

Proceedings *of the*



2nd LONDON SWINE CONFERENCE

The Pork Industry in the 21st Century -
Conquering the Challenges

April 11-12, 2002
London, Ontario



Proceedings
of the
LONDON SWINE CONFERENCE

**The Pork Industry in the 21st Century –
Conquering the Challenges**

Edited by
J.M. Murphy and C.F.M. de Lange

April 11th and 12th, 2002
London, Ontario

Proceedings of the London Swine Conference – Conquering the Challenges

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

The contents of this publication do not necessarily reflect the views of the editors and the steering committee of the London Swine Conference, nor does mention of trade names, commercial products, or organizations imply endorsement.

Copyright©2002 London Swine Conference

ISBN 0-9688770-0-2

CONTENTS

CONTENTS.....	iii
Chair's Message	v
Sponsors	vi
Steering Committee.....	vii
 HEALTH CHALLENGES	 1
Costs, Consequences and Control of Endemic Diseases	3
Threats and Consequences of Exotic Diseases	11
Meeting Endemic Disease Challenges	29
 CHALLENGES IN SWINE HOUSING AND BEHAVIOUR .	 39
Behavioural Consideration in Animal Transport Design	41
Causes and Prevention of Tail Biting in Growing Pigs: A Review of Recent Research..	47
Electricity Deregulation.....	57
 EMERGING OPPORTUNITIES AND CHALLENGES	 65
Changing Production Requirements	67
Swine Research at Guelph: Exploring Alternatives to Antibiotics	77
Understanding the Spread of Respiratory Disease in Nursery Pigs.....	83
Welfare Drivers of Production Practices: Where is the Animal Sector Going?	89

FACING THE CHALLENGES..... 95

Premium Pork Canada - Facing the Future.....97

Facing the Future.....99

**Understanding the Retail Sector: Towards Traceability in the Meat Production Chain
.....103**

BREAK-OUT SESSIONS “CONQUERING CHALLENGES” 115

Practical Tips and Guidelines for the Handling and Transport of Market Hogs.....117

Indoor Air Quality in Pig Buildings: Why is it Important and How is it Managed?121

Identification, Investigation and Implementation of Solutions to Health Problems137

CHAIR'S MESSAGE

Welcome to the 2nd Annual London Swine Conference!

Following a successful inaugural conference we are pleased to welcome you to the 2nd London Swine Conference.

The aim of this annual conference is to provide a platform to speed up the implementation of new technologies in pork production in Ontario and to facilitate the exchange of ideas within the swine industry. To achieve these aims we have invited internationally renowned speakers and experts in their field who will participate in this two-day conference through presentations, panel discussions and break-out sessions.

The theme of this year's conference is **"The Pork Industry in the 21st Century – Conquering the Challenges"**. Topics include swine health management, animal welfare, housing, records, research and the future pork production environment. Both practical swine management and key challenges, that will affect the future success of our industry, will be addressed.

A conference such as this would be impossible to deliver without the hard work of dedicated volunteers, the support of industry partners, and industry wide participation. Input from Ontario Pork, the Ontario Ministry of Agriculture, Food and Rural Affairs, and the University of Guelph has been critical for this conference to become a reality. We wish to thank our very generous sponsors, who have shown continued commitment to this initiative. In particular we would like to recognize the Ontario Pork Congress as the founding industry partner of the London Swine Conference and Better Pork as promoter of this event.

Enjoy the Conference!

Kees de Lange
Chair, Steering Committee
2002 London Swine Conference

SPONSORS

Industry Partner Sponsors

**Ontario Ministry of Agriculture, Food and Rural Affairs
Ontario Pork Congress**

Shared Corporate Sponsors

Acre T Farms Ltd.	Masterfeeds
BASF Canada	National Swine Genetics Inc.
BSC Animal Nutrition Inc.	Pfizer Animal Health
Clearwater Pork Inc.	Phibro Animal Health Ltd.
Farm Credit Canada	Schering-Plough Animal Health
Genex Ontario	Shamrock Genetics
Grand Valley Fortifiers	Shur-Gain/Maple Leaf Pork
Intervet Canada Ltd.	Swine Genetics Ontario Inc.
M&F Trading/PigCHAMP	

General Sponsors

ADM Animal Health & Nutrition Division	Huron County Pork Producers' Association
Agribrands Purina Canada Inc.	ITSI Inc.
Bio Agri Mix Ltd.	Kenpal Farm Products Inc.
Bodmin Swine Genetics	Minitube Canada
Danbred	Molesworth Farm Supply Ltd.
Design Concrete Systems Ltd.	Pharmacia Animal Health
Elanco Animal Health	Premium Pork
Elite Swine Inc.	Pureline Swine
Gencor	Vétoquinol N.-A . Inc.
Genetiporc Canada Inc.	Vista Villa Farms Ltd.

STEERING COMMITTEE

Chair:

Kees de Lange, University of Guelph

Facilities Sub-Committee:

Deb Campbell, Ontario Pork

Financial Sub-Committee:

Doug Richards, Ontario Pork

Promotions Sub-Committee:

* Keith Robbins, Ontario Pork

* Lilian Schaer, Ontario Pork

Steve Johns, Pfizer

Paul Nolan, Better Pork

Sponsorship Sub-Committee:

* Anne Donohoe, Anne Donohoe Enterprises

Technical Program Sub-Committee:

* Bob Friendship, University of Guelph

Helen Klemencic, University of Guelph

Janice Murphy, Ontario Ministry of Agriculture, Food and Rural Affairs

Andrew Pharazyn, Shur-Gain

Jaydee Smith, Ontario Ministry of Agriculture, Food and Rural Affairs

* denotes chair of sub-committee

HEALTH CHALLENGES

COSTS, CONSEQUENCES AND CONTROL OF ENDEMIC DISEASES

Gary Dial*, Chris Rademacher*, Barry Wiseman[†], Janelle Roker*, and Bradley Freking*

***New Fashion Pork, Inc., Jackson, Minnesota**

[†]Nextran, Inc., Princeton, New Jersey

INTRODUCTION

Now more so than ever, pig production is a competitive business. Producers are being forced to cut costs, just so that they can survive the competitive challenges proffered by other pork producers and other producers of meat protein. The optimization of revenues has become a dire necessity to those who want to continue making their living raising pigs. We have entered a stage in the competitive evolution of the pork industry when we are being forced to consider any technology promising an advantage either in terms of cost management or revenue enhancement. Fortunately, the developed world has put in place, over the last couple of decades, genetic programs in swine that are making us competitive with other producers of meat protein. These genetic advances have enabled us to take advantage of recent, highly promising scientific developments in nutrition and health. Consequently, most of us have begun to learn how to feed pigs and how to manage health influences on nutrient utilization. The intent of this paper is to highlight, in practical terms, contemporary knowledge on the costs and consequences of endemic diseases of pigs. A special emphasis will be placed on how diseases affect the growing pig. At the risk of adulterating good science with empirical observation, we will also describe the practical approaches that we use to control endemic diseases in our production system.

AN EMERGING MODEL FOR HOW DISEASE AFFECTS THE HOST

The epidemic manifestations (i.e. acute effects) of infectious agents are better understood than endemic effects. For example, we generally understand how Porcine Reproductive and Respiratory Syndrome (PRRS) virus affects fertility, abortion rates, and pre- and post natal survival. Similarly, most of us also have long understood that exposure of naïve growing pigs to *Mycoplasma hyopneumonia* (MHP) results in reduced growth performance, more variable growth rates, and higher mortality rates. What we have not understood well, at least until recently, is how endemic diseases affect the pig. Recent research has demonstrated that endemic diseases detrimentally influence pig performance without causing overt clinical signs. We have learned that infectious agents not only induce an immune response designed to clear the agent from the body but that the immune system induces cascading effects, many of them detrimental to growth, on the host's metabolic processes. Based upon replicated experiments conducted in several species, including the pig, a hypothesis is emerging which ties together the myriad of independent observations uncovered by contemporary science. This hypothesis links the health and immune function of the pig integrally with its nutrition through hormonal messenger systems. While it is still a hypothesis, the growing consensus of scientists working in the area is that technologies which minimize the activation of the pig's immune system will enhance the rate and efficiency of body weight growth while improving the deposition of carcass lean throughout the pig's life.

Several types of studies have been conducted in the pig investigating the effect of diseases on metabolism and immune function; they generally show highly similar results. Some studies have compared the metabolic and immune changes in segregated, early weaned (SEW) pigs versus pigs reared in traditional environments (Williams et al., 1997a,b,c). Others have contrasted the response of pigs exposed to specific pathogens with those of non-exposed pigs. Disease processes examined, thus far, include a variety of agents that currently challenge the modern swine industry, including: PRRS (Greiner et al., 2000), MHP (Escobar et al., 2002), *Actinobacillus pleuropneumonia* (APP) (Balaji et al., 2002), and *Salmonella typhimurium* (STM) (Balaji et al., 2000). Using an experimental model commonly used to study disease processes in other species, other investigators have contrasted the responses of pigs to lipopolysaccharide (LPS) extracts from the cell walls of *E. coli* to those of non-exposed pigs (Sauber et al., 1999; Wright et al., 2000). Collectively these studies demonstrate that during periods of health challenge, immune substances orchestrate a metabolic response to the infection such that nutrients are directed away from tissue growth in support of immune function. Even when serial disease challenges are subclinical in nature, there is a cumulative effect sufficient to cause significant alterations in metabolism with concurrent losses in performance.

METABOLIC EFFECTS OF DISEASE

Exposure of an animal to pathogenic (e.g. viruses, bacteria) or nonpathogenic substances (e.g. endotoxins present in the pig's environment) results in the release of immune substances from the inflammatory cells (e.g. macrophages) present in the blood and tissues (Klasing, 1988). These substances activate the immune system, reducing appetite and altering metabolic processes. The metabolic changes may include an elevation of the basal metabolic rate and a shift in how both ingested and stored nutrients are used by the body. There may or may not be a slight, transient elevation of body temperature in response to the body's release of inflammatory mediators combating the foreign invader. Not uncommonly, no outward manifestations of the endemic disease process are observed.

The body's hormonal system appears to be a key to the shift in metabolic processes. While it is less clear in the pig, the secretion of anabolic hormones, such as growth hormone (GH), is reduced in other mammalian species (Spurlock, 1997). Anabolic hormones stimulate the deposition of nutrients in tissues, and the development and proliferation of cells. Being dependent upon GH secretion, the release of other anabolic hormones, such as insulin-like growth factor (IGF) from the liver, is diminished following immune challenge. While the secretion of anabolic hormones is compromised, the release of catabolic hormones is stimulated. Catabolic hormones stimulate tissue breakdown and the mobilization of body stores of nutrients. Glucocorticoid hormones are released from the adrenal glands in response to the central actions of inflammatory substances on the brain. These prevent the deposition of nutrients, such as glucose and amino acids, in muscle, mobilizing them for use by the immune machinery as it fights off infections.

