46	45	42
Sort loss from over-weight, $/barn	638.99	618.73	341.70	328.92

Swine producers often face a fixed schedule for barn closeout, either due to a contracted date for delivering market hogs or the arrival of a new group of feeder pigs. With a fixed schedule, producers have to adjust their management strategies in order to shift the growth rate of the animals and raise the hogs to the packer's desired weight range. The alternative fixed schedule environments were simulated as restricted marketing dates for the last batch of pigs. Fixed schedules investigated here ranged from day 137 to 177, with a step size of 4 days. The optimal return and management of control pigs are displayed in Table 6, where day 164 yielded the highest average daily return. Thus, the restricted marketing days before day 164 were tight schedules and those after were loose schedules. When pigs were marketed at their optimal weight or age, the number of underweight and overweight pigs was both small, close to 7-8%. However, in tight or loose schedules, either the underweight or the overweight pigs were higher than the optimal level. The total amount of sort loss was the least when there was no fixed schedule restriction.

Table 6. Optimal marketing management for fixed schedules (SEW gilts without Paylean and marketed under payment scheme 3; 1,000 head/group).

Fixed schedule day [a]	137	141	145	149	153	157	161	165	169	173	177
Return, $/barn,day	47.05	131.93	178.52	238.58	266.05	279.78	286.43	286.74	282.93	277.95	271.48
Marketing batches	1	1	1	1	1	2	3	4	4	5	5
Sort weight, lbs	-	-	-	-	-	269	269	269	271	271	271
Avg. slaughter wt, lbs	220	228	235	243	251	257	263	268	272	274	276
% underweight carcasses	90.4%	78.0%	62.9%	44.4%	27.8%	16.1%	9.2%	4.5%	2.6%	1.4%	0.7%
% overweight carcasses	0.1%	0.1%	0.5%	1.2%	3.0%	3.2%	3.9%	4.8%	9.7%	10.7%	13.0%
Sort loss due to under-weight carcasses ($/1,000 head)	21,039	14,303	9,302	5,383	2,874	1551	710	342	211	109	59
Sort loss due to over-weight carcasses ($/1,000 head)	10	31	47	101	284	291	319	353	702	720	907

MODELING RACTOPAMINE USE

Nearly 50% of all U.S. grow-finish pigs are now being fed ractopamine (Paylean^{TM}) prior to market. The management of pig production with Paylean was investigated for a group of pigs using a stochastic growth model. This stochastic model was used to derive the optimal production and marketing decisions for grow-finish swine production with Paylean, which include both dietary lysine management and Paylean management (Li et al., 2001 a, b, c). To summarize, the variables to be optimized in the model were dietary lysine concentrations for three diets, the optimal starting days for diets 2 and 3, six optimal marketing days for each truckload, and an optimal sort weight.

The stochastic model indicated that pigs fed Paylean should be marketed at younger ages (5-7 days) than pigs without Paylean, as well as marketed in less batches. The returns were higher for the Paylean-fed pigs than for control pigs (Table 7).

Paylean had higher economic returns under tight marketing schedules than when pigs were marketed under the optimal marketing age or under loose schedules. With extremely tight schedules, the dietary concentration of Paylean should be increased to 13.2 ppm, while with loose schedules, the Paylean concentration should be decreased to 5.0 ppm. Under all fixed environments examined, Paylean fed pigs produced a higher return than control pigs.

MODELING NUTRIENT EXCRETION AS PART OF THE PORK PRODUCTION SYSTEM

Some new technologies provide opportunities for pork producers to mitigate some of the regulatory constraints for application of manure on a limited land base (Prince et al., 2000; Allee et al., 2001; Sutton et al., 2001). The inclusion of phytase in a swine diet greatly reduces the amount of dicalcium phosphate required in the diet and the pig utilizes much of the P that would normally have been excreted. Similarly, the cost of synthetic amino acids has declined, and their availability has increased which is an avenue to reduce N excretion in manure.

Howard (1999) developed a model for whole farm profit maximization. The model allows choice of diet composition, use of phytase, synthetic amino acids, manure disposal as well as crop mix. The model addressed the interactions between manure disposal regulations, pig diet and crop production decisions allowing the farm to mitigate some of the compliance cost while retaining the constraint on availability of resources between crop and livestock production at crucial times of the production cycles.

Yap et al. (2004) further developed the model of Howard to specifically investigate the economic impacts of a phosphorus land application policy. The impact depended primarily on the degree to which the farm was constrained in land suitable for P application, application alternatives, and the use of alternative diets. For example, for a 1500 acre crop farm with capacity to raise 12,000 grow-finish hogs per year, the cost of compliance with the phosphorus policy was as low as $0.56 per pig space but if custom application and alternative diets were not available to the farm the estimated compliance cost was $21.74 per pig space. Phytase diets and diets with synthetic amino acids were optimal under various scenarios in all three (Howard, 1999; Yap et al, 2004 and Echarnier, 2003) studies.

Table 7. Predicted Optimal Return and Management for SEW Gilts with ractopamine (RAC; 1000 head/barn).

Payment system	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Return, $/barn-day	245.60	281.89	314.96	346.65
RAC, g/ton	4.5	5.0	5.9	8.6
%lysine in diet 1	0.77	0.83	0.79	0.82
%lysine in diet 2	0.91	0.97	0.95	1.01
%lysine in diet 3	0.79	0.81	0.79	0.83
Diet 2 and Paylean start day	134	129	128	125
Diet 3 start day	146	144	144	141
Marketing age for 1st batch, d	152	152	152	149
Marketing age for 2nd batch, d	158	157	157	155
Marketing age for 3rd batch, d	160	-	-	-
Sort weight, lbs	271	271	271	266
Avg. slaughter age, day	158.3	156.2	156.2	154.0
Avg. days on RAC	24.3	27.2	28.2	29.0
Days on RAC (last batch)	26	28	29	30
Return over control, $/pig [a]	1.77	2.62	3.12	4.93
Under-weight carcasses, head	45	73	75	98
Sort loss from under-weight, $/barn	355.60	676.55	578.08	1164.42
Over-weight carcass, head	118	104	108	55
Sort loss from over-weight, $/barn	717.28	1291.08	833.74	498.77

[a] Return over control is calculated as the daily return of RAC-treated pigs minus that for control pigs under the same payment scheme, then the difference is multiplied by the number of days on feed for RAC pigs from a feeder pig of 50 days of age.

In recent research (DeCamp, et. al., 2001; Hankins, et al., 2001), pigs fed a 16.1% CP-ractopamine diet (18 g/ton) excreted 14.9% less total N compared to the 13.8% CP diet. A majority of the N reduction was from reduced urinary N excretion. In a 30-d feeding period and 4 less days to market, N excretion would be reduced 206 g per pig marketed. Slurry pH was reduced 0.5 units and ammonia was reduced 8-21% from pigs fed ractopamine. Of the limited research studies completed, ractopamine decreased N excretion, decreased manure output and could result in additional environmental benefits that have not been thoroughly investigated under practical situations (Sutton et al., 2001).

FUTURE OF PIG GROWTH MODELING AND PRODUCTION SYSTEMS ANALYSES

Additional development of models to evaluate the alternatives of manure treatment systems, feeding technologies and management technologies on lean growth requirements of genetic lines of pigs, nutrient excretion, and balance of nutrients in the operation is essential for profitable pork production that is compatible with environmental sustainability. A holistic economic model to determine the critical control points and factors influencing profitability, costs, nutrient flows and pollution potential is needed. This data can be used by producers, technology providers, educators and regulators to implement new technologies and develop effective regulatory policies for sustainable environment and profitable animal agriculture.

CONCLUSIONS

The most profitable production of pigs for the pork processors demand for uniform products requires several items to be evaluated. The current economic objective for pork producers is to maximize daily returns above feed and other variable costs. The management of the pigs including health status and other stressors, the feeding program, the marketing strategy and use of Paylean must all be evaluated. In the future, the costs and benefits of alternative diets, nutrient excretion, alternative manure handling systems and nutrient utilization by plants will also need to be evaluated. Systems analyses of pork production and nutrient excretion which combine pig growth models and economic optimization will be increasingly used by the pork industry.

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BREAK-OUT SESSIONS

INVESTIGATIONS INTO OPTIMAL WASHING AND DISINFECTION TECHNIQUES FOR PIG PENS

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Washing of pens or barns is a routine part of pig production. The reasons are numerous, but the main one is that washing removes bacteria, viruses and parasites left behind from the previous batch of pigs. Most diseases are dose dependent; meaning, the more pathogens pigs are exposed to, the sicker they will get. Washing the pens reduces the number of disease causing organisms and so the animals grow better and are healthier. In Table 1 below are the survival times of some common pig pathogens. The length of survival is dependent on degree of initial contamination, protection by organic matter and exposure to drying and sunlight (Hurnik, 1997). Generally, warm temperatures, drying and sunlight will kill pathogens, and moisture, darkness and cold (especially freezing) will preserve them.

Table 1. Survival times of common pig pathogens.

Agent	Survival in Environment
Mycoplasma Hyopneumoniae	Up to 7 days in organic matter
Actinobacillus Pleuropneumoniae	Few days in organic matter
Bordetella Bronchoseptica	
Pasteurella Multocida	8 days in water 6 days in liquid manure
Hemophilus parasuis	Short
Streptococcus suis	25 days @ 9 ^{o}C 100 days @ 0 ^{o}C
Salmonella sp	Years in manure, 115 days water 120 days in soil
Serpulina Hyodysenteriae	61 days @ 5 ^{o}C 7 days @ 25 ^{o}C
Lawsonia intracellularis	?
E coli	11 weeks in manure
PRRSv	3 weeks in organic matter 11 days in water
Pseudorabies virus	18 days on steel, manure 2 days, urine 14 days, well water 7 days,
TGE/PRCV	Low summer, stable when frozen
Influenza virus	24 - 48 hours
Ascaris suum	Years

Cleaning and disinfection, while critical to disease prevention, have not been given as much analysis as they could. Of all the chemicals used inside pig buildings, disinfectants are probably the most potentially hazardous. Listed below are the common disinfectants used in pig production and their characteristics (Table 2).

Table 2. Properties of common disinfectants (Linton et al., 1987).

Disinfectant	Range of Activity	Toxicity
Acids	Bacterial spores, vegetative cells, some viruses	Corrosive
Formaldahyde/ Gluteraldehyde	Bacterial spores, vegetative cells, viruses, fungi, acid-fast bacteria	Potential carcinogen
Iodines	Bacterial spores, vegetative cells, viruses, fungi, acid-fast bacteria	-
Chlorines	Bacterial spores, vegetative cells, viruses, fungi, acid-fast bacteria	-
Hydrogen Peroxide	Vegetative cells, some viruses	_
Phenols, cresols	Vegetative cells, fungi, acid-fast bacteria, some enveloped viruses	Accumulates in body, neurotoxic
Quaternary Ammoniums	Vegetative cells, Gram positive bacteria, fungi, acid-fast bacteria, enveloped viruses	Non-toxic

Disinfectants may be sold in combinations and sometimes with soaps which will improve their activity. It is critical to follow directions and safety warnings. Some disinfectants such as chlorines may react with other disinfectants, and should not be mixed. This paper will present findings from some trials we have done to evaluate washing and disinfection methods.

Cleaning of a barn is of critical importance as no disinfectant will work in an unwashed barn. Hot water pressure washers offer the use of hot water for washing which has the potential of cleaning more efficiently, however they are more expensive and require more energy and maintenance. Presoaking the pens is used by some producers to help with the washing process which increases the washing time and may increase the water requirements. The use of soap is suggested because it breaks down the biofilm and waxy residues which water alone will not remove (www.cqa-aqc.ca/downloads/producer_manual/PMD3eng.pdf). This paper will describe washing pig pens in a commercial finishing barn and compare the use of hot water to cold, presoaking the pens prior to pressure washing, and the use of soap under Canadian conditions with the aim of providing information to make washing a more efficient process.

EXPERIMENTAL DESIGN

20 pens were washed alternating hot water, cold water or a soap and the study was repeated with all the pens presoaked with water before beginning the washing process. All pens were of equal size (9’x22’) fully slatted with one two space wet-dry feeder in each pen. All the pens were dirty from the previous fill of pigs and required washing and disinfection prior to

placement of the next group of pigs. The time required to wash each pen was recorded. Once the pens were washed and allowed to dry one of two disinfectants was applied and compared to four pens which were washed only. The cleanliness was measured with a commercial sanitizing test kit (www.millipore.com/catalogue.nsf/docs/MTSK10025).

The pens were filled with 9 week old feeder pigs from one source and placed on a common diet. All pigs were weighed on entry (9 weeks of age) and on marketing.

RESULTS

Table 3. Average wash time per pen with varied washing protocols.

WASH PROCEDURE	Time to wash pen (minutes)	Difference (Minutes)	Time Savings %
Cold Water No Soap No Presoak	68.03	0	0
Cold Water Soap	59.80	-8.23	12.1
Cold Water Presoak	41.39	-26.64	39.1
Cold Water Presoak Soap	36.38	-31.65	46.5
Hot Water No Soap No Presoak	52.61	-15.42	22.6
Hot water Soap	46.24	-21.79	32.0
Hot Water Presoak	32.01	-36.02	52.9
Hot water Presoak Soap	36.81	-31.22	45.9

Table 4. Bacterial swab counts after washing and disinfection.

Disinfectant	Number of bacterial colonies per swab
None	28.4^{a}
Disinfectant 1 Hydrogen Peroxide	13.2^{b}
Disinfectant 2 Quaternary Ammonium	$19.6^{a,b}$

Table 5. Pig growth rate.

Washing Method	Days to Market 25 kg to 110 kg
No Disinfectant	98.14 [a]
Disinfectant 1	95.40 [b]
Disinfectant 2	95.11 [b]
Soap Only	95.59 [b]
Soap and Disinfectant 1	92.96[c]
Soap and Disinfectant 2	92.66[c]

DISCUSSION AND CONCLUSIONS

Overall, the use of hot water decreased washing time about 22%, except in the case of presoaked pens where there was no decrease in wash time compared to cold water. Also, while hot water was more comfortable to apply, it created a fog that made it harder to see. Presoaking the pens with water to loosen manure appeared to cut washing time almost in half. The use of a soap decreased washing time about 8 minutes a pen (about 12%).