Collectively, the immune-mediated effects on the hormonal system induce a shift in the way nutrients in the body are transported and utilized. In animals challenged by infectious agents, glucose uptake by tissues is dampened as the body seeks to repartition energy to meet the energetic demands of the immune system. Products of the body's immune response to infection induce a resistance by the body's peripheral tissues to insulin, the hormone involved in glucose regulation. Consequently, glucose uptake by skeletal muscle and adipose tissue as well as key internal organs, such as the heart and liver, is compromised. Insulin, which functions in part to lower circulating levels of sugar by driving tissue uptake, is less able to preserve liver and muscle stores of glucose during periods of immune-system activation.

Protein and amino acid metabolism is also modified under immune challenge. During endemic infections, the liver augments its stores of amino acids so as to enable the body to meet its increased requirement for the amino acids incorporated into substances produced to combat infections. Blood flow to the liver as well as amino acid transport into cells is augmented during times of infection. The modification of liver function appears to be the consequence of the effects of the glucocorticoids on receptors in liver cells producing immune mediators (i.e. cytokines). In contrast to the liver, skeletal muscle uptake of amino acids is suppressed during periods of immunological stress.

In sum, it appears the peripheral tissues, such as skeletal muscle and adipose, are deprived of nutrients as a consequence of the orchestrated effects of immune substances on insulin responsiveness and glucocorticoid secretion. The net result is that immune responses precipitate a flux of amino acids from skeletal muscle pools to the liver. If the immune response is prolonged, skeletal muscle pools may be depleted of essential amino acids.

PHYSIOLOGICAL EFFECTS OF DISEASE

Protein. The accretion of protein in skeletal muscle reflects the balance between relative rates of protein synthesis and degradation. When animals are challenged by disease, protein synthesis is lowered while protein degradation is accelerated. As described in detail by Spurlock (1997), the balance between synthesis and degradation shifts toward degradation as a consequence of at least three things, two of which have been previously discussed. First, the release of immune substances following exposure to disease agents is often associated with reduced feed intake; thus, the body's supplies of amino acids are progressively consumed as the body's defenses wage an ongoing war against invading pathogens. Second, the immune responses mounted by the host to confront a infectious agent requires the consumption of amino acids in the synthesis of acute phase proteins from the liver and other products of immune tissue (e.g. antibodies). Lastly, because of the mismatch in the amino acid composition of muscle and immune products, the body is forced to catabolize a disproportionate amount of muscle in order to achieve the necessary complement of amino acids needed by the immune system. Thus, protein losses during an immunological challenge are greater than what can be sustained by feed intake, especially if it is reduced.

Skeletal muscle may not be the only source of protein used by the body during periods of infection. In other species beside the pig, the intestinal tract has been found to be a source of

amino acids required by immune synthetic processes. The body apparently is able to activate multiple proteolytic processes as it robs nutrients from tissues having a lower priority, making them available for the immune systems. It appears that the body will readily consume itself as it prioritizes resources for its fight with invasive challenges.

Fat. In addition to effects on protein synthesis, the catabolic processes initiated by immune-challenged pigs also encompass major shifts in fat metabolism. Typically, as energy is consumed during periods of immune activation, fat reserves are broken down as a source of energy. Immune substances secreted as the body fights off infections induce the expression of genes involved in the production of lipase enzymes. These enzymes cleave lipoproteins to triglycerides and then to free fatty acids and glycerol, which are used as energy by the immune system.

CONSEQUENCES OF DISEASE

Growth Performance. As mentioned, immune modulators cause reductions in appetite, divert nutrients from muscle to the immune system, and depress protein synthesis while stimulating protein degradation by skeletal muscle. Consequently, pigs endemically infected with disease agents experience reductions in average daily feed intake (ADFI), average daily body-weight gain (ADG), and the efficiency of conversion of feed to body weight gain (FCE). Differences between challenged and unchallenged pigs persist throughout the growth phase, from weaning to market (Williams et al., 1997 b,c). This prolonged effect of the immune system persists even though one would expect the pig to be less immunologically susceptible to pathogen challenge during the late growth phase. Poorer ADG and FCE are due, in part, to reduced ADFI. However, immune-mediated perturbations in anabolic and catabolic hormone release and associated metabolic shifts in muscle protein retention are thought to be the principle causes of reduced growth performance.

The amount of dietary lysine required to maximize ADG and FCE is greater for pigs that are not immune challenged versus those that are undergoing endemic infections (Williams et al., 1997 a,b). The reduction in lysine use by challenged pigs appears to be attributable, to a modest extent, to poorer digestibility (perhaps as a result of immune-mediated intestinal wall damage) and, to a greater extent, to a compromised ability to deposit protein. The higher protein accretion occurring in non-challenged pigs is associated with a higher demand for energy, particularly during stages of growth when energy intake is limiting. Health challenged pigs have a lower efficiency of energy utilization in association with the overfeeding of protein. Apparently, energy is consumed in challenged pigs in the elimination of excess protein. While nutrient needs for growth differ dramatically, maintenance requirements are similar for challenged and unchallenged pigs.

Carcass Characteristics. The carcasses of pigs that are health challenged have a lower protein:lipid content than those of non-challenged pigs (Williams et al., 1997 b,c). Pigs that are not exposed to pathogens accrue both protein and lipid at a faster rate than diseased pigs; however, the rate of fat accretion as a proportion of body weight is lower in unchallenged than challenged pigs. Carcasses from non-challenged pigs have less backfat, larger longissimus

muscle areas, and greater overall carcass muscle content than diseased pigs. In addition, pigs that have not undergone immune stimulation had lighter liver, heart, lungs and gastrointestinal tract weights and less leaf fat than immune-challenged pigs. In sum, these observations indicate that pigs that remain healthy throughout their growth period will have higher yields and a greater percentage of lean and primal cuts.

Pregnancy. Numerous studies have demonstrated that some pathogens have an affinity for the various tissues of the developing embryo or fetus. The consequences of such infections include: increased rates of abortion and pregnancy termination (resulting in lower farrowing rates), increased embryonic and fetal mortality (resulting in smaller born-alive litter sizes), and increased peri- and post natal mortality (resulting in smaller weaned litter sizes). In addition to these affects, the results of several recent studies, as reviewed by Spurlock (1997), suggest that immune challenge of the pregnant female also has more subtle affects on the developing fetus that include alterations in the metabolic processes of the placenta.

The fetal immune system becomes potent to respond to agents that cross the placenta as pregnancy advances. In a manner similar to the postnatal pig, fetal growth and development apparently is altered by challenges occurring during gestation. When exposed to foreign substances crossing the placenta, the immune system of the fetal pig precipitates metabolic changes, similar to the post natal pig, which divert nutrients from growth to the production of immune products. In addition, placental transfer of amino acids is compromised during periods when the sow is immune challenged, resulting in reduced nutrient availability to the developing fetus. The combined consequence of fetal immune system activation and maternal immune effects on the placenta is that the growth and development of the fetus is retarded, especially if the health challenge occurs during a critical phase of development. The result is lower birth weights, more variable birth weights, a higher proportion of low-viability pigs and fetal abnormalities.

Prenatal exposure to pathogens also appears to affect the proliferation and differentiation of tissue precursor cells (Spurlock, 1997). Substances associated with the immune response act synergistically to retard the differentiation of precursor cells for both muscle (myoblasts) and fat (adipocytes). The potential, therefore, exists for prenatal immune challenges to cause permanent alterations that are carried over postnatally to production and carcass traits.

Lactation. The exposure of lactating sows to lipopolysaccharide (LPS) has long been known to disrupt the secretion of hormones required for the maintenance of lactation (e.g. prolactin, GH, IGF). Sows exposed to LPS during lactation have depressed appetites, lower daily milk production and lighter litter weight gains. Total milk protein and milk energy are reduced in LPS-challenged sows, even though milk composition is not changed (Sauber et al., 1999). Apparently, immune-system challenge interferes with the mammary gland's ability to produce milk, when the amount of nutrients derived from the diet and mobilized from tissue reserves cannot match the needs of the body for both its immune response and milk production.

ENDEMIC DISEASES CHALLENGING THE SWINE INDUSTRY

All pathogens that cause an immune response in the host have the potential to disrupt metabolic processes, thereby interfering with nutrient utilization. The body mounts immune responses whenever any organ system is infected, whether the infection resides in the respiratory tree, the gastrointestinal or urogenital tracts, joints, or CNS. Blood-borne infections as well as localized infections of organs perturb the body's metabolism through effects on the immune system. In recent years, endemic diseases such as APP, swine dysentery, pseudorabies, mange, and lice have been largely eliminated from the herds of progressive producers. We call these Type 1 infections and believe that there is no excuse for producers tolerating infections of this type. Presently, approaches for the elimination of endemic infections with agents such as PRRS and MHP are being investigated. We call these Type 2 infections and believe that producers are currently under considerable pressure, for economic reasons, to eliminate endemic infections of their herds with these agents. In the future, it is likely that diseases such as *Salmonella cholerasuis* (SCS), ileitis, swine influenza virus (SIV), *Hemophilus parasuis* (HPS), *Actinobacillus suis* (AS), and *Streptococcus suis* (SS) will be targeted for elimination. These are Type 3 diseases. While we believe that endemic infections of these agents are economically important to the producer, they will be more difficult to eliminate from and/or keep out of a herd. Ultimately, we believe that swine producers will be forced by market forces and, perhaps, legal pressures to eliminate agents that are pathogens to humans but relatively inconsequential to the pig. We call these Type 4 diseases.

We speculate that as each of the Types 1, 2 and 3 diseases is sequentially eliminated, there will be a step-wise improvement in growth performance and, conceivably, increases in carcass value. As preventative and therapeutic treatments are reduced, facilities are used more efficiently, and productivity improves, costs of production will decline synchronous with the elimination of each endemic disease.

DISEASE CONTROL STRATEGIES

More because of the effects of endemic than epidemic diseases, the swine industry is likely to develop a growing intolerance of diseases. Historically, we have focused on diseases that cause mortality in growing pigs or infertility in the sow herd. In the future we will be increasingly concerned about diseases that chronically affect the growth performance of our pigs, reduce carcass value, and keep us from consistently weaning a high quality pig that does not carry infections with them into the growing phase. Approaches for managing endemic diseases will have near-term and long-term components.

Near-term Strategies. The near-term disease-control objectives for most producers are to (1) wean naïve pigs from sow herds that are endemically infected with either Type 1 or 2 pathogens and (2) keep them from becoming infected during the growing phase.

We believe that the health status of the growing pig herd is integrally related to the status of the breeding herd. Sow herds that have circulating PRRS, MHP or other agents will likely

pass on those agents to their offspring prior to weaning. Current strategies for reducing the occurrence of immune challenges of the growing pig herd include several technologies designed to first stabilize, then slowly upgrade the health of the commercial breeding herd.

- Populate gilt multipliers, genetic nucleus farms and boar studs with breeding stock that are free of Type 1 and Type 2 diseases.
- Wean naïve gilts into dedicated gilt development units, which are used to ensure that incoming gilts are immune to endemic diseases and non-shedding before they enter the commercial herd.
- Minimize litter-to-litter transfers of suckling pigs, so that moved pigs do not transfer infectious agents from an infected sow to the pigs from another litter.
- Establish separate breeding, gestation, and farrowing flows for gilts and sows within each breeding herd, so that gilts and sows are housed separately.
- Segregate pigs weaned from gilts from those coming from sows.
- Wean pigs a minimum of 16 days, so that they start well during the nursery phase; avoid weaning pigs more than 7 days older than the youngest pigs weaned in the group.
- Avoid co-mingling of pigs from multiple sow farms.

Once weaned, there are several production systems being used to keep the pig free of infection.

- Rear pigs all-in/all-out by barn and by site, as possible.
- Restrict the number of finishing barns on a site to what can be filled within 1 week.
- Use wean-to-finish technologies in place of conventional 3-site production.
- Place pigs in geographic pods of barns containing only pigs from the same sow farm source.
- Use vaccines when there are effective commercial or autogenous vaccines, and when it is likely that pigs will be exposed to an economically challenging agent (e.g. ileitis, salmonella, MHP, SIV).

Long-term Strategies. The long-term health objectives of producers will likely be to: (1) wean pigs from sow herds that are endemically infected with Type 3 pathogens, (2) control non-specific challenges to the immune system, and (3) eliminate the risk of consumers being exposed to contaminants in pork (i.e. food-borne pathogens of humans, antibiotics).

Production systems that we expect to be put broadly in place in the future include:

- Populate all commercial sow farms with high health breeding stock free of Type 1, 2 and 3 diseases.
- Populate all herds with breeding stock that is free of Type 4 agents having zoonotic potential to human consumers.
- Rear pigs in geographic areas where there is reduced likelihood of cross-contamination from nearby herds.
- Eliminate the use of feed-grade and non-therapeutic antibiotics and growth promotants.
- Increasingly broad use of specific vaccines to prevent pigs from becoming infected.

LITERATURE CITED

- Balaji, R., Wright, K.J., Hill, C.M., Dritz, S.S., Knoppel, E.L., and Minton, J.E. 2000. Acute phase responses of pigs challenged orally with *Salmonella typhimurium*. J. Anim. Sci. 78:1885-1891.
- Balaji, R., Wright, K.J., Turner, J.L., Hill, C.M., Dritz, S.S., Fenwick, B., Carroll, J.A., Zannelli, M.E., Beausang, L.A., and Minton, J.E. 2002. Circulating cortisol, tumor necrosis factor-alpha, interleukin-1 beta, and interferon-gamma in pigs infected with *Actinobacillus pleuropneumonia*. J. Anim. Sci. 8:202-207.
- Escobar, J., Van Alstine, W.G., Baker, D.H., and Johnson, R.W. 2002. Growth performance and whole-body composition of pigs experimentally infected with *Mycoplasma hyopneumoniae*. J. Anim. Sci. 80:384-391.
- Greiner, L.L., Stahly, T.S., and Stabel, T.J. 2000. Quantitative relationship of systemic virus concentration on growth and immune response in pigs. J. Anim. Sci. 78:2690-2695.
- Klasing, K.C. 1988. Nutritional aspects of leukocyte cytokines. J. Nutr. 124: 906-1003.
- Sauber, T.E., Stahly, T.S., and Nonnecke, B.J. 1999. Effect of level of chronic immune system activation on the lactational performance of sows. J. Anim. Sci. 77:1985-1993.
- Spurlock, M.E. 1997. Regulation of metabolism and growth during immune challenge: An overview of cytokine function. J. Anim. Sci. 75:1773-1783.
- Williams, N.H., Stahly, T.S., and Zimmerman, D.R. 1997a. Effects of chronic immune system activation on the rate, efficiency and composition of growth and lysine needs of pigs from 6 to 27 kg. J. Anim. Sci. 75:2463-2471.
- Williams, N.H., Stahly, T.S., and Zimmerman, D.R. 1997b. Effects of chronic immune system activation on body nitrogen retention, partial efficiency of lysine utilization and lysine needs of pigs. J. Anim. Sci. 75:2472-2480.
- Williams, N.H., Stahly, T.S., and Zimmerman, D.R. 1997c. Effects of level of chronic immune system activation on the growth and dietary lysine needs of pigs fed from 6 to 112 kg. J. Anim. Sci. 75:2481-2496.
- Wright, K.J., Balaji, R., Hill, C.M., Dritz, S.S., Knoppel, E.L., and Minton, J.E. 2000. Integrated adrenal, somatotropic, and immune responses of growing pigs to treatment with lipopolysaccharide. J. Anim. Sci. 78:1892-1899.

THREATS AND CONSEQUENCES OF EXOTIC DISEASES

**Terry Whiting
Veterinary Services Branch
Manitoba Agriculture and Food**

ABSTRACT

In all previous risk assessments for outbreaks of foreign animal disease (FAD) in North America, there was only consideration of the effect of accidental introduction of highly transmissible agents such as hog cholera or foot-and-mouth disease. The events of September 11th, 2001 in New York and Washington and subsequent Anthrax scares have changed the perception of risk related to FAD. For Canadian pork and swine industries which are heavily dependent on access to the US market, the impact of even a limited introduction of FAD into either the US or Canada would be immense. If a FAD were to be intentionally introduced, the resultant outbreak probably would not be a limited incursion. Current Canadian FAD preparedness plans have been lead by the National Veterinary Service (Canadian Food Inspection Agency, CFIA) and are focused on planning the operational activities related to stamping out the disease. These "eradication plans" do not consider the overall risk management and, specifically, no consideration is given to the consequential impacts of a significant domestic outbreak or an outbreak in the United States. Risk management and contingency planning for foreign animal disease must be extended to include other activities in addition to disease eradication and be extended to include industry and producers in the planning and funding.

INTRODUCTION

Biosecurity at one time meant a boot wash and controlled access to swine barns. The tragedy of September 11th has reminded us of the need for sector bio-security and brought the topic of "Biological Terrorism" to public forum. The threat of mail dissemination of Anthrax in the US and in other countries has raised serious concerns about wider implications. Thinking about bio-terrorism is often limited to the possibility of direct threats against the health of people. Another significant form of biological terrorism, which has escaped the eyes of media is "agricultural terrorism." For this discussion we will define bio-terrorism as *"the risk caused by potential deliberate acts to destabilize the health status of a population through disease or other health threats"* and bio-security as *"health plan or measures designed to protect a population from transmissible infectious disease...including emergency response"*.

The term's *emergency* and *disaster* are often used interchangeably in colloquial language. Emergencies result from incidents, regardless of their size, which are matched by adequate or nearly adequate resources. Emergencies are usually resolved quickly with minimal loss of most valued assets. Disasters result from incidents, regardless of their size, which are not matched by adequate resources. Disasters are slow to resolve and are accompanied by loss of most valued assets. The art of emergency management is to try and convert a potential disaster into an emergency. Some things that could contribute to an animal health-FAD

disaster are lack of resources, lack of political commitment to respond, failure of early detection, emergence of a type of incident that was hitherto unanticipated and malicious introduction. No one can anticipate every possible detail of all possible scenarios however; good management should be able to anticipate and plan for the probable and the likely. For instance, if hog cholera was identified in Michigan, no one should be surprised that the border crossings between Ontario and Michigan would immediately close to live animal movement. No one should expect that border to re-open for at least 60-90 days.

INFECTIOUS AGENTS

The Organization International de Epizooties (OIE), located in Paris, is recognized by the World Trade Organization as the expert reference center on animal diseases as they relate to international trade. The OIE classifies animal diseases into List A, List B and unlisted. List A diseases of swine do not occur in Canada and are very highly transmissible infectious agents with the potential for very serious and rapid spread, irrespective of national borders. List A diseases are of serious socio-economic or public health consequence and are of major importance in the international trade of animals and animal products. List B diseases are transmissible diseases that are considered to be of socio-economic and/or public health importance within countries and that are significant in the international trade of animals and animal products. Table 1 lists these diseases for swine.

The concept of transmissibility used in the OIE assessment of risk includes both consideration of the animal to animal transmission efficiency and the ability for some infectious agents to survive in pork and pork products. Most List A diseases of swine are infective agents that can survive in pork and pork products.

Table 1: Diseases considered economically important to the trade in live pigs and pork products in the international marketplace

List A	List B
Foot and mouth disease (FMD)	Atrophic rhinitis of swine
Swine vesicular disease	Enterovirus encephalomyelitis
Classical swine fever (CSF, Hog Cholera)	Porcine brucellosis
African swine fever	Porcine cysticercosis
Vesicular stomatitis	Porcine reproductive and respiratory syndrome
	Transmissible gastroenteritis (TGE)
	Anthrax
	Aujeszky's disease (Pseudorabies)
	Rabies

ROUTE OF ENTRY INTO A DISEASE FREE ZONE

The major risks of introducing a FAD into Canada come from uncontrolled live animal movement, uncontrolled animal product movement and the movement of people. The Canadian Food Inspection Agency (CFIA) and Canada Customs and Revenue Agency (CCRA) provide excellent control of the risk related to movement of live animals. Canada has only one land border and that is with the USA, a country at equivalent health status for all List A diseases. Live swine can not move undetected by air. The risk of accidental introduction of a FAD by international travelers without food products is also pretty low (Bridges & Cummings 1998). The risk associated with legal meat import is well documented and measures are in place to make this route of introduction of a FAD to Canada or the USA very unlikely (Callis JJ 1996, Metcalf HE et al 1996, Horst HS et al 1996). The risk of uncontrolled meat movement is considerably higher. One estimate of the amount of illegal food products entering the U.S. is between 450,000 and 4 million-kg annually (Corso B 1997). Contaminated meat products have the potential to infect swine with FMD, CSF, Swine Vesicular Disease and African Swine Fever. The feeding of human food waste to swine is a well-recognized method of transmitting FAD's across international boundaries.

Prior to the terrorist attacks on Washington and New York City on September 11th 2001, most thinking around risk of introduction of FAD into North America was related to the control of accidental introduction. Most risk management efforts were centered on the factors *import of livestock*, *import of animal products* and *swill feeding*. Malicious introduction has to be added to the list of potential routes of introduction of FAD into North America.

HISTORY OF AGRICULTURAL TERRORISM

In the past, despite many national level research programs in biological warfare, agricultural terrorism has rarely been used. During World War I the Germans inoculated horses and mules with Anthrax and shipped them from US ports to allies. This was Germany's largest biological sabotage program in which they attempted to infect cavalry and military livestock between 1915 and 1918 in Romania, Spain, Norway, Argentina and the US. Japan is also reported to have used animal and plant pathogens against Russia and Mongolia in 1940 (Kohnen, A 2000).