The use of Disinfectant number 1, a Hydrogen Peroxide based product, was able to reduce bacterial load of the pens compared to undisinfected pens. This indicates that to complete the washing process, certainly the use of a disinfectant is beneficial. There may be some variation due to choice of disinfectant.

The use of hot water had no effect on growth rate, but both disinfectants and the use of soap did. While the use of soap did not appear to lower bacterial counts, it did improve the performance of the pigs. The sanitation swab test kits measure only some bacteria, and would not detect difference in viral load or detect difficult bacteria to grow such as *Lawsonia intracellularis* which have a known effect on pig growth and efficiency.

Soap acts like a degreaser, and looses dirt and dissolves the waxy biofilm that can coat pen floors and walls. The biofilm can protect bacteria and viruses from washing and disinfection. The biofilm can be hard to remove except with a soap, which helps dissolve it.

It appears that washing and disinfection protocols can have a significant impact on productivity. Where possible, producers can evaluate their washing methods to see if they can be optimized.

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CHOOSING THE RIGHT CLEANING AND DISINFECTION PROGRAM FOR YOUR OPERATION

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Virtually all producers include power washing and disinfecting as part of their routine pork production practices. Despite the fact that this is a common activity, most have given little thought to why they do it or whether the method that they use is the most effective for them.

Why do we do it? It is clearly recognized that disease in pigs can come from the previous groups of pigs occupying that space. What is less often recognized is that there are costs to having the new pigs mount an immune response to the pathogens left by the previous pigs, even if no signs of disease are seen. The immune response requires energy and protein. The results of mounting that immune response are decreased growth rate and more uneven growth rate between pigs within the pen. Given that we are going to clean and disinfect, what are the options for doing the job?

OPTIONS FOR DOING THE JOB

Doing It Yourself

Using Dr. Hurnik's data, let's work through the cost of washing a 1000-head finishing barn with 40 pens. We can compare the cost of using similar hot and cold water washing systems and presoaking the barn first. The average finishing barn would be washed three times per year.

	Hot		Cold		Net
Time (hrs)	21.33		27.60		
Time (min)	1278 min		1656 min		
Cost ($)	$14.00/hr	$299		$386	
Water Used	3 Gal. /min = 3834 gal		3 gal. /min = 4968 gal		
Manure/Water Removal Cost	1 ¢/gal	$38	1 ¢/gal	$50	
Disinfecting	16,400 sq. ft.	$21		$21	
Capital Cost of Machine (10 yr life)	$8500	$284	$5000	$167	
Operating - Repairs & Maintenance		$43		$20	
Cost/Pig Space/Batch		$0.685		$0.644	

Hiring a Custom Operator

The cost of hiring a custom washer varies with the operator but for 2004 it averaged $40 per hour per man. They typically supply the equipment, disinfectant and use hot water. It is to the barn operator's advantage to presoak and clean up major debris and empty the feeders. Using Dr. Hurnik's figures the cost to have a 40 pen (1000 head) finishing barn washed would be $1280 plus disposal of the manure water generated ($38) for $1.32/pig place.

CHOOSING CLEANERS AND DISINFECTANTS*

Which cleaner or disinfectant is right for your operation? The answer to that question will depend on the goals of your cleaning program and the constraints of things like water pH.

- Organic Matter Removal: Regardless of what specific organism you are looking at controlling, the first and most important step is to remove all evidence of organic matter. Start with a physical clean up of the area as soon as the animals are removed. Empty feeders and remove large amounts of feces. Presoak. The presoaking is most effective if the ventilation system for that area is shut off or reduced to a minimum during a 6 – 12 hour presoaking period. This aids in retaining moisture in the room or building and softening the residue left. Restart the ventilation system when you begin to power wash.
- Select a disinfectant appropriate to the organisms that you are looking to control and the physical conditions that you are working in.
- Calculate the correct amount of disinfectant to apply. The product monolog on the package will indicate the area that a certain amount of disinfectant is meant to cover. Calculating the surface area of the barn is fairly simple. Assume pen partitions and equipment are solid surfaces and add that area to the surface area of the floors, ceiling and walls. This will allow you to calculate the amount of product to apply to each room or barn. The product can be mixed in a fixed amount of water and sucked through the pressure washer with a venturi apparatus. Most products are most effectively applied through a low-pressure wand on the power washer.
- Provide protective clothing, etc. to the operator. Apply the disinfectant and allow it to dry.
- Plan to use a biofilm removal agent at least once per year, especially if your water is hard or very alkaline.

* This list may not be complete

Class of Compound	Trade Name/Manufacturer	Description and Comments
Chlorine Based	Dettol – Reckitt & Coleman Canada Ltd Hibitane – Ayerst Savlon – Ayerst	Disinfectant for bacteria & fungi - Work best at pH 6 – 8, poor residual activity, and poor if organic debris present
Quaternary Ammonium	Ascend –Huntington Labs. Biosentry 904 – Pfizer	Germicide, fungicide, detergent - As a group, work best on Gram + bacteria with some activity on viruses, fungi and Gram -. Effective at pH 6 - 8, hard water reduces speed of kill, some activity in the presence of organic debris, some residual activity
Aldehydes	Fumalyse – Bio Agri Mix Profilm- Pfizer	Disinfectant, germicide, fungicide, virucide, vapour phase. - Kills wide range of organisms, effective at wide pH range, not affected by hard water, active with organic debris, residual activity
Phenol	Beaucoup – Ecolab Creolin – Stella Pharmaceutical Multi Phenolic Disinfectant - Bio Agri Mix 1 Stroke Environ Prosovet – Pfizer	Germicidal disinfectant - Good bactericide, but poorer on other organisms, effective at alkaline pH, not affected by hard water, active with organic debris, residual activity
Iodine based	Betadine Providine	Most common as skin or equipment sanitizers. - Wide range of organisms killed, effective at acid pH, not affected by hard water, not active if organic debris, some residual activity
Oxidizing Agents	Synergize - Preserve International Virkon – Dispar	- Glutaraldehyde and quaternary ammonium combined – combines properties of aldehydes & quats. - Wide range of organisms killed, effective at wide pH range, not affected by hard water
Biofilm Removing Agents	Acid – A-Foam – Pfizer Wipe Out – Ecolab	- Acid cleaner to remove biofilm (biological material trapped in hard water scale) - Degreaser, to aid in biofilm removal

MAKING CHANGES TO GET TO 30 PIGS/SOW/YEAR

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INTRODUCTION

This article will discuss the changes that can be made in an existing production operation to help move the farm closer to reaching the goal of 30 pigs weaned/sow/year (PSY). Although there are several areas integral in reaching this goal, this paper will discuss and expand upon four areas that producers can change with greater ease and includes: gilt management procedures, estrus detection and AI, and management of the breeding herd during gestation, farrowing and lactation.

GILT MANAGEMENT

The period of time from gilt selection until entry into the herd influences immediate and even lifetime performance. It has been suggested that gilts should have *ad libitum* access to feed during development. From 130 days until expression of pubertal estrus, feed gilts a standard grow-finish diet that provides at least 14.2 MJ of DE/kg of feed, and which contains 0.72% lysine. Gilts should be limit fed beginning at 240 pounds to prevent excessive body weight at service. Once gilts reach puberty, they should be maintained on limited feeding until flushing. Flush feeding provides a 200% energy increase through increased feed in the 10 days before estrus. The flushing procedure increases the number of eggs ovulated by two to three at estrus and improves the chances for larger litter size. Gilts should have both adequate muscle and backfat at the time of mating. Once gilts are serviced, it is important to limit feed them in the following two weeks to prevent decreases in progesterone, and increases in embryonic loss as a result of increased gut activity clearing progesterone from circulation.

Attempt to mate gilts between 210 and 250 days of age. At this time they should weigh between 270 and 345 pounds. At this age and weight, litter size is maximized. Mating gilts at ages younger and older than this and at weights lighter and heavier may cause slight or even dramatic decreases in litter size. However, despite the focus on litter size, it is important to remember that lifetime pig production increases as breeding weight increases from 220 to 280 pounds with some evidence to support shorter longevity when first mating occurs at heavier weights. Another important aspect of gilt development involves the amount of backfat at time of mating. Target gilts for mating at 0.7-0.8 mm of backfat. They can be expected to weigh approximately 260 to 310 pounds at these backfat levels. In the development of fat stores, backfat measurements increase from 12 mm at 200 pounds near the time of selection, to 13 mm at the time of onset of puberty when gilts commonly weigh 240 pounds. After onset of first estrus, backfat increases dramatically and by the time gilts reach 280 pounds, they should have nearly 18 mm of fat at the P-2 site. One exception to this pattern of growth may involve fast growing gilts, some of which may exceed the targeted weight. In this case, feed restriction may be necessary or the diet should be altered to provide less energy.

One essential aspect of gilt development is the controlled exposure to a mature boar in order to induce fertility, advance breeding age, and to synchronize estrus in the replacement gilts. The induction of early puberty and ensuing early mating appears related to improved longevity and lifetime productivity. Boar exposure can be initiated as early as 140 days and as late as 200 days of age. The choice for when to expose gilts may depend upon the location of the gilts, the space available, and the labor. Early exposure will be expected to advance age of puberty but will spread the synchrony of the exposed group over a much longer period of time. This may or may not have any beneficial or detrimental effect. In contrast, boar exposure at later stages has the advantage of still advancing age at puberty and providing greater synchrony for the exposed group. This occurs because the stimuli occurs closer to the time of natural puberty for more of the gilts. Regardless of the age of exposure, boar exposure itself improves the percentage of females that cycle before 240 days of age when compared to no boar exposure at all. However, age of exposure may not influence the overall percentage that become cyclic by 240 days of age. In light of this fact, the age at exposure becomes the prerogative of the farm management system.

Consideration should be given to the choice of boar for induction of early puberty. Factors which can advance the age of puberty include having boars at least 11 months of age and that are active in vocalization. Each of these measures has the potential to advance puberty more than 10 to 20 days. Avoid having gilts in groups of more than 40 and fewer than four. Physical or fenceline exposure are both desirable, but physical exposure has been observed to have a more potent effect on advancing age of puberty.

ESTRUS DETECTION AND AI MANAGEMENT

The key to getting to 30 PSY must center on methods that can improve estrus expression and detection. Some advocate continuous boar contact for cyclic gilts and weaned sows for advancing estrus and ensuring fertility. However, although this practice may have some beneficial effects on fertility, it can also prevent estrus detection, since pigs exhibit refractory behavior from excessive exposure to the boar. Refractory behavior occurs when estrous females are near boars for extended periods or are able to detect their pheromones or vocalizations from close housing. The female's ability to detect the boar stimuli elicits the standing behavior, but this behavior usually only lasts 10 to 15 minutes before refractory behavior occurs, and the female will not stand for the same stimulus. Thereafter, many estrous females will not stand for a period of at least 2 hours. The essential requirement then, is to ensure that boars are absent from the estrous females at least for 2 hours prior to detection of estrus.

When the objective is to determine the onset of estrus accurately, it should be noted that the efficiency of estrus detection is greatly improved when the boar can be seen, smelled, is vocal, and physical stimuli such as back pressure and side rubbing are provided from the boar itself or from humans. The female's estrus response is most effectively elicited in situations that allow boar odor, sound, sight, and physical contact to be maximized. This can be facilitated by good lighting, short distances between the boar and the sow, reduced ventilation during this period, and low noise levels.

Accurate detection for onset of estrus is especially important across days. The sensitivity of estrus detection may be a factor that has been overlooked as a method for improving the timing of insemination for impacting both farrowing rate and litter size. Too much, or too little sensitivity may alter the accuracy of estrus onset and AI timing. Too much sensitivity can occur as a result of increasing the amount of boar stimulation on one day compared to another. Some examples of this occur in cases where the number of boars used for detection changes from day to day, the age of the boar used on different days differs by age of maturity, and the duration of exposure or frequency of contact within a day changes across days. Too little sensitivity can be caused by continuous boar contact, too short an interval between the last boar exposure event, or housing boars too close to the females to be checked so that they are refractory as a result of over exposure to the sounds and smells of the boar. Estrus detection should occur once or twice daily using the same method, time of day, and duration of exposure each day. Since there is inherent error in the accuracy for onset of estrus with detection performed at 12 to 24 hour intervals, it is important to maintain the same intervals and perform the check at the same time each day to provide for the needed level of accuracy. This should also involve the weekend labor since weekend labor limitations and skill levels often differ from the full time weekday laborers. A reminder should be noted in that the symptoms of estrus are not the same as the standing estrus response. For example, vulval swelling and mucus discharge are not accurate indicators for onset of estrus when compared to the rigid stance under full weight of either man or boar. It is often important to remind the breeding herd personnel that application of physical stimuli to the females is important and should involve rubbing on the sides and back of the sow, and in some cases may require full human weight on their back. The clear symptoms of estrus that should be used to determine time of mating should include that a standing female does not vocalize, becomes rigid under weight, and may show some evidence of ear reflexes regardless of whether ears are lop or erect in structure.

Twice daily detection can improve AI timing. AI can occur at 12 or 24 hour intervals using an am/am, pm/pm, or pm/am system. The timing of the insemination should be placed to make sure that semen is in the reproductive tract anywhere from 4 to 24 hours before ovulation. Producers should ensure that at least two inseminations occur at 12 to 24 hour intervals during the time the sow is standing. Too many single serviced females indicate a problem in estrus detection or AI timing. Two inseminations for each sow is the standard recommendation due to cost of semen, labor, and limited increases in farrowing rate and litter size. However, there is some evidence to suggest three and even four inseminations given during the standing period can slightly increase both measures. More inseminations may not be cost justified in some operations but could be beneficial in others.