However there are numerous other incidents that suggest use of biological warfare, particularly in agriculture, during World War II. For instance, Britain accused Germany of dropping small cardboard bombs filled with Colorado beetles onto potato fields in southern England. Germany itself was worried about the possibility of an enemy introducing Colorado beetles into its fields. During the Cold War there were many allegations of biological warfare from both the sides. For instance, Cuba accused the US of attacking its people and crops with a variety of biological agents. The first documented case of agricultural terrorism, however, came up in 1952 when a group called Mau Mau used plant toxin to poison 32 steers at a Kenyan Mission (Kohnen A 2000).

The attack on the twin towers in New York City could be seen as an attack on a symbol of American economic power. Modern agriculture is certainly a symbol of North American excellence and may also have some symbolic target value to individuals and groups harboring anti-American or one-issue sentiments.

BIOLOGICAL WARFARE: THE ULTIMATE FAILURE OF BIOSECURITY

A question normally arises in the mind as to why one would use biological warfare when other forms of weapons are readily available. The answer is simple. While conventional weapons can be detected in metal detectors and other machines, biological warfare agents cannot be detected easily nor do they arouse suspicion. Also livestock and crops can be easily targeted. Although most farm buildings are somewhat secure, the public has access to pastoral animals, assembly yards and livestock trailers when stopped at fueling stations. Creating a bio-weapon to kill livestock and crops is not necessary. Animal and plant specific bio-weapons such as FMD/CSF already exist in other countries' animal populations.

Apart from their easy use, agricultural attacks are in many ways nearly risk free to the perpetrator. Agents infective to animals are not infective to people carrying out the attack. Agricultural targets are soft targets or ones that maintain a low level of security and destroying a pig or a cattle population or a standing crop, will also not risk as much world condemnation as the killing of people. In some societies, the killing of pigs would not bear any negative moral connotations at all, as pigs have a distinctly lower status than ruminants and poultry. Agricultural terrorism also carries an advantage of easy escape because of the time delay prior to identification of the crime as was the case with rabbit haemorrhagic disease virus (RHDV) which was illegally released in New Zealand in August 1997 (O'Keefe JS et al 1999).

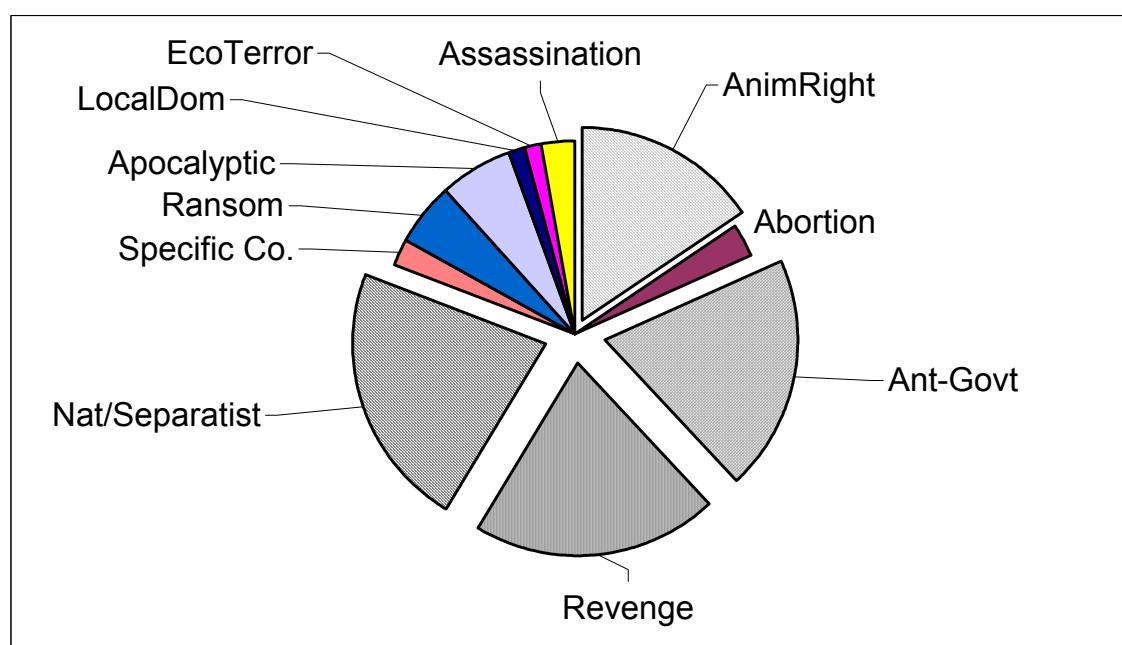
Terrorism is only possible where there are individuals or groups ideologically committed to an outcome with such conviction that they are willing to partake in criminal acts. In a recent review of 417 well-documented terrorist attacks since 1960 the most common motivation was political or ideological in nature (n=219) (Tucker JB 1999). Of the remaining cases, 160 were criminal in nature either to ransom money or to achieve revenge and only 38 were classified as state sponsored assassination (Figure 1). If history tends to repeat, then agriculture-based terrorism is most likely to come from ideologically based groups. There may be good rational to take very seriously animal rights groups and anti-US international movements. As Canadian agriculture and livestock production is very tightly aligned with US agriculture production any threat to US livestock is a threat to Canadian agriculture production.

IMPACT OF FOREIGN ANIMAL DISEASE

The financial impacts of FAD incursions are difficult to establish even in retrospect (Saatkamp HW et al 2000). One of the best-documented cases of a FAD eradication program was the 1997 CSF outbreak in the Netherlands. The outbreak involved 429 farms and lasted for 450 days and cost about 2.3 billion US\$ (Horst HS et al 1999a). In a Canada-US outbreak

the actual loss of infected livestock would probably cause miniscule financial damage in comparison to the justified trade restrictions which would immediately take place as allowed by and in compliance with international agreements made under the World Trade Organization. Even a limited outbreak of hog cholera anywhere in the US or Canada would have immediate and significant impact in live animal and pork movement at the US-Canada border.

Figure 1: Motivation for the attack in 147 cases of biological terrorism documented between 1960 and 1999 (Redrawn from Tucker, J.B. 1999). If you consider nationalist motivations, animal rights, and anti-government sentiment all to be forms of ideology, then ideology accounts for over 60% of the acts of bio-terrorism documented in this review.



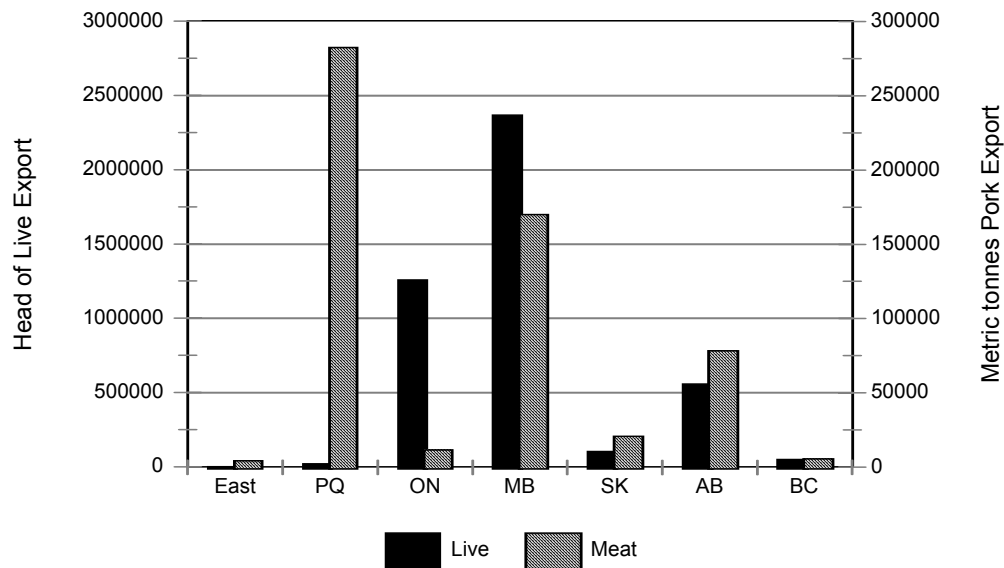
Manitoba and Ontario are particularly sensitive to export access for live pigs. The development of multi-site production in western Canada produces a very time-sensitive commodity in iso-weaned piglets (5-6 kg). Many iso-weaned piglets are exported to fairly specialized nursery facilities in the USA. Of the provinces of Canada, Quebec has the most mature pork production industry as export in live animals is primarily breeding stock and the overwhelming volume of exports are in finished pork product (Kellar, J. et. al. 2001) (Figure 2).

POTENTIAL ECONOMIC DAMAGE

The main tools of response to contain a FAD outbreak are animal movement restriction, immediate killing of infected and contact animals and active surveillance. In most eradication

operations animal movement restrictions or quarantine are applied to all animals at risk due to geographic proximity or due to recent contact (trace-in-trace-out).

Figure 2: Regional volumes of export in pork and live pigs in the year 2000. Hatched bar is pork export in metric tonnes (right axis) solid bar is live pigs exported (left axis). Quebec has a mature pork production chain with only finished product exported whereas Manitoba and Ontario are large exporters of live pigs. (Redrawn from Kellar, J. et. al. 2001).



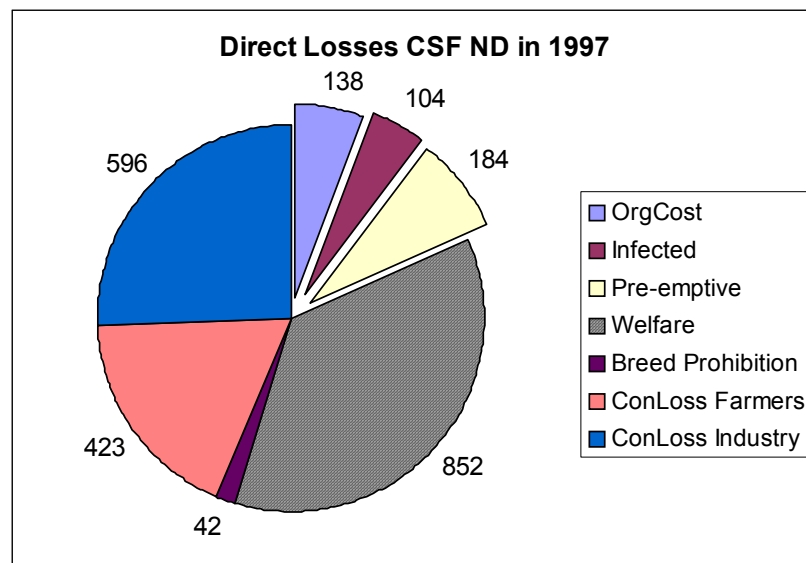
In Europe the costs associated with destroying infected herds represents a small component of the impact of eradicating CSF. In the standard EU stamping out protocol, all infected herds are depopulated as soon as possible. In the 1997 CSF outbreak in the Netherlands, more than ten million swine were destroyed (Meuwissen MPM et al 1999). Movement restrictions, in this case lasting 450 days, caused about five million disease free swine to exceed market weight (130kg) and be destroyed due to overcrowding on the farm of origin and a further four million uninfected weaner weight swine (25kg) were killed due to overcrowding. With the introduction of pre-emptive slaughter (the killing of herds' prior to the detection of disease), a large number of high-risk herds were also depopulated. However; destruction due to herd depopulation of both infected and high-risk herds is a small component of the overall numbers of pigs destroyed (Figure 3).

HUMANE ISSUES

The disease eradication response plan in the European Community includes the option to kill pigs for welfare reasons with full compensation to the farmer (Council Directives 80/217/EEC and 85/511/EEC)). Pigs killed for humane reasons are disposed of as infected material. Overcrowding will occur on fixed population farms (feeder barns) as pigs exceed market

weight. On breeding farms in addition to every pig growing and requiring more space, new pigs are being added to the population with each weaning.

Figure 3: Direct losses due to the epidemic of classic swine fever in the Netherlands in 1997 (From Horst, H.S. et. al. 1999a). The total cost was estimated at 2,339 million US\$. The numerical labels indicate the losses in million US\$ associated with that particular activity. OrgCost is the expense associated with administration and office support for the response program. Infected refers to the cost for compensation and destruction of infected farms. Pre-emptive refers to the cost of destroying herds in close proximity to infected herds or high-risk trace outs. Welfare is the cost of purchasing pigs from farms under quarantine for some time, due to pigs outgrowing the space available on the farm. In this outbreak, there was a breeding prohibition on some herds with compensation for down time. ConLoss refers to consequential losses to farmers and the related industries. In the current CFIA-FMD&CSF stamping out plan there is authorization for compensation (Federal monies via the CFIA) for Federal organizational costs and herds ordered destroyed due to infection and for preemptive slaughter in FMD only (Anon. CFIA 2001, Anon. CFIA 1997). If a large outbreak similar to Netherlands-CSF-1997 occurred in Canada, we would have 82% of the costs of the outbreak response unfunded under our current national FAD response model.



Quite early in the Netherlands 97-98 outbreak the volume of suspect pig meat was exceeding the rendering capacity of the country. A simple solution was to kill nursing piglets at 14 days of age, i.e. a smaller body weight, when a reasonable “value” for compensation could be established. After several weeks of consultation with industry the authorities went forward with piglet killing. It lasted about 3 days until public outcry put an end to it. Public outcry against piglet killing caused a return to raising weaners to 25 kg and killing as the farm became overcrowded. After a cooling off period, nursing pig slaughter was successfully re-initiated. This point emphasizes that the killing of healthy animals is not viewed as a morally

neutral decision in the eyes of the public. Humane issues are a significant risk to manage when planning for emergency situations requiring the destruction of animals.

NORTH AMERICAN SWINE PRODUCTION ORGANIZATION

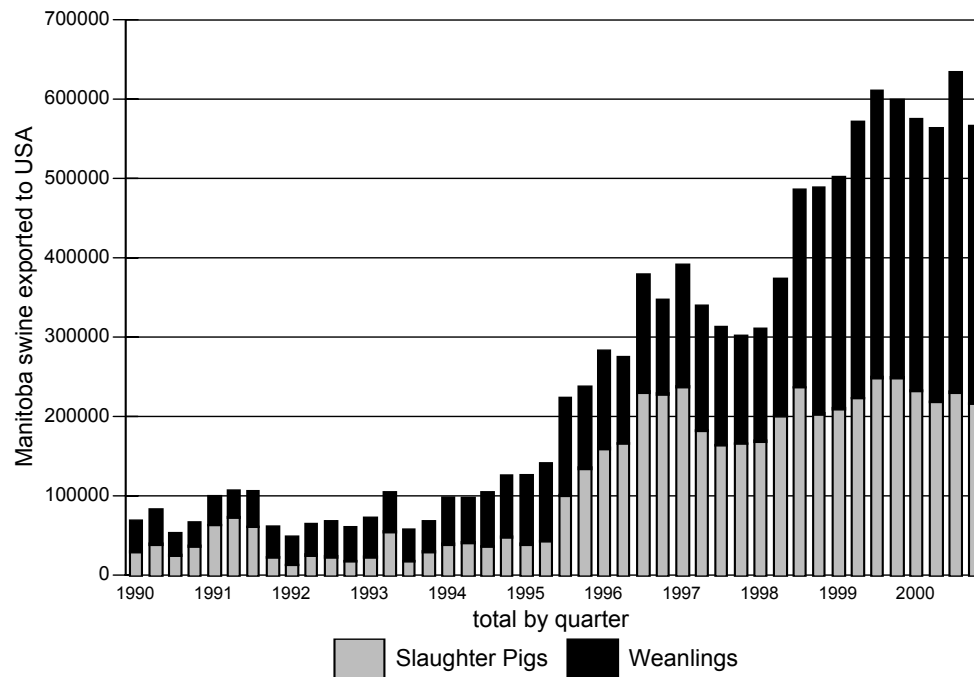
In conventional hog farming, as was most common through the '80's, pigs are born, weaned at around 30 days of age and raised to market weight often in the same building. At market weight the pigs are carrying the same profile of swine pathogens as the sow herd. Multi-site production systems (Harris DL 1999) have developed as a non-surgical method of deriving specific pathogen free pigs from infected sows and has been widely implemented in the past 5 years. Isowean effectively prevents the transmission of conventional disease agents between pigs of different ages. Inherent in iso-wean programs are all-in-all-out (AIAO) management strategies, disinfecting of premises between production batches, strict biosecurity measures and only housing pigs of the same age together. In isowean application, isolation is often best accomplished by moving the pigs to another location as an off-site nursery or to a separate wean to finish operation. Many isolated weaning production systems are large, as piglets must be grouped together within about 5-7 days of age, and managed as AIAO. To fill two 1000-head finishers, one for barrows and one for gilts per week, a pool of 5000 sows is needed. In addition to being large, isowean production is very sensitive to delays in, or problems with, pig flow.

Isowean also allows wide geographic separation between the place of a pig's birth and the location of the fattening unit. A portion of the feeder barns in the mid western USA are populated by piglets born in Manitoba and Ontario. In Manitoba, about 40% of the swine units are one-site (farrow to finish), while iso-wean based multi-site production units produce a further 40-45% of production. About 13% of commercial hog operations produce weanlings only, however this 13% of producers represents far more than 13% of the pigs born (Honey J 2000). In Manitoba, 5 major weanling producers combined produced about 500,000-600,000 weanlings in 2000. Manitoba exports about 1.5 million weanlings yearly and most of those come from weanling-only producers (Figure 4). Current data sources do not indicate how many weanlings are produced for sale to local feeder barns within Manitoba. A guess would be another 500,000-700,000 per year. This indicates that half of all pigs born in Manitoba originate on a weanling-only production site.

COST OF ANIMAL WELFARE CONCERNS

In large outbreaks of CSF in Europe the cost related to the killing of infected animals was only a small component of the overall response. In the 1997 Dutch outbreak the cost of killing infected animals was 104 \$US million, less than a quarter the cost of slaughter of animals under quarantine where the facilities became critically overcrowded (Meuwissen MPM et al 1999). To answer the question, is there any reason to suspect that a large outbreak in North America would behave differently, we can consider the planned eradication response and the structure of the industry.

Figure 4: Number of pigs exported to the USA from Manitoba by quarter in 1990-2000. In the calendar year of 2000, 1,439,872 feeder pigs (Isowean and weaner pigs) and 900,477 slaughter pigs (market hogs and cull sows and boars) were exported to the US from Manitoba. Total pig production for 2000 was 5,350,000, the preliminary estimate for 2001 hog production in Manitoba is 5.7-5.8 million head (J. Honey, MAF).



In the current Canadian draft strategy to respond to a FAD incursion, farms are declared infected upon laboratory confirmation of the disease (Anonymous, CFIA Draft CSF-1997, FMD-2001). Additional farms would be considered suspect and placed under quarantine if they were considered "trace-back" or if they fell in the infected or security zones. The initial infected zone would be a 3km radius around infected premises and the security zone a 10km wide radius around the infected zone. Manitoba is an area of low pig density by international standards and the impact of geographic based movement restrictions could be small. Some areas of Ontario may have somewhat higher hog concentration but, nothing like the European situation. With the development of multi-site production many systems are vertically integrated. With an estimated 50% of Manitoba sows currently in isowean production the impact of trace-back quarantine could be very significant. If a nursery barn was identified as infected; all feeder barns which purchased pigs from that nursery and all isowean facilities that sold pigs to that nursery in the past 90 days would probably be placed under quarantine. Quarantine would remain until clinical examination and serological testing could establish the *not infected* status of each trace out premises. Serological testing ability, ramping up to deal with volume demand and establishing confidence in serologic results would all take some time to develop.

Identifying FAD within a production chain could bring the whole chain under suspicion and therefore complete movement restriction for some time. In multi-site production there is very little holding capacity in some locations especially nursery pig production units (Bargen & Whiting 2002). The nurseries receiving piglets may be miles away and even on the other side of the US-Canadian border. Even in the case of a serious false alarm, it would be reasonable to expect a delay of at least 7 days to 2 weeks to allow testing and removal of the quarantine. A false alarm could be a Canadian herd that received pigs from or delivered pigs to US premises identified as infected. Even if the Canadian contact was eventually proven not to be infected that process would take some time. During those days of movement stand down, isowean production units would develop serious overcrowding. Isowean production facilities that could not be released from the movement restriction within a week would require veterinary intervention and welfare slaughter. In FAD contingency planning there is a need to recognize that early on in the response, veterinary resources will need to be diverted from direct disease control operations to concerns for the welfare of uninfected pigs under quarantine.

DISSECTING DUTCH SUCCESS

Despite some difficulties, the bio-security programs operating in the Netherlands were able to eradicate hog cholera in 1999 and foot and mouth disease in 2001. The evolution of funding, and the management structure for agriculture industries in the Netherlands is significantly different from the funding for the national Animal Health program delivered by the CFIA in Canada. Historically the Canadian National Animal Health Program, as represented by the bovine brucellosis and tuberculosis eradication initiatives was funded 100% from general revenue. Very few current programs in Canada other than National Security are funded in this manner. The current Canadian taxpayer may not be so willing to pay for expensive future animal health programs as was the case in the past. It is likely the current UK FMD outbreak will cost around 30 billion US\$, that is 30,000 million or 10X the cost of the Netherlands CSF outbreak.

In 1840 in the Netherlands, a regional check-off program based on cattle production was introduced to fund animal health concerns, with matching government funding introduced in 1850. The fund evolved to a stable administrative structure where by 1988 the government and the livestock industry "stamping-out" fund was applied to African swine fever, hog cholera, foot-and-mouth, swine vesicular disease and Newcastle Disease of poultry. Farmers whose operation was subjected to depopulation were paid full market value for healthy animals, 50% for clinically ill animals and nothing for animals which died of a reportable disease. This compensation program is designed to encourage early reporting of a suspect FAD where a FAD is identified every couple of years. In the early 90's obligatory farm biosecurity measures were introduced such as special clothing and boots, disinfecting facilities and for growing hogs, sourcing from 3 or less suppliers with identification of all pigs to herd of origin. Producers found out of compliance with these regulations at the time of depopulation, were discounted 35% on their compensation. If herd of origin could not be identified for market hogs ordered destroyed, compensation is zero (Horst, H.S. et. al. 1999a).