It is important to practice and promote hygiene when performing AI, since unsanitary conditions at AI can introduce bacteria into the uterus and may contribute to poor sperm reservoir establishment, uterine infections, and pregnancy failure. The presence of the boar at the time of mating is desirable for inducing the standing response, for reducing leakage at insemination, and for enhancing semen uptake and transport. Insemination should be performed using either natural uptake as a result of the uterine contractions of the sow and gravity flow, or through application of mild pressure and some gravity flow. In most cases, inseminations typically require between 2.5 to 4 minutes to get 80 mL of extended semen to be deposited. Many producers suggest leaving the catheter locked into the cervix and bent to prevent backflow for a period of 5 to 10 minutes following semen deposition. This procedure may be beneficial to prevent immediate backflow out of the cervix and uterus as a result of high levels of stimulation and uterine contractions as a result of the fluid within the uterus, the hormones released from stimulation by the boar, and resulting from oxytocin release from the side and back-rubbing during insemination. Most AI procedures today involve the deposition of 2.5 to 3 billion sperm cells in extenders that may be classified as short, intermediate or even long-term. Yet most semen is used within 96 hours from collection. The semen is deposited into the cervix and uterine body using a conventional foam-tip or spiral-tipped AI catheter. Leakage at the time of AI typically averages 10 to 20% of the total volume, but this loss probably has little impact on fertility. However any leakage indicates that catheter positioning, lock, or sow stimulation technique could be improved. It appears that by four hours following AI, nearly half of the sperm are lost in backflow as the uterus eliminates the less fertile sperm cells not transported to the reservoir. This elimination of infertile sperm is important to allow the uterus to prepare for pregnancy.

The goal for high pregnancy rates and large litter sizes has been to ensure that inseminations occur within 24 hours before the time of ovulation. Since this time period is not known to the producer, multiple inseminations are performed to ensure that at least one AI hits the targeted window. The detection for onset of estrus can be underestimated by as much as 12 to 24 hours depending upon the time interval between estrus detection. In fact, in this scenario, it is not the first, but the second AI that typically hits the targeted window 75% of the time. The reason for this is that most AI procedures are based on AI occurring at 24 hour intervals. Since estrus lasts on average 52 hours in sows, and ovulation occurs at 42 to 44 hours after onset of estrus, inseminations are timed to occur at 0 to 12 and 24 to 36 hours from onset of estrus. From the time of insemination, the sperm require a 2 to 4 hour time period in the uterus to become capacitated and able to fertilize an egg. So it is of utmost importance for sperm to be inseminated ahead of the time of ovulation. The ovulated eggs that are fertilized show the highest rate of embryo development and quality when they are fertilized by sperm within the 8 hour period from the time they are ovulated. Avoid late inseminations, and remember that sows will remain standing for 12 to 18 hours after ovulation has occurred. Late inseminations are undesirable and may do more harm than good, since they may facilitate embryo loss and uterine infection. This can sometimes be a contributing factor in cases of low litter size and discharges at 21 days post-mating. Lastly, it should be noted that not all sows and gilts will have the same estrus to ovulation intervals. The interval from onset of estrus is variable for gilts and sows and is influenced by the interval from weaning to estrus and is highly related to the duration of estrus. Most females will ovulate at 60 to 75% of the way through the duration of the standing estrus period. If twice daily estrus detection is performed, even temporarily, it can be used to help improve and help pin-point time of ovulation and improved AI timing. For example, sows that return to estrus soon after weaning on day 3 or 4, frequently have longer durations of estrus and longer estrus to ovulation intervals, while those returning to estrus on days 5 and 6 tend to have much shorter durations of estrus and shorter intervals from estrus to ovulation. AI timing can be much more precise for either of these groups with this knowledge in hand.

GESTATION MANAGEMENT

Ensuring mated sows establish and maintain pregnancy and maintain and maximize embryos and fetuses to challenge the limitations of uterine capacity is a primary goal of gestation management. A related, but somewhat distant, goal involves optimizing body condition of the sow during gestation. This aspect is of great importance since it ultimately controls performance of the sow at farrowing, lactation, and the rebreeding period. Therefore the control of sow gestation weight gain and body condition becomes a critical control point. This level of body condition control is often only possible in some type of individual or electronic feed management system. In many situations, a body condition score (BCS) can be used to classify sows and can be practical and useful for adjusting sow weight gain and body condition during gestation. The body condition score has been shown to be relatively accurate for estimating the level of P-2 backfat. For example, a BCS of 2 estimates the sow has about 16 mm of backfat, a BCS of 3 has 19 mm, and a BCS of 4 has 22 mm. With a good and consistent assessment for either backfat or BCS, the targeted backfat level can meet the expected increase to >20 mm at the time of first farrowing for gilts and can near, meet or exceed this level in older sows. Gilts and parity one sows are expected to gain 80 to 100 pounds during gestation. Older sows on the other hand should only gain 55 pounds during gestation as their lactation appetites are expected to be greater and their loss of muscle and fat lower during lactation. Yet while weight gain is important, excessive weight gain and over-conditioning can cause problems in the form of dystocia, stillborns, and reduced lactation feed consumption. For example, sows that consume an average of 4.5 lb of feed during gestation will have greater longevity when compared to sows that consume 5.5 lb of feed during gestation. This is predominantly related to lower feed intake during lactation and loss of body weight. For weight gain and increased feed intake, make sure this occurs during the third to eighth week of gestation and not any earlier or later.

Controlling non-productive days is a necessity for management for a variety of reasons. From the time of animal breeding, sows that fail to conceive must be identified as quickly as possible to rebreed or cull. Check sows once daily using a mature boar at 18 to 24 days. Rebreed first time returns at estrus. Most sows that fail to conceive will return to estrus in weeks 3 and 4. Some will also return during weeks 5 and 6 post-mating. If ultrasound is available perform as soon as possible. For real-time ultrasound, perform at 26 to 35 days. Avoid culling sows based on an open diagnosis for ultrasound performed at 24 days and earlier, since fluid may be limiting even in pregnant females. Also avoid culling based on an open diagnosis with real-time ultrasound performed between days 39-50, as in this stage, in pregnant females, the fetus grow at the same time that fluid volumes are reduced. This is important because fluid visualization is the display parameter that we use to distinguish between open and pregnant sows when using real-time ultrasound.

FARROWING AND LACTATION MANAGEMENT

Farrowing management is one of the keys for 30 PSY. This involves ensuring that pigs that are healthy and fully formed are born alive and stay alive during the first three days after farrowing. Almost all production operations have stillborns in the 5 to 10% range. When stillborns are above 5%, it is possible to reduce this loss by attending farrowings and by expending more efforts in preparation and through observation and intervention during the farrowing process. In most cases, attended farrowing and intervention can save 0.5 to 1.0 additional pigs/sow/year.

To prevent or minimize losses of liveborn pigs during the first three days following birth, management techniques must concentrate on prevention of the major reasons for piglet losses, chilling and inadequate energy intake, both of which predispose pigs to crushing. Oxytocin administration is one method used to stimulate milk letdown after farrowing to ensure piglets will have an adequate supply of energy through milk. Some also suggest that if pigs are confined to a creep area for one hour post farrowing, they can effectively be warmed and dried. In large litters that exceed 12 pigs born alive, the smaller pigs of the litter can get a jump start by being allowed to nurse for one hour before the remaining larger pigs of the litter. The fact that most of the pigs lost, are lost in the first three days due to crushing and trauma due to the sow is mostly preventable. These injuries increase as the piglets become chilled and the sow becomes over heated. These situations are easily rectified with properly placed heat lamps and heat mats that warm the pigs but not the sow. The room temperature should be controlled to meet optimal sow comfort. The use of heat lamps and mats prevent piglets from climbing on and under the sow to find warmth. A cool room is optimal for sow comfort and eliminates the sow getting up and down too frequently when she is too hot. Milk supplement can also be provided during days 3 to 10 and can be very effective for aiding piglet survival, energy intake, and growth, especially in large litters. However, care and attention must be paid to ensure milk is fresh and clean. From day 10 until weaning, pigs can be provided creep feed. This is clearly beneficial in helping pigs adjust to dry feed when weaned, and for increasing growth and weaning weight. Additional measures that can help to ensure that adequate energy is available for pigs during lactation and for the sow at weaning include the practice of feeding sows at least three times each day in order to maximize sow feed intake.

In some Danish production systems that are close to 30 PSY, they ensure gilt rebreeding and longevity by successfully extending the nursing period. In this system, gilts are weaned at 20 days and are then given piglets that are 5 to 7 days old. The gilt will then nurse an additional 12 to 15 days to allow them additional time for uterine repair. The sow providing the 5 to 7 day old pigs will then receive the extra pigs from other large litters and will typically nurse for 25 to 27 days before they are weaned. Caution should be used when cross-fostering pigs due to disease, regrouping stress, and establishment of new group hierarchy. Movement of pigs should be performed with whole litters where possible, since improper timing and procedures may cause lower growth rates and even reduced survival.

PERSONNEL

The last element in making changes toward 30 PSY involves the production staff. How should employees be selected? Consider their interests, skills, strengths, and willingness to learn and develop. Try to select those who are reliable. These are people who agree to a task and they perform that duty as they were trained to do. Get those who are careful and pay close attention to detail and ask when uncertain. This prevents frequent and repeated mistakes. Select those with initiative who try to improve on existing problems and situations when they recognize an opportunity. Successful team members have confidence in their skills and know they can do the task. They also take an active interest in learning about their area of work and what other factors may impact their performance. Investing effort and time to get professional pig production staff requires training and development of people. Helping employees realize their importance and their impact to the success of the business, their fellow workers, and the animals themselves, is a foundation for long-term success. Help build interest and excitement through sharing knowledge, expertise, taking an interest in people, and their performance, and sharing with them how they also can benefit from improved performance. These people will have immeasurable impact on areas of gilt management, estrus and AI, sow management in gestation, farrowing and lactation, to help move producers closer toward their goal of 30 PSY.

GETTING TO 30 PIGS/SOW/YEAR

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Bearing in mind the physiological limitations discussed in our earlier paper, gilt development programs can be refined to match the individual needs of the producer (i.e. "in house" or outside source), to identify the potential fertility of the gilt and provide opportunities to improve fertility and retention through gilt "conditioning" and pre-breeding management. Three key aspects of a good gilt management program should include:

1. Implementing a strict selection program that identifies 75-80% of the most fertile animals.
2. Achieving appropriate weights at first breeding to sustain maximum lifetime performance. A minimum body weight after farrowing of 175 kg (135 kg at breeding) may be necessary to protect against excessive loss of protein mass in first lactation.
3. Minimizing accumulated non-productive days (NPD) in the gilt pool. Low growth rate, unnecessary delays in stimulating pubertal estrus and breeding gilts, and inefficient allocation of gilts to breeding groups, are the largest contributors of NPD's in the herd.

Identifying "select" gilts at an early age is a critical part of a successful gilt development program. Gilts should undergo a strict selection process before being chosen to be a part of the breeding herd. This selection process will involve three steps.

Pre-Select 1. Occurs at the time the gilts leave the nursery. At this time gilts must have good conformation, 12-14 teats and be free of hernias or ruptures. As more data becomes available, it may also be appropriate to exclude gilts with inadequate growth rate at this stage. After gilts leave the nursery an opportunity exists to "condition" gilts to achieve adequate weights and body condition at puberty to sustain lifetime performance. Available data consistently show that at commercially acceptable growth rates (0.55 – 0.80 kg/d) (birth to 100 days of age), growth rate does not limit age at puberty. Experience in commercial practice suggests that modified, high energy, "conditioning" diets can be used to increase body fat stores in very lean gilts. In studies in which we attempted to slow growth in gilts with high fibre diets from 50 kg until puberty induction we had very little impact on bodyweight at first estrus.

Pre-Select 2. Pre-Select 2 will occur at 140 days of age, at which time gilts will be weighed to determine weight, growth rate and backfat depth. At this stage, gilts must achieve a lifetime growth rate of at least 0.6 kg/d. It is important to remove gilts with low growth rates, because a slow growing (< 0.6kg/d) and early maturing gilt (first estrus at 160 days) would weigh approximately 96 kg at first estrus. If this gilt was bred in the appropriate weight range (135 – 150 kg body weight), she would need to be bred at 4th or 5th estrus and would accumulate nearly 84 days in the gilt stimulation/pre-breeding area. Similarly, a slow growing (<0.6 kg/d) and late maturing (190 days) gilt would accumulate 30 days in stimulation and an additional 42 days to reach the minimum breeding weight. Therefore, at Pre-Select 2, gilts not achieving a growth rate of 0.6 kg/d at 140 days of age would not be permitted to enter the stimulation phase. Instead, they would be considered ”Non-Select” gilts and become a market animal. In a study conducted at the University of Alberta, 13% of 228 gilts would have been culled because they did not meet the minimal growth criteria.

At “Pre-Select 2” gilts will be further examined to ensure that all gilts have good conformation, locomotion, 12-14 teats and are still free of hernias, ruptures and other ailments. Again, conformation data obtained at “Pre-Select 2” can be used to set up gilts on “fattening” diets if needed.

The number of gilts required to enter the stimulation phase will depend on the breeding requirements of the herd. In a trial recently completed at Prairie Swine Centre, the results indicated that approximately 125% of breeding gilt requirements should enter the stimulation phase (expecting 22% not to cycle and 3% to be culled) to obtain the required number of gilts cycling within 40 days. However, if the target number of gilts needed to enter the gilt pool cannot be met with gilts that meet minimal growth targets at “Pre-Select 2”, an appropriate number of “Non-Select” gilts can enter the puberty induction phase, *as a last resort*, accepting that these gilts will either tend to be bred below target breeding weight, or will accumulate excessive NPDs before breeding.

Final Selection – Puberty Induction

The age to begin puberty stimulation will depend on a number of factors. Generally, as illustrated in Figure 4 (refer to page 37), a younger age at stimulation corresponds to a decreased age at puberty, but requires more days in stimulation; and vice versa, older gilts at stimulation are typically older at puberty, but require fewer days of stimulation. If a large proportion of gilts are required to reach a synchronous puberty, commencing boar exposure at an older age is desirable. This is also probably most efficient in terms of labour and space utilization. However, stimulating gilts at an earlier age has several benefits (Figure 6; refer to page 39).

- Stimulating gilts at a young age enables the producer to identify gilts that are most sexually mature.
- Stimulating gilts early would permit a producer to cull non-cycling gilts as market animals, reducing the number of gilt NPDs and the financial cost to the producer.
- A producer is able to manage gilts so that at breeding, gilts have achieved a target weight (135 – 150 kg) and body condition.
- Early stimulation also allows a producer to synchronize estrus in gilts and thus meet breeding requirements from a smaller pool of select (service eligible) gilts.
- Finally, early stimulation of gilts permits producers to take advantage of the increased productivity of gilts bred at second or third estrus.