Both the Dutch government and the organized livestock industries contribute 50% to the stamping-out fund. The industry half of the fund is met by levy on producers. In 1998 a new levy structure was introduced where management practices associated with increased risk would be accompanied by an increased levy. So a 2,000 unit feeder barn sourcing from 3 nurseries would pay a higher levy per animal produced than a 2,000 unit feeder barn with a single source of feeder pigs. This is consistent with a philosophy that those who contribute most to the overall risk should contribute most to the financial reserves required to cover the consequences of disease outbreaks.

One of the down sides of the Dutch model is that funds derived from multiple sources are generally managed in cooperative approach. Decisions made in regards to the fund have to be made in consultation with the contributors and consultation takes time, a commodity in short supply during a FAD incursion (Enserink, M. 2001).

MINIMIZING THE IMPACT

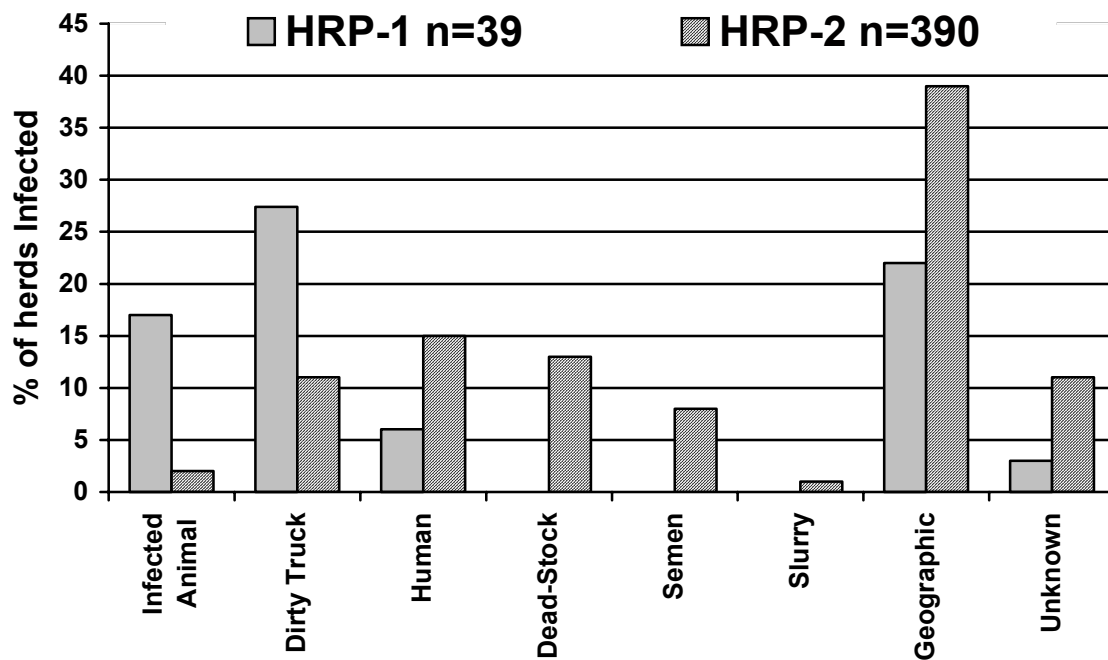
Natural Immunity

Canada is an isolated country with a single international border, fortunately, with the richest and most politically stable country in the world. As a sub arctic nation, most vector born diseases are also exotic. The risk associated with all this fortuitous animal health is complacency. The fact is security is so seductive, and insecurity is so frightening that there is a general difficulty in being objective about risks. However, security is always false, and insecurity is always real. Another hazardous by-product of our natural security is that we in Canada have not developed a culture to deal with changes in animal health risk nor have we made sufficient long term investments in preparedness. I would suggest the lack of a financial structure to compensate for losses related to FAD incursions is a risk to the sustainability of livestock production as we now know it.

How Big an Outbreak is Likely?

The major determinates of the final size of a FAD outbreak are described by the High-Risk-Period-1 (HRP-1), and HRP-2 (Horst HS et al 1998). HRP-1 is defined as the time period from when the infective agent is first introduced into a region and the first detection of infection. HRP-2 is the time from the detection of the agent until all herd to herd transmission has stopped subsequent to implementation of control measures. The Canadian HRP-1, for the CSF virus (time present in the country but not yet detected), would probably exceed the 1997 Netherlands HRP-1 which is accepted as between 21 and 42 days; introduced late Dec-Early Jan and identified on to Feb 4th 1997 (Horst et al 1999b). The HRP-1 for CSF is known to vary widely even within the EC (Horst et al 1999b). The Dutch veterinary infrastructure has a long history with CSF and considerable sensitivity in field and laboratory diagnosis. Prior to diagnosis, CSF will probably have been in Canada for at least 6-10 weeks. The Canadian HRP-2 for CSF, the time from identification to successful stoppage of herd-herd transmission is anyone's guess, as we have no data on which to base a speculation.

Figure 5: Method of introduction of CSF into 429 swine herds in the 97-89 Netherlands outbreak (From Elbers, A.R.W. et. al. 1999). Prior to identification of the emergency, HRP-1, movement of infected animals and dirty trucks were largely responsible for herd to herd transmission with some early geographic spread. Once the disease is identified these risks for transmission are addressed by animal movement controls. In this swine production area animals are at a very high land based stocking density of up to 3000 market hog equivalents per km². In North America only parts of North Carolina approach these stocking densities. It is unlikely that the geographic spread of CSF to neighboring farms as seen in the Netherlands would be repeated in Canada or in most pork production areas of the US.



The relative contribution of different forms of herd-herd transmission is well documented for the Dutch CSF outbreak (Figure 5). There are however significant differences in structure of production in North America and Europe. A major sector of the Canadian swine industry is organized as multi-site production and our concentration of swine per square kilometer is generally at least a log unit less than the Netherlands pork production zone. A strict geocentric model to predict CSF spread/control in Canada is probably inappropriate. So, the transmission of CSF by infected vehicles, fairly common in the Netherlands would be rare here. CSF transmission by geographic spread would be rare due to low stocking density in most Canadian production areas. CSF transmission by infected animal movement would probably be at least as important and proportionally greater than ND especially if the index herd was a weanling production unit. Multi-site production results in more swine movement and our relative lack of veterinary diagnostic sensitivity would result in a longer HRP-1. If first introduction was into an isolated finish facility and was detected early, there may be no spread at all.

In the EU experience, if more than 10 herds are infected the cost of humane slaughter always exceeds the cost of stamping out infected herds (Saatkamp HW et al 2000). It is hard to imagine a scenario in North America where CSF or FMD would be detected prior to the infection of more than 10 herds (Author may lack imagination).

There are three basic scenarios that one can imagine in the US-Canada swine market place in relation to FAD. Those are; a limited (1-2 state) or widespread (Multi-state) outbreak confined to the US, a limited outbreak confined to Canada, and an outbreak involving both Canada and US. Because the flow of live animals is predominantly from Canada to the US, it is hard to imagine a widespread outbreak in Canada, which did not involve the US systems. In North America the USA has roughly 10-times the human and animal population as Canada which would suggest 10-fold risk for the index herd in a FMD/CSF outbreak to be located in the US over Canada. The US has thousands of garbage feeding operations (Corso, B. 1997) compared with less than 100 in Canada. The Oklahoma City bombing and other recent incidents would suggest that the US might not have to shop internationally to find individuals capable of terrorist actions. It is therefore likely in a Canada-USA FAD outbreak that the index infected swineherd will be in the US. Paradoxically; with Canadian veterinary infrastructure and emergency planning resources focused on eradication of the disease in Canada, we are currently most prepared for the scenario least likely to happen.

Response

Control of a FAD in Canada-US would probably use the same tools as have proven effective elsewhere, which are the mechanisms of stamping out and movement restriction (Pluimers, F.H. et. al. 1999). We can be confident the initial response to a FAD introduction into either Canada or the USA or both, would include closure of the US-Canadian border. The border would remain closed until sufficient time had passed to assure regions were free of the disease and it was safe to move animals. In a limited distant outbreak, such as hog cholera in Florida, the border could open in 4-6 weeks based on what has occurred in the European Union under regionalization rules of international trade. If there was a multi-centered, outbreak or if both countries were involved, it would take longer to sort things out and return to normal. Manitoba is particularly sensitive to access to the US market for live animals, as we have about 6,000 pigs a day weaned in Manitoba with the nursery barn located in the United states (based on 1.5 million exported weanlings in 2000 and 260 business days).

CANADIAN ANIMAL HEALTH BIOSECURITY PROGRAM

A complete National or Regional bio-security program involves prevention, preparedness, response and recovery. Recognizing the importance of the "war against terror" it is important that nations and regions concerned must take adequate steps to protect their agriculture. In Canada the CFIA describes bio-security protocol at border crossings which is largely delivered by the Canada Customs and Revenue Agency (CCRA). CFIA also directly negotiates health certification requirements for the international trade in products of animal origin and live animals. Both of these systems work exceedingly well.

Some producers may feel confident that we are fully prepared to respond to a FAD outbreak. CFIA has a commitment to responding to eradicate a FAD identified in Canada, however; we can have a very substantial emergency in Canada without ever having FAD identified here. A US border closure does not currently trigger a federal response. The 2000 tripartate exercise would also suggest that even for eradication our North American partners and we are ill prepared (Speers, R. et. al. 2000). Many provinces are generating Foreign Animal Disease Eradication Plans (FADES). These plans are essentially designed to assist the CFIA in the stamping out of infected herds. Currently our "Preparedness" extends only to being able to respond to a limited outbreak (8-10 herds). Response has never been field tested in North America and there has been little effort into preparation for the recovery phase.

There is an ongoing need to educate our farmers and veterinarians about FAD recognition to increase the probability of early detection and early regulatory intervention to avoid spread to other areas. The provision of veterinary diagnostic capability has changed in much of Canada in the past 10 years, from Provincially supported central diagnostic laboratories to private laboratory services. Manitoba may be the only province in Canada with has retained a central veterinary diagnostic service. The impact of privatization of veterinary diagnostics on the ability to early detect an outbreak of FMD has not been evaluated to my knowledge.

CFIA is the lead agency recognized as responsible for the eradication of a FAD identified in Canada (Bowman & Arldni 1999). Currently the CFIA has authority to pay compensation for animals ordered destroyed because they are infected or have been in close contact with animals infected with a FAD. On February 5, 2001 Prime Minister Jean Chrétien announced the creation of the OCIPEP, the Office of Critical Infrastructure Protection and Emergency Preparedness. While the response structure for stamping-out infected herds is organized from Ottawa, all other emergency response models (fire, floods, tornado, earthquake) are organized at the sub-provincial level through provincial Emergency Measures Management Organization and Nationally through OCIPEP. The Minister of National Defense is the Minister responsible for OCIPEP, which will also encompass the previous functions of Emergency Preparedness Canada.