It is important to understand that stimulation of early onset of puberty does not mean that these gilts have to be bred at first estrus, or at an early age or light weight.

Historically, age at puberty has been shown to be normally distributed when growth rate is not limiting. The full extent of this variation in age at first estrus is most apparent if gilts are exposed to mature boars at an early age (say 140 days as in the studies discussed earlier). As previously mentioned, puberty induction at an early age serves to identify the precocious animals. In a recent experiment, out of 508 gilts stimulated with direct daily boar contact from 140d of age, 75% of gilts were pubertal within 40 days of stimulation. When stimulation is delayed to at least 160 days, it is possible to identify 33, 16 and 7% of gilts that do not respond to boar stimuli within 20, 30 or 40 days, respectively.

It is becoming increasingly important to identify the 75 – 80% of gilts that respond best to boar stimuli, because there are sound biological reasons, and increasing amounts of production data, to support the suggestion that late maturing gilts will have reduced lifetime fertility. An on-going study being conducted at Prairie Swine Centre, Saskatoon is examining the relationship between age at puberty and lifetime performance in Camborough 22 and L42 gilts. The gilts were housed in groups of twenty and received 20 min direct exposure to an epididimectomized boar daily, starting at 140.0 ± 4.7 d of age. Gilts attaining puberty by 180d of age were deemed to be "select" gilts and classified as Early (EP), Intermediate (IP) and Late (LP) with respect to age at first estrus. Gilts were deemed to be "Non-select" (NP) if first estrus was not shown by 180 days of age. "Select" gilts were bred at third estrus, regardless of age or weight. "Non-select" gilts were added to the gilt pool by production staff using available techniques (i.e. treatment with PG 600). To determine sow lifetime performance, data on sow body weight, loin and backfat depth at farrowing and weaning, total litter size born alive, dead and mummies, weaning to estrus interval and reason for culling are being collected over three parities.

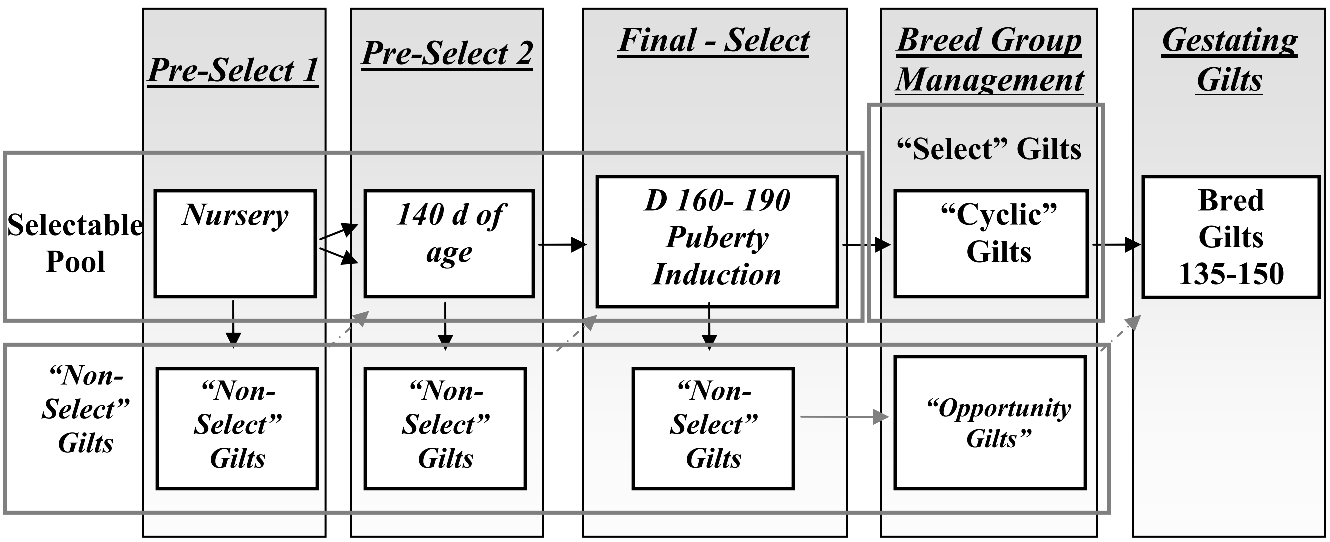
As a percentage of the total number of gilts on inventory at the start of stimulation in each group, fewer "Non-Select" gilts were bred than any of the classes of "Select" gilts. Consequently for NP gilts, pregnancy rate, farrowing rate, weaning rate and the percent rebred after weaning after first parity (expressed as a % of gilts originally on inventory) were lower than for EP, IP or LP gilts. Furthermore, considering only those gilts successfully weaned as parity 1 sows, class of gilt affected ($P < 0.02$) the percentage of animals pregnant as parity 2 sows (EP: 94.2; IP: 87.2; LP: 91.0; and NP: 76.6 %). Similarly, breeding herd efficiencies (Non-Productive Days/pig born) declined as age at puberty increased, when gilts were bred at third estrus irrespective of weight or age. Taken together, these data lead to the obvious suggestion that response to a standardized protocol of boar stimulation can be used to identify the 75-80% of gilts that are likely to be most fertile.

As illustrated in Figure 1, to meet breeding targets, or in start-up situations, it may be necessary to retain Non-Select gilts as part of the breeding herd. However, retention of "Non-Select" gilts within the herd would;

- Incur costs of unknown numbers of additional NPD.
- Represent less efficient use of pen space within the gilt pool.

- Still not guarantee that gilts would eventually cycle.

Figure 1. Schematic diagram of an efficient gilt management system.



It is also important to emphasize that even if these gilts are bred, their expected fertility would be low. It may be good management practice to already designate these "Non-Select" gilts at parity 1 culls, if they are included in the herd to meet initial breeding targets.

Taking these factors into account, and considering cost-benefits of efficient use of space and time, we recommend that the puberty induction phase begins when gilts reach 160 days of age and continue until they exhibit their first estrus or until 190 days of age, whichever comes first.
However, be aware that puberty stimulation at a delayed age (> 160 days of age) will be reflected in the high body weight of "Non-Select" gilts (gilts that did not exhibit first estrus within 30 days). In our recent study, even when puberty induction began at 140 days of age, nearly 80% of "Non-Select" gilts at 180 d were over market weight (120 kg), creating financial penalties to the breeding unit if these gilts were then culled.

BREEDING GROUP MANAGEMENT

The results of the ongoing study at Prairie Swine Centre indicate that early exposure (135 - 140 days of age) of gilts to boars resulted in a large variation in weights and ages at puberty, ranging from 75.8 to 151.4 kg, and 132 to 190 d, respectively. Because all gilts were bred at third estrus, this variation in weight at puberty resulted in weights at breeding ranging from approximately 100 to 190 kg. These large ranges present several problems to the producer.

- Gilts that are heavyweight at breeding increase feed costs and may cause welfare problems because of potentially larger increased physical size of mature sows.
- Conversely, gilts that are lightweight at breeding may lack the necessary body reserves to sustain body condition through several parities.

Recent studies at the University of Alberta, and elsewhere, suggest that a minimum body weight after farrowing of 175-180 kg may be necessary to protect against excessive loss of protein mass during the first lactation. A body weight of 135-140 kg at breeding, assuming a 35-40 kg weight gain during the first gestation, would theoretically result in body weight after farrowing being 175 kg or greater. Development and implementation of gilt management strategies that ensure that all gilts achieve adequate body tissue reserves at farrowing are necessary.

To overcome the problems associated with large variations in weight, a stricter selection program should be implemented, stipulating that all gilts weigh between 135 – 150 kg at breeding. If 1), during Pre-Select 1 and Pre-Select 2 the slowest growing gilts were already culled, and 2), an upper limit of 3rd estrus for breeding was stipulated, the number of non-productive days can be dramatically reduced. It was predicted that 10, 32 and 58% of gilts would be bred at their first, second and third estrus, respectively. As the average cost of one NPD is believed to be greater than $2.00 per day ($1.70 - $2.25), these will be considered cost benefits if NPD could be reduced through efficient gilt management strategies. Our recent studies suggest that if a producer was to implement a gilt management program that incorporated such a strict selection program, a puberty induction phase that removes "Non-Select" gilts, and a breeding program that requires gilts to be bred between 135-150 kg or 3rd estrus, on a 600 sow unit, expected savings of $11,426 in NPD could be recognized.

CONCLUSIONS

PigCHAMP 2002 data shows that on Canadian farms the average herd female inventory is 1046 (range 240-2740) with an average replacement rate of 58.7% (range 33.4-74.4%). From these data, it is evident that an excessively large pool of cycling gilts is needed to meet these replacement requirements. Apart from the extra costs of maintaining a large gilt pool, the bias of production towards lower parity females places major constraints on breeding herd performance. Therefore, it is essential that a producer adopt a gilt management program that will meet replacement targets from a smaller pool of gilts with improved lifetime breeding potential. This will ultimately result in improved production through reducing animal replacement rates to a target of <45%, improving sow "fitness", decreasing sow death losses and increasing labor efficiency and space utilization

EFFECTIVE TREATMENT AND HANDLING OF POOR DOING PIGS

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ABSTRACT

Because no farm enterprise is immune to production or health challenges the poor doing pig inevitably makes its appearance in every barn. It is, therefore, important to have a plan in place for the early detection, treatment and handling of poor doing pigs. In the event that there is no reasonable prospect of recovery or salvage then there must be a plan for timely euthanasia using a technique that meets current animal care standards.

INTRODUCTION

As margins continue to tighten in the pork industry the tolerance for increased production costs associated with increased variability of growth, off sort sales and death loss continues to decline. The best way to minimize the impact of poor doing pigs is to prevent the occurrence of these pigs in the first place. Prevention is closely associated with procedures related to the optimization of post weaning feed intake. By maintaining an ideal environment, the demands on the piglet's body reserves are minimized as the pig learns to eat solid feed. The treatments for poor doing pigs most commonly involve procedures that will stimulate the pig to eat as well as any medical interventions.

AT RISK PIGLETS

At risk piglets are piglets at weaning that have an increased risk of becoming a poor doing pig. The increased risk may be associated with very young weaning age, low weaning weights or disease. These pigs need to be placed directly into a special needs pen where they can be kept warm and receive a little tender loving care. It is important to treat any incoming piglets that are sick. It is helpful to coordinate with the farrowing room staff so that treatments that were started in farrowing can be completed after arrival at the nursery. Not all of these disadvantaged pigs need to be medicated.

Feed

Most pigs will make the transition from milk to solid feed without any problems. If the transition is handled poorly the piglet will lose weight as it catabolizes fat and muscle for maintenance. If the process goes well then the piglet continues to grow and meet its targeted weight gain over the first week. When sows are not milking well most piglets will be very familiar with the concept of eating solid feed as they will have had great motivation to consume spilled sow feed or creep feed. When the sows are milking very well the piglets will have had little need or desire to consume solid feed. These piglets can be a greater challenge to get started on to solid feed at weaning. A properly managed creep feed program will greatly assist in the post weaning transition period.

Provide clean fresh feed to the weaned pig on a regular basis. Start with a relatively complex nutrient dense ration. This feed should be fed on a controlled basis. The controlled feeding should not be misinterpreted as limit feeding. In controlled feeding the feed is supplied on a "just in time" delivery basis in order to maintain freshness and therefore palatability.

The largest and oldest pigs are often started directly on the phase 2 feed or a blend of phase 1 and 2. By starting these larger pigs directly on the phase 2 feed it is then possible to hold more of the phase 1 feed in reserve for the smallest pigs. These smaller pigs may receive 2.5 kg more of the phase 1 feed than the average pig. This feed can be saved in a covered cart or feed bag.

A simple rule of thumb for feeding frequency for weaned pigs is the "4,4,4" rule. Provide four feedings per day for four days post weaning for a pig weaned at four weeks of age. If pigs are weaned at a younger age the number of feedings per day can be increased. For example, a ten day old piglet would normally be fed 6 times per day. The frequent feeding of piglets in "piggy barrels" in farrowing rooms is a testament to the effectiveness of frequent feeding in the young weaned pig. The frequent feeding in the farrowing room is associated with the frequent vocalization of the sow that causes the piglets in the barrels to get up and eat solid feed from the trough at the same time that other piglets in the room are nursing.

Increased frequency of feeding is more easily achieved in farrow to finish operations where staff is available to visit the nursery many times throughout the day. In contract nurseries the operator may be doing chores in the morning and evening but are often working off farm through the day. This can present some challenges in optimising the number of feedings per day. No matter how many feedings are available, the goal is to have the feed completely cleaned up between feedings. If only two feedings per day are available you may simply have to make the best of it. Be prepared, however, to detect and respond to "stall out" pigs as soon as possible.

In order to calculate the targeted feed placement at each feeding start by establishing the expected feed conversion and the average daily gain for the feeds and genetics to be used. Given this information the average daily feed intake can then be estimated. This can be used to estimate the targeted total daily feed intake per group. This can then be divided into the number of feedings per day. Relatively small amounts of feed are required at each feeding for the newly weaned pig. Less is more in feeding the weaned piglet. Overfeeding will result in stale feed and less group activity at the feeder. Feed intake will gradually decrease as the feed becomes less palatable over time. When the less palatable feed is finally consumed and is then replaced with palatable feed there is a risk of engorgement.

The first feeds are usually supplied in sealed plastic lined bags. These bags should be kept closed when not in use and stored in a dry, cool, odour free place. This will help to keep the feed fresh. The increased freshness of feed will improve palatability and feed intake.

Group feeding of piglets for a few days after weaning will greatly assist in getting the greatest percentage of the pigs started on solid feed. This group feeding imitates the piglet's group feeding behaviour in the farrowing room. A small proportion of the first feed is usually provided in a tray style feeder. If a tray style feeder is not available then some feed can be placed on a solid floor, heat pad or comfort mat. The piglets may waste some of this feed, but this small amount of wasted feed is a trade off against getting the piglets accustomed to solid feed. These tray feeders or mats increase the available feeding space making it possible for all pigs to eat at the same time. The bulk of the feed is placed into the feed trough of the hopper style feeder.

A predetermined amount of feed can be more easily delivered using a scoop that has been calibrated according to the weight to volume ratio of the feed. The scoop size should be matched to both the targeted intakes per group and the common increments of feed that will occur over the first few days. Avoid using a scoop that is overly large as this will often result in over and under feeding except in the hands of a very skilled operator. All tray feeders should have some sort of fastener so that they can be held in place when empty. These feeders should be cleaned and disinfected before being moved to another pen.

Track the feeding quantities by group on a card or some other temporary recording device. A clothespin can be moved along a series of marks that are placed about half an inch apart on the feeder. The marks on the feeder correspond to the number of scoops being placed in the feeder at each feeding. In this way anyone that is feeding can feed the appropriate amount on a pen by pen basis. If the piglets do not clean up all of their feed at the previous feeding, then the amount they are fed in the subsequent feeding is reviewed and possibly reduced. Limits can be placed on how rapidly the feed may be increased depending on previous history. Rapid increases in intake that could lead to increased risk of stale feed should be avoided. By using the recording system you can more closely track feed disappearance by group and the amount of feed placed in the feeder will be more closely matched to actual intakes.

Remove any spoiled feed or accumulations of fines from the feeders at least daily. Feeders should be adjusted as necessary to control feed wastage and to monitor feed intakes. Often the feeder openings are increased at weaning or agitators are loosened off to make it easier for small pigs to access the feed. The feed system drop tubes should be adjusted before filling the feeders. When the pigs enter the room the drop tubes should be set close to the bottom of the feeder so that the feed is kept fresh. Feeders should be adjusted such that 30% to 40% of the feed trough or pan is visible. After the pigs are eating well this can be tightened such that 50 % of the bottom of the trough is visible.

Once the pigs have made the transition from sows milk to solid feed at weaning the pigs are then gradually switched to free choice feeding. The objective at this point is to keep the feed fresh and uniformly available from the self-feeders. As the pigs grow the complexity and density of the ration will decrease.

Water

Ensure adequate water quality and appropriate water flow. If the height of the water drinker is adjustable it should be set to a height slightly above the back of the pig. Record the water disappearance on a daily basis if a water metre is available. Ensure proper operation of the medicator and refill stock solutions as necessary. If protocol dictates, stock solutions should be mixed and purged into the lines in order to treat the piglets effectively as soon as they need it. If the pigs exit the nursery at 28 to 32 kg then aim for 0.75 liter per minute water flow. If water temperatures are extremely cold the water can be preheated by running the water through coils of water line inside the barn.

Environment

The duration of lighting and the age at which pigs are weaned can influence their immune system and weight gains. Pigs that were weaned at 28 days of age gained more weight with 16 hours of light per day during the period from weaning to 10 weeks of age, compared to control pigs receiving only eight hours of light per day. On the first day, however, you can shut off all lights when leaving the barn as this will calm the pigs after a heavy day of activity including the stress of weaning, movement, vaccination and sorting. All lighting should allow for easy observation of the pigs. Without proper lighting it will be difficult to detect stall outs.

Aim for a relative humidity (RH) of 65% in the spring, winter and fall. This will allow for improved disease control by reducing bacterial populations in the air. The RH can be measured with a relatively inexpensive RH measuring device. Readings above 65% will indicate excessive moisture and increased bacterial disease loads. Readings below 60% will indicate excessive ventilation rates with a risk of chilling related to increased air speeds. The lower humidity will also dry out the respiratory passage making it more difficult for the pigs to clear respiratory infections from their lungs.

A static pressure manometer can be used to check ventilation efficiency. Aim for 0.04 inches of static pressure in the barn in the summer. This will allow for the optimum exchange rate of air that will keep the pigs comfortable in the summer. Aim for 0.08 inches in the winter. This will allow for the adequate inlet air speed in winter. Proper static pressure maintenance in the winter is only possible when the room is properly sealed.

Ensure that the ventilation controllers are set according to targeted entry and exit levels with an appropriate step down program. Some mercury max / min thermometers will help to establish if the digital probe is accurate. When the electronic probe connections become corroded the readings on the digital controller may not accurately reflect the true barn temperatures.

The growing pig's body posture and behavior will tell you more about whether or not they are comfortable than the thermostat readings. The pig's behavior takes into account effective temperatures as mitigated by conduction, convection, radiation and evaporative heat transfer.

Provide a warm, dry, and draft free environment in a properly insulated room. This includes both the walls and the ceiling. Do not be afraid to top dress with additional heat in order to maintain air quality including gases, dust, humidity and temperature. Avoid excessive variability in temperature and humidity. Floor heating can take approximately 24 hours to reach normal operating temperatures. The thermostats that control these pads should be adjusted and setup in advance of receiving piglets and are usually warmed to 32°C where the room temp is 25°C. The exhaust fans should be set to a minimum ventilation rate prior to the arrival of the piglets. Return to the facility several hours after placement as a precautionary visit to check temperatures and the comfort level of the piglets and make any environmental adjustments as necessary. Excessive drafts should be identified and corrected as soon as possible. All ventilation covers should be ready for use and in their proper location and position. Backdraft boxes for the first and or second stage fans should be mounted in their proper location for the winter months.

Create a "micro-environment" for the newly weaned pig if and when specific sub-populations require warmer temperatures than the rest of their roommates. A microenvironment can be achieved with the addition of solid pen partitions in the sleeping area. A movable plywood or plastic lid with a valence and a heat lamp can be used to increase the temperature within the sleeping area. These solid dividers will also help to prevent drafts in the sleeping area. The area of the pen close to the water drinker and feeder will be the activity area of the pen. A comfort board can be used to provide a comfortable sleeping area with reduced updrafts and less contact with cold floors. If the pigs start to manure on the comfort board then it is normally removed and washed and may not be replaced if the pigs appear comfortable.

Daily Inspections

Careful observation of each pig allows the pigs to tell if there is a problem. Perform a routine check of the pigs every morning and late afternoon. The comfort of the pig can be assessed by careful observation of the pig's laying patterns. A rule of thumb is that half of the pigs should be sitting up and the other half lying on their sides. If all of the pigs are lying on their sides it is excessively warm. If all are sitting straight up, hunched up, piling or shivering then the pigs are too cool.

As long as there are no active diseases that may be transmitted from pen to pen via boots you can walk through the pens looking for sick or stall out pigs. Walk through the pen in a calm manner using a circular route around the outside perimeter of the pen watching for poor doing pigs as they parade past. It is important to note any piglets that do not rise to the stimulus of being fed. The piglets that are not up and active should be inspected in order to determine the problem and allow for the appropriate action to fix the problem.

Sick pigs should be identified and treated promptly. A medication kit that can be brought into the room will make it easier to attend to health issues immediately when they are detected. This kit should contain important items such as syringes, needles, antibiotics, and markers. The operator should also have a notebook and pen to document specific treatments.

A treatment guideline for common problems should be established. Problems can be assessed through a decision tree. For example, the type of problem could be initially divided into two categories such as scouring or not scouring. If the problem is determined to be scouring then further questions such as blood or no blood in the manure can be used to point towards a specific cause and therefore treatment. If the piglet is not scouring then the decision tree could be further classified by including assessments of coughing or not coughing, skin condition or no skin condition, etc. The treatment guideline should discuss injectable, topical, feed or water treatments. Sick pigs may be removed from the group immediately if very sick or if they present a significant risk of infection to their pen mates. Less severely affected animals may remain in the pen but should be moved to a hospital pen if they fail to thrive.

Gruel Feeding

At risk pigs or normal pigs that are having trouble adjusting to solid feed can benefit from a technique such as gruel feeding. This is a very effective way to encourage at risk or stall out pigs to consume feed. The gruel feed is a mixture of complex starter ration that is soaked in warm water prior to feeding. The gruel feed is usually fed three times per day. The feedings usually occur early in the morning, at noon and then again at the end of the day. The gruel feeding can be provided for 5 to 7 days post entry. The gruel should be consumed within about 15 minutes. Gruel fed pigs should also be given small amounts of dry fresh feed in their regular feeders.

On occasion the water drinkers may be turned off so that the only source of water is the water contained in the gruel. The pigs are then more likely to consume the gruel in order to satisfy their thirst. The piglet's water intake for the day is calculated by multiplying the pig's body weight in kilograms by 10%. For example, if the pig weighs 6.5 kg it will drink approximately 0.65 kg of water or 0.650 liters of water per day. This amount of water is divided into three feedings and mixed with 1/3 of the pigs expected daily feed intake. The piglet should be eating well within a few days.

Hand Feeding

At risk pigs or stall out pigs can be fed a small amount of moistened feed by hand. A small handful of phase 1 starter is wetted. The soft pellets are placed in the piglet's mouth. A small 12 cc syringe with the end cut off can be used to push a more gruel-like mixture into the piglet's mouth. When the mixture contacts the tongue it will stimulate a swallowing reflex. The pig should be placed near the feeder so that they will associate the hand feeding with the feeder. As little as 20 to 30 grams of feed can be sufficient to prevent a piglet from starvation. A hypoglycaemic pig will appear quite dull. They may become increasingly disoriented as their blood sugar drops.

"Overstock and Sort"

"The sick are the greatest challenge to the healthy!" "Overstock and sort" refers to the practice of placing 5 to 15% more pigs in the pens when filling the room. Because only the target numbers for the nursery are placed in total there are a number of empty pens that are left at the beginning of the nursery stage. As non-competitive pigs or sick pigs arise, they are removed from the overstocked pens and placed into a sort pen or hospital/recovery pen. This procedure allows for a non-competitive environment for the least competitive pigs. This practice also allows for removing or streaming the sick pigs from the group.

This practice subsequently reduces the disease challenge to the “at risk” pigs in the pen. The 5 to 15% is adjusted based on genetic variability of growth and expected incidence of disease. If variability or disease is less than anticipated then the pens will still need to be thinned down before the end of the batch in order to allow for the growth of the pigs.

Sort Pens

Sort pens are the pens that are left empty when the barn is filled so that small noncompetitive pigs can be removed from the regular pens where they were originally placed. The pigs that are removed to the sort pen are usually healthy but simply noncompetitive pigs. If these pigs stay in with the regular pigs they will probably become sick. Some operators simply trade these pigs between pens in order to make the pen groups more uniform by size. This practice of swapping pigs is very disruptive to the pen social order and is more likely to spread disease.

Hospital Pen / Recovery Pen

Hospital pens are used to house acutely ill piglets that present a significant infective challenge to their pen mates or need some tender loving care away from the more aggressive healthy pigs. These pigs often successfully recover from their various ailments, and they can then be transferred to the recovery pen.

The hospital pen is usually located in the warmest and the most draft free area of the room. These hospital pens should be located on interior walls, as this will reduce the heat loss due to radiation. The hospital pen is usually equipped with supplemental heat in the form of a heat lamp. A third of the pen should be covered with a lid in order to create a warm, draft-free comfort zone. The front of the lid should have a valence fastened to the underside of the cover. The valence should descend 10 to 12" below the level of the lid in order to hold in the warm air.

The water nipples can be used to dispense medicated water to the piglets or the supplemental tray feeder can be used to distribute treated drinking water with medications, electrolytes and vitamins.

When the pig has sufficiently recovered it can be transferred to the recovery pen. If fully recovered the pig can be placed back into a regular pen especially with large group housing. In many cases the recovered pigs are kept intact as a group even as they are moved to the finishing barn.

Euthanasia

When treatments, segregation for extra care or humane slaughter are not acceptable or if the pig is experiencing abnormal intensity or duration of pain then the pig should be euthanized. Once a decision has been made that euthanasia is the best answer then the most appropriate technique must be selected. The decision process must take into account the needs of the people, the pig and society as a whole. There are a relatively limited number of practical options for euthanasia in the nursery. A few of the most common alternatives are presented here.

Captive bolt pistol trauma. An explosive charge is used in a specially designed pistol to fire a "bolt" into the cranium. Gun powder cartridges, compressed air or a spring under tension may be used to drive the bolt into an appropriate area of the top of the head/brain with sufficient force such that the animal is rendered unconscious instantaneously. In addition, there may be sufficient trauma to the brain such that respiration and cardiac output cease and the animal dies without regaining consciousness.

Alternatively the trauma may not have been sufficient to cause respiration or cardiac output to cease. The animal may regain consciousness if no other action is taken. If respiration and cardiac output do not cease then the procedure must be followed immediately by an additional procedure such as exsanguination. Exsanguination is more commonly required in larger animals following the use of a captive bolt pistol because of poor penetration to the brain. A high degree of skill is required in order to carry out this procedure. The animal must be properly restrained in order to ensure proper contact and targeting of the captive bolt pistol. The pistol is directed at the midline of the forehead, one inch above the level of the eyes, and the pistol is most often directed upwards at approximately 20^o towards the brain**.** Some adjustment to targeting may be required because of slight anatomical differences between breeds. As the pig grows, the position of the brain relative to the eye remains relatively static as the optic nerve stops growing relatively early in life. It is important to note that the power that must be generated by the cartridge will vary based on the size of the pig to be euthanized. Cartridge strength may diminish over time if the powder is exposed to moisture. " Keep your powder dry!" The equipment must be cleaned on a routine basis as the explosive charge is very corrosive. The round cup shaped cutting edge of the bolt must be maintained in order to achieve maximum penetration. It has been reported that some producers have modified the internal collars on some equipment to allow for greater penetration of the cranium but the safety implications of this modification are not defined. If the procedure is carried out effectively the animal should collapse immediately. This is followed by a 15 second period of spasm and then by "galloping" movements of the legs of increasing frequency.

Advantages:
- When performed with properly maintained equipment, proper charge selection and targeting this method can be quick, humane and cost efficient.

Disadvantages:
- If improperly performed can be inhumane. Some types of captive bolt pistols with less powerful charges will provide poor repeatability in larger animals.

- Aesthetically displeasing for personnel performing or observing the procedure because of the trauma itself as well as the involuntary thrashing.
- Accidental or malicious discharge can be dangerous to farm staff.
- Care must be taken to accurately and safely cut into the jugular and carotid artery or the axilliary blood vessels.
- Some cleanup of blood required.
- Requires some investment in equipment ($200 to $1000), cartridges and maintenance.