Foreign Animal Disease is a special type of emergency, which may stand outside current national emergency response structure. This may have been a good design feature when agriculture producers could count on national funding from General Revenue to provide for program delivery. Since our last FMD response in Saskatchewan in 1952 the Federal government has stepped back from program delivery in many areas. Even if a guarantee of central comprehensive funding was present, currently problems like welfare slaughter are not addressed in the National Plans. There is currently no pre-authorized funding for other losses, which would reasonably be expected consequential to the identification of a FAD emergency. Canada is a world leader in not subsidizing agriculture. At the provincial level Manitoba Agriculture and Food is working with the Emergency Measures Organization (EMO) to explore all options for a FAD emergency. Manitoba has a proven track record in responding to natural disasters like the periodic flooding of the Red River. EMO administers the Disaster Financial Assistance (DFA) Program. DFA may be available for eligible costs when a disaster creates an unreasonable financial burden. Assistance is generally provided to help local governments, individuals, full-time farmers, small business and some non-profit

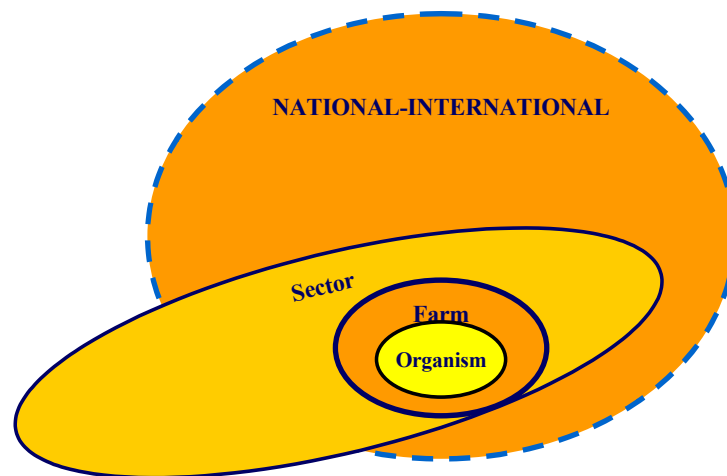
organizations. Government on an event approves provincial emergency programs and assistance is not available for loss of income and opportunity or inconveniences.

Biosecurity (Anti-bioterrorism) is a multidimensional program involving a wide range of participants. Experts suggest that such a program could be maintained and bioterrorism countered at four levels (Figure 6) namely: National, Sector, Farm, and the Organism.

Figure 6: Biosecurity can be assured at four levels:

1. at the **organism** level by breeding disease resistance eg. Scrapie in sheep, biotechnology in crops at this time;
2. at the **farm** level, by management techniques that prevent disease introduction and transmission;
3. at the agriculture **sector** level through early disease detection and response preparedness including funding for consequential losses;
4. and at the **national** level, through policies designed to minimize the societal and economic impacts of a catastrophic disease outbreak and minimize the risk of foreign animal disease introduction.

Modified From Kohnen A. 2000. She considered a sector to be clustered within a country. In Canada only supply-managed industries can be considered to be clustered within the country.



CONCLUSIONS

Biosecurity encompasses your farm, your region, the country and international risk management. In all, the challenge is to anticipate the threat, identify it early and counter it while the damage can be minimized. If a FAD were identified in Continental North America, it would be possible to have a significant impact in Manitoba and Ontario without the disease actually being in Canada. Very little preparation has been done to mitigate the risk of business interruption related to a FAD in North America. The pork industry at all levels - farmer, financier, and food processor - must have enhanced participation in all aspects of

biosecurity assurance. With heightened efforts we can hope to effectively protect animal agriculture, one of the economy's critical infrastructures

LITERATURE CITED

- Anonymous. May 2001. Foot-And-Mouth Disease Strategy. (Draft) Canadian Food Inspection Agency. Available from Dr. D. Geale, CFIA, Ottawa.
- Anonymous. Feb. 1997. Classic Swine Fever Strategy. (Draft) Canadian Food Inspection Agency. Available from Dr. D. Geale CFIA, Ottawa.
- Bargen, L.E. and Whiting, T.L. 2002. Time to critical overcrowding in isolated nursery barns placed under quarantine. Proceedings of the American Association of Swine Veterinarians Annual Meeting, Kansas City.
- Bowman, Q.P. and Arnlid M. 1999. Management of animal health emergencies in North America: prevention, preparedness, response and recovery. *Rev. Sci. Tech. Off. Int. Epiz.* 18(1):76-103.
- Bridges, V.E. and Cummings, D.J. 1998. The potential for international travelers to transmit foreign animal diseases to US livestock and poultry. USDA:APHIS:VS, Centers for Epidemiology and Animal Health, 555 South Howes Fort Collins, CO 80521.
- Callis, J.J. 1996. Evaluation of the presence and the risk of foot and mouth disease virus by commodity in international trade *Rev. Sci. Tech. Off. Int. Epiz.* 15:1075-1085.
- Corso, B. 1997. Likelihood of introducing selected exotic diseases to domestic swine in the continental United States of America through uncooked swill. *Rev. Sci. Tech. Off. Int. Epiz.* 16(1):199-206.
- Council Directive 80/217/EEC of 22 January 1980 introducing Community measures for the control of classical swine fever (with amendments from: 08/07/1993 last updated: 07/08/2000) available from http://europa.eu.int/eur-lex/en/consleg/main/1980/en_1980L0217_index.html
- Council Directive 85/511/EEC of 18 November 1985 introducing Community measures for the control of foot- and-mouth disease (with amendments) Available from http://europa.eu.int/eur-lex/en/lif/dat/1985/en_385L0511.html
- Elbers, A.R.W., Stegman, A., Moser, H., Ekker, H.M., Smak, J.A., and Pluimers, F.H. 1999. The classic swine fever epidemic 1997-1998 in the Netherlands: descriptive epidemiology. *Prev. Vet. Med.* 42:157-184.
- Enserink, M. 2001. Infectious diseases. Rapid response could have curbed foot-and-mouth epidemic. *Science* Oct 5, 294(5540):26-27.
- Harris, D.L. and Turney-Harris I. 1999. One site and multi-site swine rearing systems: Standardized nomenclature and alphaumeric notation. Proc. 7th Iowa State Univ. Swine Dis. Conf. pp. 135-147 .
- Honey, J. 2000. Manitoba livestock industry profiles 2000 Market Analysis and Statistics Section. Manitoba Agriculture and Food .
- Horst, H.S., Hurine, R.B.M., and Dijkhuizen, A.A. 1996. Eliciting the relative importance of risk factors concerning contagious animal diseases using conjoint analysis: a preliminary survey report. *Prev. Vet. Med.* 27:183-195.

- Horst, H.S., Dijkhuizen, A.A., Hurine, R.B.M., and de Leeuw, P.W. 1998. Introduction of contagious animal diseases into The Netherlands: elicitation of expert opinions. *Livest. Prod. Sci.* 53:253-264.
- Horst, H.S., Meuwissen, M.P., Smak, J.A., and Van der Meijs, C.C. 1999a. The involvement of the agriculture industry and government in animal disease emergencies and the funding of compensation in western Europe. *Rev. Sci. Tech. Off. Int. Epiz.* 18(1):30-37.
- Horst, H.S., Dijkhuizen, A.A., Hurine, R.B.M., and Meuwissen, M.P.M. 1999b. Monte Carlo simulation of virus introduction into the Netherlands. *Prev. Vet. Med.* 41, 209-229.
- Kellar, J., Lees, W., and Power, C. 2001. Protecting Canadian export markets of livestock and animal products through zoning. Canadian Animal Health Network, Canadian Food Inspection Agency, 3851 Fallowfield Rd., Nepean, Ontario K2H 8P9.
- Kohnen, A. 2000. Responding to the threat of agroterrorism: Specific recommendations for the United States Department of Agriculture. BCSIA Discussion Paper 2000-29, ESPD Discussion Paper ESPD-2000-04, John F. Kennedy School of government, Harvard University.
- Metcalf, H.E., Blackwell, J.H., and Acree, J.A. 1996. Application of risk assessment to international trade in animals and animal products. *Annal. N.Y. Acad. Sci.* 791:280-295.
- Meuwissen, M.P.M., Horst, S.H., Huirne, R.B.M., and Dijkhuizen, A.A. 1999. A model to estimate the financial consequences of classical swine fever outbreaks: principals and outcomes. *Prev. Vet. Med.* 42:249-270.
- O'Keefe, J.S., Tempero, J.E., Motha, M.X., Hansen, M.F., and Atkinson, P.H. 1999. Serology of rabbit haemorrhagic disease virus in wild rabbits before and after release of the virus in New Zealand. *Vet. Microbiol.* 66(1):29-40.
- Pluimers, F.H., de Leeuw, P.W., Smak, J.A., Elbers, A.R.W., and Stegeman, J.A. 1999. Classical swine fever in the Netherlands 1997-1998: a description of organization and measures to eradicate the disease. *Prev. Vet. Med.* 42:139-155.
- Saatkamp, H.W., Berentsen, P.B.M., and Host, H.S. 2000. Economic aspects of the control of classical swine fever outbreaks in the European Union. *Vet. Microbiol.* 73:221-237.
- Speers, R., Robinson, M., and Webb, M. 2000. Tripartite 2000 Exercise observations, comments and lessons learned. Operations Evaluation Group CNA Corporation. Available from <http://www.humanitarian.net/eidnet/fmd>
- Tucker, J.B. 1999. Historical Trends Related to Bioterrorism: An Empirical Analysis. *Emerg. Infec. Dis.* 5:498-504.

Other Reading

- Brown, C.C and Slenning, B.D. 1996. Impact and risk of foreign animal disease. *J. Amer. Vet. Med. Assn.* 208(7):1038-1040.
- Horst, H.S., DeVos, C.J., Tomassen, F.H.M., and Stelwahlen, J. 1999. The economic evaluation of control and eradication of epidemic livestock diseases. *Rev. Sci. Tech. Off. Int. Epiz.* 18(2):367-379.
- Knowles, N.J., Samuel, A.R., Davies, P.R., Kitching, R.P. and, Donaldson, A.I. 2001. Outbreak of foot-and-mouth disease virus serotype O in the UK caused by a pandemic strain. *Vet. Rec.* 148(9):258-9.

- Krystynak, R.H.E. and Charlebois, P.A. 1987. The potential economic impact of an outbreak of foot-and-mouth-disease in Canada. *Can. Vet. J.*28: 8 523-527.
- Ramsay, G.C., Philip, P., and Riethmuller, P. 1999. The economic implications of animal diseases and disease control at the national level. *Rev. Sci. Tech. Off. Int. Epiz.*18(2):343-356.