Carbon dioxide gas. Carbon dioxide (CO_2) is an anaesthetic gas that causes depression of the central nervous system via a lowering of the pH in brain tissue. Inhalation of 60 % CO_2 will result in unconsciousness within 45 seconds and respiratory arrest within 5 minutes. Inhalation of CO_2 in concentrations of 7.5% increases the pain threshold while higher concentrations of CO_2 have a more rapid anesthetic effect. Pure CO_2 is an odorless gas that is heavier than air. Animals do not detect the CO_2 immediately and because of this its depressant action takes place almost unnoticed. The chamber design for exposing the pig to the CO_2 should allow for precharging with CO_2 prior to placing the pig in the chamber. The chamber should be easily cleaned with easy access for removal of the dead animal. In order to minimize cost and maintain effectiveness there should be minimal loss of CO_2 from the chamber.

Because of the container size needed, it is not normally practical to do pigs over 70 to 80 pounds. A plastic garbage pail type bucket with a lid could be used. Carbon dioxide is heavier than air so it should enter at the top with any air vented from the bottom moving to a non-occupied area. Compressed CO_2 gas in cylinders is the most common source. Inflow to a euthanizing chamber needs to be regulated with compressed CO_2. The optimal flow rate appears to be one that will displace approximately 20% of chamber volume per minute. When using compressed CO_2, O_2 can be added providing a mix of 30% O_2 and 70% CO_2 such that the discomfort associated with the lack of oxygen prior to unconsciousness is minimized. The area must be well ventilated. Animals should remain in this atmosphere for 5 minutes until they are dead. Effective CO_2 anaesthesia includes the elimination of all withdrawal and palpebral reflexes. The use of levels of CO_2 above 30% may cause some nasal irritation prior to unconsciousness. CO_2 generated by dry ice or fire extinguishers is unacceptable.

Advantages:
- The use of CO_2 is well understood.
- CO_2 gas can be easily purchased in cylinders.
- It is nonflammable and non-explosive so it poses minimal hazards to farm staff.
- CO_2 is widely used for humane slaughter of swine for human consumption.

Disadvantages:
- The main disadvantage to CO_2 is that it is heavier than air so incomplete filling of the chamber may permit a tall or climbing animal to avoid exposure and survive.
- In immature animals, the time required for euthanasia may be substantially prolonged.

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EFFECTIVE TREATMENT AND HANDLING OF POOR DOING PIGS IN THE FINISHING BARN

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ABSTRACT

A small percentage of grow/finish pigs fail to thrive in the finishing barns of well-managed swine production units. Slow growing pigs in the finishing barn represent a lost investment and are a source of frustration to stockpeople. Poor doing finishing pigs are the result of poor doing nursery pigs, pigs that fail to make the transition to the finishing phase of production for unknown reasons, and pigs that get sick. These pigs die "naturally," are euthanized, or live without growing. Many can return to productive growth if identified early and treated appropriately. Early identification combined with standard diagnostic and treatment protocols is important. Equally important are decision rules for culling, euthanasia, or return to the finishing barn. Hospital pens and individual care are necessary to allow for efficient handling of some poor doing market hogs.

INTRODUCTION

There appears to be a renewed interest in reaching the mark of 30 pigs/sow/year. Together with an interest in weaning every pig born, we must increase our efforts to save pigs after weaning. The intensive management afforded suckling pigs on some farms is often not matched at later stages of production. However, the same type of early intervention can work for growing pigs. When pigs do not grow as expected they represent lost income for the farm and serve as a source of frustration to the caretakers.

Pigs that grow poorly in the nursery barn should not be moved to the finishing area. These pigs should be sent to cull markets or to hospital pens specifically designed to deal with such individuals. This paper will address the health of fast-growing pigs that "stall-out" when they enter the finishing barn. Some stockpeople expect and accept poor doing pigs as part of hog production. However the percentage of poor doing pigs varies from farm to farm so the opportunity exists on many farms to reduce their numbers.

HEALTHY PIGS THAT FAIL TO THRIVE UPON ENTERING THE GROWER BARN

When the environment in a finishing barn is inappropriate, a large number of pigs will be negatively affected at the same time. Overcrowding, temperature extremes, inadequate ventilation, restricted access to feed or water, unpalatable, poorly ground, mixed or balanced rations, and many other pen factors will depress growth in large proportions of pigs. This situation is rare but when it does occur, the large number of affected pigs generally leads to rapid recognition and resolution of the problem.

Finishing barns that are “by the book” in terms of stocking density, temperature, feeder space, water placement and flow, and all the other factors recognized to impact the comfort and health of the growing pig are often appropriate for 97, 98, or 99% of pigs placed. One to three percent of grower pigs will not thrive in the finishing barn for reasons that are not necessarily obvious. These pigs may be difficult to identify during the first week they are in a finishing pen. A pig that is not eating but is otherwise alert and healthy in a group of 20 or more pigs can be difficult to see. After a week, these pigs are gaunt and pale although often still relatively bright and alert.

Pigs that fail to make the transition from the nursery to the finishing barn are not much different from pigs that fail in making the transition from the farrowing crate to the nursery. The reason why a few pigs fail to eat and grow in a finishing pen although they had previously thrived in their nursery pen is not easily explained. Social factors associated with new penmates, different feed or feeders, different sounds, temperatures, flooring, etc. may all be involved in the failure to adapt to the new environment. If pigs do not start eating normally within one to two days of entering the grower pen, problems lie ahead. Often these pigs put their snouts in the feeder but consume little or no feed. They will drink and grow some in stature but become thin, pale, and gaunt. They may be treated with antibiotics, vitamins, or other medicines but seldom respond. If they are sent for post mortem examination they usually have no significant gross or microscopic lesions. The stomach and intestinal tract are empty, there may be small, superficial gastric ulcers, but no cause for the failure to thrive is identified. It has been hypothesized that some of these pigs fail to start on feed and then become so debilitated that they no longer seek food. Occasionally these pigs will respond to B vitamin injections to stimulate their appetite but more often they respond to a change in their environment, social structure, and nutrition. Moving these pigs to another pen, with different penmates, a different feeder and different feed (nursery diet for example) can put these pigs back on the growth curve. Wetting feed and placing small amounts of the wet feed in the mouth of a gaunt pig once or several times over a 1 to 3 day period can stimulate the pig’s appetite and return the pig to the feeder and to productivity.

Recent work with group housing of sows has shown us that even in relatively non-competitive computerized feeding systems some sows either forget or are too afraid to approach the feeder. The reason for this is unknown but may be related to recent or past confrontations associated with approaching the feeding station. The mixing of newly arrived pigs in a finishing pen requires the establishment of a social hierarchy within that pen. It is possible that in the creation of this social structure, an occasional pig becomes “feeder shy” and starts on the road towards becoming a “poor doer.” This would explain why many of the “stall-outs” in some barns have no obvious signs of pneumonia, diarrhea, lameness, etc. and no lesions on post mortem examination.

DISEASES THAT SLOW OR STOP THE GROWTH OF FINISHER PIGS

A number of diseases can slow or stop the growth of pigs. Respiratory disease is one of the more common diseases of grower pigs. It is characterized by coughing, rapid, laboured and sometimes open-mouthed breathing. Occasionally, the first sign of an outbreak of respiratory disease is sudden death.

When a respiratory infection is treated but a large proportion of the lung tissue has already been destroyed a "cured" pig may fail to grow. The scarred lung tissue results in a decreased capacity to oxygenate the blood and subsequent ill thrift. A number of viruses and bacteria cause respiratory disease in pigs. Submissions to a diagnostic lab are often necessary to identify the exact cause or causes of the respiratory disease. Management changes together with the use of vaccines and antibiotics normally control respiratory disease in most pigs. A few poor responders however may be candidates for culling or euthanasia.

Diseases of the gastro-intestinal tract may result in pigs that show ill thrift. A disease that affects the intestinal tract can decrease the absorption of nutrients through the intestinal wall. The inflammatory response that the pig mounts to the intestinal disease will also suppress the pigs appetite adding further to the pig's loss of condition. Most enteric diseases of finishing swine respond to changes in diet, or to vaccines, or antibiotics.

A common postmortem finding in finishing pigs demonstrating ill thrift is stomach ulcers. Stomach ulcers can cause sudden death in pigs when the ulcer eats through a major blood vessel causing death from blood loss. This situation is rare as many pigs at slaughter have gastric ulcers without demonstrating signs of disease or discomfort during the finishing period. Factors that increase the risk of ulcers include feed that is too finely ground, pigs off-feed or without feed for as little as 12 hours or pigs with respiratory disease. Therefore when a thin, pale, poor doing pig is found dead or euthanized because of a failure to respond to injectable medications, it is not uncommon to find one or more gastric ulcers and an empty gastro-intestinal tract. There are then two possible conclusions to be drawn. Either the ulcer caused a decrease in the pig's feed consumption or decreased feed consumption caused the ulcer. If a post mortem examination on a typical fading pig finds no abnormalities other than small, superficial gastric ulcers, similarly affected pigs should be encouraged to eat by changing feed, wetting feed, or if possible, placing feed in the pig's mouth.

Another reason for ill thrift in finishing pigs is infectious arthritis with inflammation or abscessation of one or more joints. Affected pigs are easy to identify due to swelling of the affected joints and a reluctance to bear weight on the affected limb(s). Early identification is key to the successful treatment of affected individuals. Pigs that are so severely affected that they cannot move competently about their pen should be removed to a less competitive environment with good footing and supplemental heat if required. Pain killers as well as antibiotics are the treatments of choice for infectious arthritis in grower pigs. If pigs with severe inflammation in one or more joints are not aggressively treated early, they may not respond to treatment. Although the infection can be eliminated, if treatment is delayed, damage to the joint from the infection can permanently cripple the pig.

A large number of other conditions stunt the growth of pigs. Large inguinal or umbilical hernias impede normal intestinal activity and retard growth. Tail bitten pigs may be weak in the hind quarters and struggle to access feed and water. Other pigs may have abscesses and adhesions internally that cannot be seen in the living animal. Poor doing individuals occur in all large populations. The goal must be to reduce their numbers as much as possible. Stockpeople should have an organized approach to dealing with those poor doing pigs that do occur.

ARE HOSPITAL PENS AND INDIVIDUAL PIG ATTENTION WORTH THE TIME AND EFFORT?

At one time hospital pens existed on nearly all swine farms. More recently economic analyses of hospital pens have failed to show a reasonable return on investment. One reason for this poor return is that hospital pens are often not hospital pens. They are sick pens. There is no doctoring or nursing in most hospital pens on most farms. They are holding areas for sick pigs. When used in this manner, sick pens have little chance of demonstrating an economic return nor do they significantly improve the pig's welfare.

It seems appropriate to remove a severely ill pig from competition with its penmates. Unfortunately, in many hospital pens, although there are fewer total pigs, there is no improvement in stocking density or flooring. Since there is also little medical attention or nursing care in these pens, the pig is left in the pen for an undetermined period of time to "see how it does." The pig may share the pen with a tail bitten pig, two gaunt, pale, ridgebacked pigs, a pig with a basketball sized umbilical hernia, a pig that only turns left, a pig with a prolapse, and two "lungers." Sporadic treatments may be offered in this situation but in general the pigs are on their own. You don't need a computer to demonstrate the low rate of return on this square footage.

Sick pens are a poor investment. Properly operated hospital pens can provide an economic return to the farm while improving worker morale and the welfare of compromised pigs. To do this, hospital pens must have some basic features such as extra warmth, good footing, easy access to feed and water and established protocols for treating, culling and euthanizing pigs.

If lameness or weakness is a reason to move a pig to the hospital pen, then the hospital pen must have appropriate flooring. The floor should not be slippery and should not be fully slatted. If the hospital pen is fully slatted, a rubber cow mat designed for dairy cow tie stalls can be cut to cover part of the slatted area to improve footing for weak or lame pigs. Such a mat also insulates sick pigs from the cement floor. This is important because sick pigs have trouble maintaining their correct body temperature and chilling suppresses appetite and attitude and delays healing. The hospital pen can also be made warmer by the use of supplemental heat such as a heat lamp or by the use of bedding materials when practical.

TREATMENT DECISIONS FOR POOR DOING PIGS

Every farm should have an established protocol for treating routine ailments in the finishing barn. Part of this protocol should be rules to follow in determining whether a sick pig is best treated and left with its penmates or whether it is more appropriate to remove the pig to a hospital pen. The decision is based on the severity of the condition and the likelihood that the affected pig will improve within a relatively short period of time. Reasons to remove pigs from their original group will vary from farm to farm but should be based on their ability to compete for warmth, feed, and water.

For each common ailment, the farm should have a strict treatment protocol that involves medications when indicated along with appropriate nursing care. For example, although penicillin is often the drug of choice to treat meningitis in pigs due to *Streptococcus suis*, it can take days for the brain to heal after the bacteria has been destroyed by the antibiotic. If the recovering pig is not given water to maintain its hydration status during this recovery phase, it will appear that the pig did not respond to the treatment when actually it died of dehydration. Likewise pigs with severe infectious arthritis should be treated with pain killers in addition to antibiotics to encourage them to eat, drink and move about the pen while the infection in their joint is resolving. Those pale, gaunt pigs with no outward clinical signs should have wet feed placed in their mouths several times a day to stimulate their appetites. Veterinarians can assist producers in devising practical and effective treatment and nursing protocols for the common types of poor doing pigs encountered in the finishing barn.

EUTHANASIA AND CULLING DECISIONS FOR POOR DOING PIGS

Every treatment protocol on a farm should include rules for stopping treatments and indications for culling and euthanizing pigs. An example of a protocol for a pig with meningitis due to *Streptococcus suis* may be: "Treat with penicillin for three days. Keep pig warm and ensure adequate water intake. Stop penicillin treatments and keep the pig warm and hydrated for an additional three days. At the end of this time period if marked improvement is not noted, euthanize the pig." Such protocols will vary from farm to farm. A farm protocol for *Streptococcus suis* meningitis however is never simply "penicillin." It is a specific dose for a specific period of time, it includes associated nursing care, and rules for humane destruction of non-responders.

A pig that dies in a hospital pen should always be a surprise. If the caretaker thinks, "I am glad to see that pig finally died," then euthanasia decision rules are not adequate on that farm. Stockpeople who say they never euthanize a pig on their farm are neglecting one part of their responsibility as animal caretakers.

The use of a captive bolt gun is the most appropriate means by which to euthanize a pig between 20 and 120 kg in body weight. The manufacturer of captive bolt equipment and your veterinarian can ensure that the captive bolt gun is used properly. One shot should produce an immediate lack of consciousness as evidenced by a lack of any reflex motion of the eyelid when the eye itself is touched. All motion including respiratory efforts and the heartbeat should stop within 2 to 3 minutes. Pigs should never be removed to a deadstock holding area until the producer is certain that the animal is dead.

CONCLUSIONS

A small percentage of individuals will fail to thrive in any large population. This may be due to physical problems such as infectious diseases or social problems such as an inability to adjust to a new social structure. Since the occurrence of such pigs should be expected on any swine farm, protocols should be in place to identify, treat, cull, or euthanize affected pigs. Easy-to-follow protocols will maximize returns from poor doers and improve worker morale and animal welfare.

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USING A STOCHASTIC MODEL TO EVALUATE SWINE MANAGEMENT WITH PAYLEAN®

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ABSTRACT

A bio-economic stochastic model was developed, which incorporates the economic optimization principles of pig replacement, growth under limited dietary lysine intake, and growth response to Paylean. The net returns from using Paylean increased as payment for carcass lean percentage increased and were estimated to be from $5,624 to $16,368 per year for a 1000-head grow-finish facility. The net returns from using Paylean ranged from $1.77 per pig with no payment for carcass lean percentage to $4.93 per pig with full payment for carcass lean percentage. The optimal Paylean concentration ranged from 5 to 9.5 ppm, which increased as payment for carcass lean percentage increased. The optimal average Paylean feeding duration of all marketed pigs varied slightly across payment schemes, ranging from 24 to 29 days for the four payment schemes. Pigs on tight schedules had relatively higher optimal Paylean concentrations than those with loose schedules. The net returns per dollar spent on Paylean were higher for tight schedules than for loose schedules.

INTRODUCTION

The economically optimal use of ractopamine (RAC, Paylean) had been examined using a growth model for a single pig with population average growth (Li et al., 2002). However, with all-in/all-out management, the turnover of the barn depends on the marketing day of the last batch of pigs, not the pig with the average growth rate. In this research, the management of pig production with Paylean was investigated for a group of pigs using a stochastic growth model, which allowed each individual pig to have a unique body weight growth and carcass composition growth curve (Schinckel et al., 2003a).

A bio-economic model was developed based on the stochastic growth model, which incorporates the economic optimization principles of pig replacement, growth under limited dietary lysine intake, and growth response to Paylean (Schinckel et al., 2003b). This model was used to derive the optimal production and marketing decisions for grow-finish swine production with Paylean.

Model Development and Assumptions

Seven parameters were taken into account when modeling the effects of RAC. The two key parameters are the increase in daily empty body protein accretion and relative response (RR).

A 25% increase in daily empty body protein accretion (PA) over the last 40.8 kg of live weight gain was assumed. The increase in PA was modeled as .25 x $(RC/20)^{0.228}$ where RC is the ractopamine concentration in ppm. The relative RAC response (RR) was modeled to describe the rapid increase and subsequent decline in the RR with either increasing time or weight gain on RAC. The response of RAC to increase average daily gain (ADG), and gain:feed (G:F) all decrease with the duration of feeding (Table 1). The greatest response occurs during the first 14 days and declines slowly thereafter. The RR was predicted from weekly serial real time ultrasound, live weight measurements, and based on the weekly response of RAC to increase gain:feed and average daily gain. An equal weighting of the body weight (BW) gain and days on ractopamine functions was used to describe the effect of ractopamine.

The model assumed all-in, all-out animal management. The objective function of the model was set as maximizing daily return for a 1000-head grow-finish barn. Model parameters were estimated for modern high lean pigs. The return was optimized under 10-year average prices and costs (Table 1). The price of Paylean was assumed to be $2.25 per gram, the market price of 2002.

The optimal management was derived for four payment schemes, including: (1) carcass payment with discounts on underweight and overweight carcasses; (2) carcass merit payment system adopted from Hormel's Carcass Lean Value Program; (3) lean to fat price ratio of 2:1, with discounts on underweight and overweight carcasses; and (4) lean to fat price ratio of 4:1, with discounts on underweight and overweight carcasses. The carcass weight discount grid for payment schemes 1, 3 and 4 were also adopted from Hormel's Carcass Lean Value Program. Payment schemes 1 and 2 reflected the marketing approaches by independent producers. Payment scheme 3 simulated the producers under limited coordination with packers, while payment scheme 4 reflected vertically integrated producers and captured the full benefit of the increase in carcass value.

The model optimized the return for 50-day-old feeder pigs to market. The optimization for dietary lysine and Paylean concentration management focused on the late finishing pigs starting at age 101 days (mean weight of 66 kg for gilts). Pigs were assumed to be fed with 3 diets from 101 days of age to market, with switching days for diet 2 and 3 optimized by the model. For RAC-treated pigs, the second and third diets contained the same concentration of Paylean.

It was assumed that pigs were marketed by semi-truck with a capacity of 170 head. Thus, the 1000 pigs were to be marketed in six truckloads. One or more truckloads can be marketed on the same day. The model specified that pigs must be marketed as long as the number of pigs heavier than the sort weight (also a variable optimized in the model) exceeded one truckload, except that pigs can be marketed in the last batch regardless of the weights.

The variables to be optimized in the model were: dietary lysine concentrations for three diets, the optimal starting days for diets 2 and 3, the optimal marketing days for each truckload, and an optimal sort weight. The RAC starting time was the same as diet 2.

Table 1. The effect of four ractopamine use programs on weekly ADG, ADFI, and feed efficiency in late finishing pigs.

	Control[d]	Constant[d]	4,2 Step-up[d]	3,3 Step-up[d]	2,2,2 Step-up[d]	Std. Error	Significance, P <		
							Diet	Sex	Diet x Sex
Number of pigs	54	54	54	54	53				
Initial BW, kg	70.4	70.6	70.5	70.4	70.1	0.621	0.980	0.048	0.960
Week 1									
ADG, g/d	925[b]	1075[ab]	1004[b]	1169[a]	1022[ab]	55.6	0.041	0.147	0.064
ADFI, kg/d	2.70[b]	2.75[ab]	2.65[b]	2.93[a]	2.70[b]	0.069	0.070	0.001	0.067
Gain/Feed, g/kg	371	396	365	434	380	27.1	0.384	0.743	0.347
Week 2									
ADG, g/d	1039	1125	1140	1155	1017	59.5	0.342	0.053	0.836
ADFI, kg/d	2.63[b]	2.77[ab]	2.69[ab]	2.85[a]	2.70[ab]	0.071	0.230	0.001	0.703
Gain/Feed, g/kg	395	404	426	406	379	20.4	0.565	0.841	0.944
Week 3									
ADG, g/d	1012	1047	1035	1020	1108	52.8	0.704	0.338	0.581
ADFI, kg/d	2.86	2.89	2.81	2.85	2.88	0.100	0.981	0.001	0.704
Gain/Feed, g/kg	355	364	372	358	386	15.2	0.570	0.009	0.080
Week 4									
ADG, g/d	885[b]	986[ab]	978[ab]	1016[a]	1014[ab]	46.3	0.255	0.052	0.346
ADFI, kg/d	2.94	2.91	2.83	2.98	2.76	0.106	0.550	0.001	0.911
Gain/Feed, g/kg	314[b]	343[ab]	347[ab]	346[ab]	378[a]	18.9	0.221	0.064	0.464
Week 5									
ADG, g/d	817[c]	925[b]	1050[a]	1019[ab]	961[ab]	38.6	0.001	0.402	0.199
ADFI, kg/d	3.15	2.97	3.11	3.09	3.04	0.104	0.764	0.002	0.056
Gain/Feed, g/kg	266[b]	311[ab]	343[a]	332[a]	323[a]	17.3	0.025	0.008	0.749
Week 6									
ADG, g/d	943[b]	958[b]	1013[ab]	1122[a]	978[ab]	55.0	0.152	0.047	0.722
ADFI, kg/d	2.95	2.88	2.87	3.01	2.97	0.081	0.713	0.001	0.228
Gain/Feed, g/kg	323	336	356	371	331	20.9	0.447	0.896	0.684
Final BW, kg	109.6[c]	113.1[ab]	113.8[ab]	115.8[a]	112.2[bc]	1.004	0.002	0.001	0.565

[a,b,c] Within a row, means without a common superscript letter differ ($P < 0.05$)

[d] Control: no RAC; Constant: 5-ppm RAC wk 0-6; 4,2 Step-up: 5-ppm RAC wk 0-4, 10-ppm RAC wk 5-6;
3,3 Step-up: 5-ppm RAC wk 0-3, 10-ppm RAC wk 4-6; 2,2,2 Step-up: 5-ppm RAC wk 0-2, 7.5-ppm RAC wk 3-4, 10-ppm RAC wk 5-6

Overall Analysis

For pigs fed Paylean, the optimal number of batches was two for payment schemes 2, 3 and 4, and three under payment scheme 1 (Table 2). Therefore, pigs were marketed in fewer numbers of batches when fed Paylean. The marketing ages for the last batch ranged from day 155 to 160, which was 5 to 7 days earlier than control pigs. The sort weights for control and Paylean-treated pigs were very close, indicating the payment grid was important in determining the optimal market weight.

Table 2. Predicted optimal return and management for SEW gilts with ractopamine (RAC; 1000 head/barn).

Payment system	Scheme 1	Scheme 2	Scheme 3	Scheme 4
Return, $/barn-day	245.60	281.89	314.96	346.65
RAC, g/ton	4.5	5.0	5.9	8.6
% lysine in diet 1	0.77	0.83	0.79	0.82
% lysine in diet 2	0.91	0.97	0.95	1.01
% lysine in diet 3	0.79	0.81	0.79	0.83
Diet 2 and Paylean start day	134	129	128	125
Diet 3 start day	146	144	144	141
Marketing age for 1st batch, d	152	152	152	149
Marketing age for 2nd batch, d	158	157	157	155
Marketing age for 3rd batch, d	160	-	-	-
Sort weight, lbs	271	271	271	266
Avg. slaughter age, day	158.3	156.2	156.2	154.0
Avg. days on RAC	24.3	27.2	28.2	29.0
Days on RAC (last batch)	26	28	29	30
Return over control, $/pig [a]	1.77	2.62	3.12	4.93
Under-weight carcasses, head	45	73	75	98
Sort loss from under-weight, $/barn	355.60	676.55	578.08	1164.42
Over-weight carcass, head	118	104	108	55
Sort loss from over-weight, $/barn	717.28	1291.08	833.74	498.77

[a] Return over control is calculated as the daily return of RAC-treated pigs minus that for control pigs under the same payment scheme, then the difference is multiplied by the number of days on feed for RAC pigs from a feeder pig of 50 days of age.

The net return from using Paylean was estimated to be from $5,624 to $16,368/year/barn (1000-head grow-finish facility). The net returns from using Paylean were $1.77 to $4.93 higher per pig than control pigs. The net returns from using Paylean increased from payment scheme 1 to 4, with high lean to fat price ratios resulting in higher net returns. Sort loss from pigs with Paylean-treatment was higher than that for control pigs under each payment scheme. The numbers of pigs receiving discounts due to under- or over-weight carcasses were also higher for Paylean treatment. This indicated that with Paylean adoption and its higher returns, it was economically optimal to sacrifice some sort loss in order to market the pigs at a younger age and have a faster barn turn-over.

The optimal Paylean concentration ranged from 5 to 9.5 ppm, which increased from payment scheme 1 to 4. Increased payment for carcass lean encouraged both increased Paylean and lysine concentrations. The optimal lysine concentration decreased as the Paylean response decreased. The optimal average Paylean feeding duration of all marketed pigs varied slightly across payment schemes, ranging from 24 to 29 days for the four payment schemes.

INVESTIGATING THE IMPACT OF OPTIMAL PAYLEAN START TIME

Currently, producers seem to have different management strategies regarding the Paylean onset weight or age. To evaluate the impact of Paylean onset ages on production returns, a stochastic model was employed to investigate the optimal return and management under alternative Paylean onset ages. In addition, swine producers face the problem of estimating the average weight of a group of pigs in order to start feeding Paylean at the right time point.

The model was used to optimize the return and management for alternative Paylean onset ages under payment scheme 3. Payment scheme 3 simulates an approximate linear relationship between return and lean mass. The model restricted Paylean to be fed either earlier or later than the optimal onset age, as well as fixed the Paylean concentration at 5.9 g/ton (6.5 ppm), while leaving the dietary lysine concentrations in each diet, time to switch to diet 3, and marketing management to be optimized.

The optimal return and management under alternative Paylean onset ages are reported in Table 3, where the first row lists the days earlier or later than the optimal onset age, with positive for shifted later and negative for shifted earlier. The optimal Paylean onset age was day 128, which corresponds to the zero value in Table 3. When Paylean feeding is delayed 28 days Paylean is not fed to the first batch of heaviest pigs.

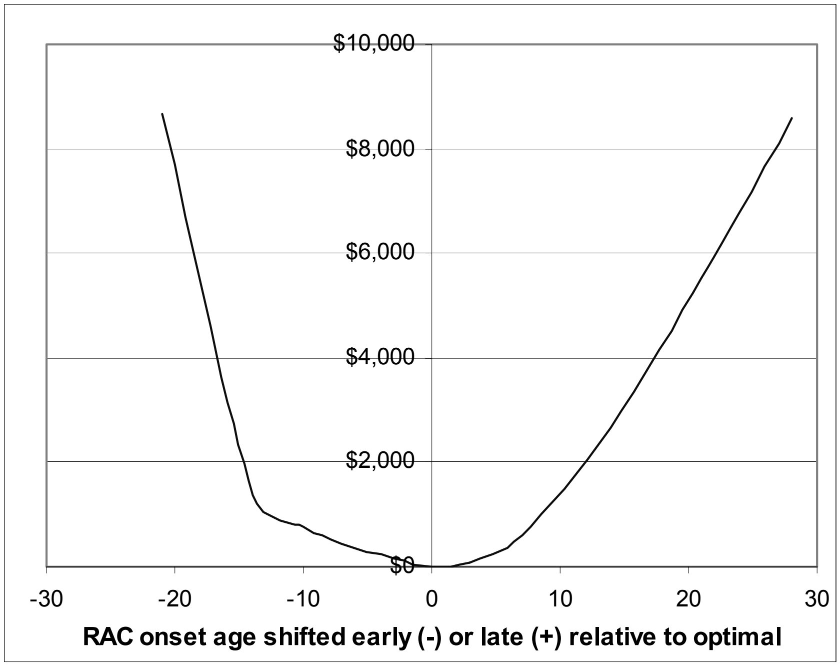
The further away from the optimal Paylean onset age, the less return was obtained. It was found that when the Paylean starting day was shifted further from the optimal, the potential loss would increase at an accelerating rate (Figure 1). The loss of delaying Paylean onset by one week was $623/barn/year, and $2,672 if by two weeks. The curve of annual losses versus the numbers of days off the optimal Paylean starting age (Figure 1) resembles a quadratic function, but was non-symmetric with respect to zero value. The magnitude of the loss suggested that the acceptable window for Paylean onset to achieve approximately 94% of the maximum return to Paylean was around 14 days, 7 days ahead of optimal and 7 days behind.

Table 3. Optimal Paylean and marketing management for SEW gilts when Paylean is started at alternative ages (SEW gilts marketed under payment scheme 3 and fed 5.9 g/ton (6.5 ppm) of Paylean, 1,000 head/barn).

RAC onset day shifted [a]	-21	-14	-10	-7	-3	0	3	7	14	21	24	28
Return, $/barn/day	291.17	311.15	312.91	313.72	314.51	314.96	314.77	313.25	307.21	299.81	296.37	291.39
% of optimal return	92.4%	98.8%	99.3%	99.6%	99.9%	100.0%	99.9%	99.5%	97.5%	95.2%	94.1%	92.5%
Potential loss, $/year	8681.2	1389.3	748.1	452.4	160.8	0.0	68.1	623.2	2672.0	5527.4	6782.8	8601.6
Return over control, loss, $/year	1502	8794	9435	9731	10022	10183	10115	9560	7355	4656	3400	1581
Days on RAC (17% of pigs)	41[d]	33	29	26	26	24	21	17	10	5	4	0
Days on RAC (17% of pigs)	41[d]	39	35	32	30	29	26	22	15	10	9	3
Days on RAC (66% of pigs)	41[d]	41	37	36	30	29	26	25	18	14	13	8.5[c]
Average days on RAC	41.0	39.3	35.3	33.6	29.3	28.2	25.2	23.1	16.1	11.8	10.8	7.6
Average slaughter wt., lbs	246.9	257.1	257.3	259.6	259.5	262.7	262.6	266.2	264.7	268.1	271.6	268.1
Barn closeout time, pig age in days	148	157	155	157	155	157	157	160	160	163	165	165
RAC intake (gram/group)	665.66	650.20	590.31	565.88	501.28	484.72	436.86	413.64	288.49	215.82	208.70	128.71
Return Ratio of RAC ($/$)[e]	0.28	1.81	2.14	2.35	2.68	2.87	3.16	3.24	3.57	3.10	2.38	1.80
% under-wt carcass, head	28.5%	10.4%	10.4%	7.5%	10.0%	7.50%	7.50%	4.30%	5.30%	3.80%	3.00%	3.30%
% over-wt carcass, head	0.3%	2.2%	2.5%	3.0%	7.5%	10.80%	10.30%	10.20%	6.40%	10.30%	18.20%	6.30%

[a] Negative days denote Paylean onset day shifted earlier relative to optimal and positive for shifted later.
[b] Return over control pigs is calculated as the daily return of RAC-treated pigs minus that for control pigs under the same payment scheme, then the difference is multiplied by 365 days.
[c] Of the 66% of pigs, 17% is fed Paylean for 7 days, and 49% for 9 days, thus the weighed average days on Paylean is 8.5 days.
[d] The same numbers indicate that all of the 1,000 pigs are marketed within one day.
[e] "Return Ratio of RAC" is the ratio of net return of RAC divided by total cost of RAC, where the number is dollars received for one dollar spent on RAC.

Figure 1. Potential loss when RAC starting days are off the optimal ($/year, 1000 head barn).



The optimal numbers of batches was between one and four. When Paylean was started too early (such as 21 days ahead), it was optimal to market pigs in one day. On contrary, when Paylean feeding was started too late (28 days delayed), it was optimal to market the pigs in 4 batches, resulting in a longer barn turn-over period. In most cases, pigs were marketed in 2 or 3 batches.

PAYLEAN MANAGEMENT WITH FIXED SCHEDULE ENVIRONMENT

Modern swine producers often face a fixed schedule for barn closeout, either due to a contracted date for delivering market hogs or the arrival of a new group of feeder pigs. With a fixed schedule, producers have to adjust their management strategies in order to shift the growth rate of the animals and raise the hogs to the packer's desired weight range. Because Paylean has proved to be able to enhance swine growth rate, as well as change the lean growth rate, it is a potential tool for producers to handle a fixed schedule environment and increase returns of swine production. The economically optimal return and management strategies for swine production with the application of Paylean were investigated for alternative fixed schedule environments.

Pigs were assumed to be marketed under payment scheme 3. The alternative fixed schedule environments were simulated as restricted marketing dates for the last batch of pigs. Fixed schedules investigated here ranged from day 137 to 177, with a step size of 4 days and day 157 being the optimal marketing age of the last batch of pigs without any restrictions. Two types of Paylean management strategies were investigated: 1) fixing the dietary Paylean concentration at 5.9 g/ton (6.5 ppm), which was optimal without restrictions; and 2) optimizing the Paylean concentration under each fixed schedule.

Model predictions of optimal return and management under each fixed schedule are displayed in Tables 4 and 5 for fixed and optimized Paylean concentration management, respectively. In both tables, the first row denotes the days when the last batch has to be marketed, and again day 157 is the obtained optimal age without restrictions. Therefore, for those marketing days less than 157, pigs are raised and marketed on tight schedules; otherwise, pigs are on loose schedules.

When dietary Paylean concentrations were allowed to be optimized, pigs on tight schedules had relatively higher optimal Paylean concentrations than those with loose schedules. As expected, the net returns of the optimal Paylean concentrations were higher than or equal to those with a fixed Paylean concentration of 5.9 g/ton (6.5 ppm). The net returns per dollar spent on Paylean were higher for tight schedules than for loose schedules. The highest return ratio for Paylean was 5.86 and the lowest was 1.83. Thus, even Paylean was cost-effective for producers with the loosest schedules.

When pigs were marketed at their optimal weight or age, the numbers of underweight and overweight pigs were both small, close to 7-8%. However, in tight or loose schedules, either the underweight or the overweight pigs were higher than the optimal level. This indicated that the optimal marketing age was obtained by balancing the number of underweight pigs with overweight pigs. The total amount of sort loss was the least when there was no fixed schedule restriction. This indicated that the packer’s discount grid was a critical factor in determining the revenue of production and the optimal marketing ages for each batch.

EFFECTS OF RACTOPAMINE ON PORK QUALITY

Recent and past research trials indicate that RAC has no significant impact on pork quality including color, marbling, firmness scores, and Hunter color values (Crome et al., 1996; Stites et al., 1994; Uttaro et al., 1993; Herr et al., 2000). Recent research also indicates that RAC has no significant impact on drip loss, loin purge loss, or loin chop cooking loss. The majority of trials have found no significant impact on 24h pH. Some research trials have found small increases in Warner-Bratzler shear force (Aalhus et al., 1990; Uttaro et al., 1993). Other researchers reported no consistent differences in either shear force or sensory tenderness scores for ham and loin samples from control and RAC fed pigs (McKeith et al., 1988; Jeremiah et al., 1994a and 1994b; Stites et al., 1994).

APPLICATION

The stochastic model indicated that pigs fed Paylean should be marketed at younger ages (5 to 7 days) than pigs without Paylean, as well as marketed in less batches. For swine production operations adopting Paylean, it is economically optimal to sacrifice some sort loss in order to market the pigs at a younger age, realize a faster barn turnover, and obtain a higher average

Table 4. Optimal Paylean and marketing management for alternative fixed schedules (SEW gilts marketed under payment scheme 3 and fed 5.9 g/ton (6.5 ppm) of Paylean, 1,000 head).

Fixed schedule day (pig age, days)	137	141	145	149	153	157	161	165	169	173	177
Return, \$/barn,day	177.52	237.43	278.72	301.51	311.08	315.64	313.11	308.14	300.79	291.91	283.95
Return over control pig (\$/head) [b]	12.00	10.13	10.02	6.55	4.86	4.02	3.09	2.57	2.21	1.79	1.65
Marketing batches	1	1	1	1	2	2	3	4	5	5	6
Days on RAC (first batch)	28	28	28	28	26	23	20	18	16	11	11
Days on RAC (last batch)	28	28	28	28	28	29	29	31	30	25	25
Average days on RAC [c]	28.0	28.0	28.0	28.0	27.7	28.0	26.8	26.9	26.7	22.3	23.1
RAC intake (gram/group)	910.04	924.62	938.06	950.04	473.70	484.72	463.98	466.50	460.76	389.19	400.87
Return Ratio of RAC (\$/\$)[d]	5.86	4.87	4.75	3.06	4.56	3.68	2.96	2.45	2.14	2.04	1.83
Avg. slaughter wt., lbs	234.5	234.6	242.1	249.8	256.7	262.7	267.3	270.9	271.6	274.9	275.9
% underweight carcass	76.0%	58.6%	40.2%	23.8%	13.5%	7.5%	3.8%	1.8%	1.1%	0.6%	0.2%
% overweight carcass	0.1%	0.4%	1.2%	4.3%	6.7%	10.8%	12.3%	14.0%	10.1%	15.9%	16.9%
Sort loss due to under-weight carcasses (\$/1,000 head)	13,285	8,321	4,664	2,455	1,267	808	259	141	83	35	20
Sort loss due to over-weight carcasses (\$/1,000 head)	24	51	116	319	574	485	883	900	644	880	931

[a] Fixed schedule day is the marketing day for the last batch.
[b] Return over control pigs is calculated as the daily return of RAC-treated pigs minus that for control pigs under the same payment scheme, then the difference is multiplied by the number of days on feed for RAC pigs from a 50 day old feeder pig, allowing 5 days with the barn empty in-between each group.
[c] Average days on RAC is computed as the weighed average of days for each batch of pigs fed on RAC.
[d] The ratio is the net return of RAC divided by total cost of RAC, which denotes the amount of dollars received for one dollar spent on RAC.

Table 5. Optimal Paylean and marketing management for alternative fixed schedules (SEW gilts marketed under payment scheme 3).

Fixed schedule day [a] (pig age in day)	137	141	145	149	153	157	161	165	169	173	177
RAC, g/ton	12.7	11.8	10.4	8.6	7.7	5.9	5.9	5.9	5.0	4.5	4.5
Return $/barn, day	182.96	241.77	281.06	302.29	311.97	315.64	313.11	308.14	301.20	292.32	284.40
Return over control pig ($/head) [b]	12.50	10.55	10.25	6.63	4.96	4.02	3.09	2.57	2.27	1.84	1.71
Marketing batches	1	1	1	1	2	2	3	4	5	5	6
Days on RAC (first batch)	26	27	27	28	26	23	20	18	16	12	12
(last batch)	26	27	27	28	29	29	29	31	30	32	36
Average days on RAC [c]	26.0	27.0	27.0	28.0	28.5	28.0	26.8	26.9	26.7	23.3	24.1
RAC intake(gram/group)	1,810.9	1,768.9	1,590.7	1,380.1	633.4	484.7	464.0	466.5	390.7	313.1	322.2
Return Ratio of RAC ($/$)[d]	3.07	2.65	2.87	2.13	3.48	3.68	2.96	2.45	2.58	2.61	2.35
% underweight carcass	74.3%	55.7%	38.5%	23.2%	13.3%	7.5%	3.8%	1.8%	1.1%	0.7%	0.3%
% overweight carcass	0.1%	0.5%	1.4%	4.4%	6.1%	10.8%	12.3%	14.0%	10.0%	14.7%	16.1%
Sort loss due to under-weight carcasses ($/1,000 head)	12,688	7,829	4,387	2,370	1,210	808	259	141	83	39	24
Sort loss due to over-weight carcasses ($/1,000 head)	24	55	124	330	469	485	883	900	602	861	922

[a] Fixed schedule day is the marketing day for the last batch.
[b] Return over control pigs is calculated as the daily return of RAC-treated pigs minus that for control pigs under the same payment scheme, then the difference is multiplied by the number of days on feed for RAC pigs from a 50 day old feeder pig, allowing 5 days with the barn empty between groups.
[c] Average days on RAC is computed as the weighed average of days for each batch of pigs fed on RAC.
[d] The ratio is the net return of RAC divided by total cost of RAC, which denotes the amount of dollars received for one dollar spent on RAC.

daily return for the facility. Producers should consider a week shorter feeding period and faster barn turn-over when Paylean is fed.

Paylean onset time determined the Paylean feeding duration to a large degree. Deviations from the optimal Paylean starting age greater than 7 days would incur losses in production return, and the further away from the optimal starting point, the higher the loss became.

Paylean had higher economic returns under tight marketing schedules than when pigs were marketed under the optimal marketing age or under tight schedules. With extremely tight schedules, the dietary concentration of Paylean should be increased, while with loose schedules, the Paylean concentration should be decreased slightly.

CONCLUSIONS

The feeding of Paylean with increased dietary concentrations of essential amino-acids and minor marketing changes can result in substantial increased net returns. The net returns from the feeding of Paylean increased as the payment for carcass lean percentage increased and as the fixed marketing schedules became relatively tighter. The optimal age of marketing Paylean pigs is 5 to 7 days less than pigs not fed Paylean.

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