Electronic Sources

- Cain, S. Agroterrorism: A Purdue Extension backgrounder September 24, 2001
<http://www.humanitarian.net/eidnet/fmd/tripartite2000.html>
- Pate, J. and Cameron, G. "Covert Biological Weapons Attacks against Agricultural Targets: Assessing the Impact the Impact against U.S. Agriculture." BCSIA Discussion Paper 2001-9, ESDP Discussion Paper ESDP-2001-05, John F. Kennedy School of Government, Harvard University, August 2001. Available at
<http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/ESDP01Cameron>.
- Horn, F.P. Statement by Floyd P. Horn, Ph.D., Administrator, Agricultural Research Service U.S. Department of Agriculture Before the United States Senate Emerging Threats and Capabilities Subcommittee of the Armed Services Committee, October 27, 1999. Available at http://www.senate.gov/~armed_services/statemnt/1999/991027fh.pdf.
- National Emergency Response to a Highly Contagious Animal Disease, U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Available at
<http://www.aphis.usda.gov/oa/pubs/fco412.pdf>.
- National Association of State Departments of Agriculture FMD Resource Page. Available at
<http://www.nasda-hq.org/FMD/index.htm>.

MEETING ENDEMIC DISEASE CHALLENGES

Scott Dee, S. Otake, K.D. Rossow, L. Batista, C. Pijoan
Center for Swine Disease Eradication
University of Minnesota

ABSTRACT

Porcine reproductive and respiratory syndrome virus (PRRSV) is an economically significant pathogen in the global swine industry today. Introduction of PRRSV into naïve herds mainly occurs through infected pigs and semen. In order to reduce the risk of the entry of PRRSV into naïve swine populations, swine producers utilize stringent measures to enhance the biosecurity of their farms including quarantine and testing of incoming animal stock, testing of semen, showering-in/out of facilities, and personnel downtime (refraining from contact with swine 12 to 72 hours); however, infection of naïve herds still frequently occurs through unidentified routes. To establish adequate biosecurity protocols for PRRSV, it is first essential to understand possible transmission routes of PRRSV. Current data regarding transmission of PRRSV by non-porcine vectors (needles, fomites, aerosols, mosquitoes, and mechanical transmission during a coordinated series of events) are discussed below.

INTRODUCTION

In today's swine industry control and eradication of endemic swine diseases is a major issue facing producers and practitioners. One of the most challenging issues is PRRS. Porcine reproductive and respiratory syndrome virus (PRRSV) is an economically significant pathogen in the global swine industry today. PRRSV induces persistent infection in sows, boars and weaned pigs, leading to shedding and transmission of PRRSV between herds and within endemically infected farms. The role of the breeding herd in the epidemiology of PRRSV is now well understood. Within this key population, it is now known that subpopulations of PRRSV-naïve, exposed and infected animals can co-exist, and persistently infected animals can transmit virus to naïve contacts over extended periods of time. Furthermore, genetically diverse isolates of PRRSV can co-exist and circulate within an individual farm. Finally, eradication strategies have been developed to eliminate infected breeding animals and appear to be quite efficacious.

Despite the success of PRRS eradication programs, the risk of re-infection is high. Introduction of PRRSV into naïve herds occurs through infected pigs, semen and non-porcine vectors. In order to reduce the risk of the entry of PRRSV into naïve swine populations, swine producers utilize stringent measures to enhance the biosecurity of their farms including quarantine and testing of incoming animal stock, testing of semen, showering-in/out of facilities, and personnel downtime (refraining from contact with swine 12 to 72 hours); however, infection of naïve herds still frequently occurs through unidentified routes. To establish adequate biosecurity protocols for PRRSV, it is first essential to understand possible transmission routes of PRRSV.

My work over the last 3 years at the University of Minnesota College of Veterinary Medicine has been devoted entirely to PRRSV. Therefore, I would like to use PRRSV as a model pathogen to address the topic assigned to me today. In this paper we will characterize the dynamics of the endemically infected breeding herd in an effort to gain an improved understanding of why PRRSV control has been such an elusive target. We will also discuss how PRRSV is transmitted, focusing primarily on current data regarding transmission of PRRSV by non-porcine vectors (needles, fomites, aerosols, mosquitoes, and mechanical transmission during a coordinated series of events).

PART 1: CHARACTERIZING ENDEMIC PRRSV INFECTION IN THE BREEDING HERD

PRRSV persists in boars ^{1,2} .

PRRSV, being a member of the *Arteriviridae* has a propensity for persistence within the male reproductive tract, and can be shed through the semen. With the global swine industry becoming increasingly dependent on the use of artificial insemination, this important fact must be considered first and foremost when discussing not only eradication, but also control and prevention of PRRSV infection of existing and start-up operations.

PRRSV subpopulations exist in chronically infected breeding herds ³ .

Within endemically infected breeding herds, PRRSV-positive and PRRSV-naïve adult swine can co-exist. Serial profiling of randomly selected sows has indicated that while some animals remain seronegative, others become seropositive, suggesting that transmission of the virus is very sporadic and exposure is inconsistent over time. This is particularly evident in large (> 1000 sows) breeding herds.

Improper replacement gilt management plays a major role in the maintenance of the viral transmission and the disease process ⁴ .

Similar to porcine parvovirus, uncontrolled introduction of PRRSV-naïve or acutely infected gilts perpetuates circulation of the virus within the breeding herd, resulting in recurrent episodes of PRRS reproductive disease, and the maintenance of subpopulations.

Closure of the breeding herd reduces PRRSV circulation ⁵ .

Early data from the field indicated that by adapting an internal multiplication program or a short-term cessation of replacement stock entry in combination with the segregation of the gilt and sow populations, it was possible to reduce the level of exposure in both groups. Serum profiling during the closure period indicated a statistically significant reduction in PRRSV-antibody prevalence in gilts and sows over time.

Endemically infected breeding herds contain foci of PRRSV-infected animals and the extent of shedding is limited ⁶ .

Diagnostic samples collected during whole-herd testing procedures suggest that PRRSV-infected animals tend to cluster together in small groups, and the percentage of sows that are serum PCR positive can range from 1 to 2 %. Furthermore, ELISA-positive sows are

normally distributed within clusters, suggesting that exposure to virus is limited to a few animals on a given day.

Genetically diverse strains of PRRSV can co-exist in a single infected farm ⁷.

Molecular sequencing of PRRSV nucleic acid recovered over a 12-month period from a chronically infected farm indicated that different strains of PRRSV that had not risen from one another by a mutation or a recombination event could co-exist and circulate within a farm. Based on both nucleotide and amino acid patterns, heterogeneity across sequences ranged from 5.8 to 11%, and viruses appeared to cluster into 1 of 3 phylogenetic groups.

The prevalence of PRRSV-positive carrier sows in an infected breeding herd is low ⁸.

This work summarized the percentage of carrier sows detected from an infected field population that had been closed for 6 months to the introduction of replacement stock. Results indicated that the level of chronically infected breeding animals was low in the population sampled (1 out of 60 animals (1.7%)), and the infected animal was detected during the ninth month following closure. PRRSV was originally isolated from lymphoid tissues and confirmed by immunohistochemistry and swine bioassay. Experimental infection of 95-day pregnant sows resulted in the production of either clinically affected litters of fetuses, or entire litters of fetuses that were grossly and microscopically normal, but infected with PRRSV.

Tonsil biopsy is not an efficacious ante-mortem method for identifying chronically infected sows ⁹.

Results from this study indicated that when applied to breeding animals, biopsy of tonsil tissue possessed a number of flaws including the inability to consistently collect tonsil samples, and resulted in injury to the animal. Furthermore, it was capable of generating false negative results due to the fact that virus frequently resides in sites other than tonsil in adult swine.

PRRSV can persist in sows and persistently infected animals can shed virus to naïve contacts ¹⁰.

An experimental model for PRRSV persistent infection in non-pregnant sows was established and tested. Specific clinical and diagnostic criteria were used to insure that the animals had progressed beyond the acute phase of the infection. Naïve contact controls were introduced 42 or 56 days post-inoculation (pi), and placed in fence-line contact with index sows. Shedding of virus to contact controls was detected in 3 of the 12 replicates, at 49, 56, and 86 days post-infection of the index sows. At necropsy, PRRSV nucleic acid was detected by PCR in multiple sites of the remaining non-shedding index sows at 72 or 86 days post-infection, indicating that these animals had the potential to shed.

PRRSV persistence and shedding in a population of breeding age females is of short duration ¹¹.

A recently completed study conducted on our SDEC research farm suggested that when a population of breeding age females (120 4-month old gilts) are infected with a known concentration of PRRSV on a given day, shedding to naïve sentinels does not occur after 90 days pi, and PRRSV cannot be detected beyond 120 days pi.

PRRSV can be eliminated from swine herds ¹².

The combined techniques of test and removal in the breeding herd and partial depopulation of the weaned pig population successfully eliminated PRRSV from a number of seedstock swine operations in the US. All farms were monitored for a minimum of 12-months prior to completion of the study, and all remain negative (> 2 years) at this time. These papers proved that PRRS eradication was possible, and has initiated widespread efforts towards eradication around the world.

PART 2: TRANSMISSION OF PRRSV BY NON-PORCINE VECTORS

Needles ¹³

Introduction & Objectives

In commercial swine farms, pigs receive numerous injections of vaccine and antibiotics. Typically, producers rarely change needles between individual pigs due to cost and labor constraints. Therefore, we conducted a study to evaluate the potential for transmission of PRRSV from infected to susceptible pigs by needles.

Materials & Methods

Fifteen 4-week-old pigs from a PRRSV-naïve source were organized into 3 groups. Group 1 pigs (n=10) were experimentally infected with 2 ml of PRRSV VR-2332 at the concentration of 10^5 TCID₅₀/ml by the intranasal route (Infected group). On day 5, 6, and 7 pi, attempts to transmit PRRSV from Infected group to Group 2 (Sentinel group, n=3) took place. A designated person administered 2 ml of vaccine (killed *Mycoplasma hyopneumoniae* bacterin) to all pigs in Infected group. Following injection of all pigs in the Infected group, the needle and syringe were transferred to the Sentinel group room. The designated person immediately moved into Sentinel group following changing fomites (coveralls, boots, gloves, and hairnet) and shower, and injected all pigs in the Sentinel group using the same needle. The PRRSV status of the Sentinel group was monitored for 21 days following the injection.

Results

Transmission of PRRSV from Infected to Sentinel group was demonstrated in 2 out of 4 replicates. PRRSV isolated from Group 2 sentinel pigs was sequenced and found to be homologous to the virus used to infect Group 1 pigs.

Conclusions

Contaminated needles can transmit PRRSV to naïve pigs following the vaccination of infected pigs. Pork producers should be strongly encouraged to change needles between sows, litters, and pens of growing pigs.

Fomites (coveralls, boots)/personnel ¹⁴

Introduction & Objectives

Because all routes of PRRSV entry into naïve farms are not known at this time, farm owners frequently require employees and visitors to comply with strict sanitation protocols prior to

entry. These protocols range from changing clothing and footwear, showering in/out of the facility, refraining from having contact with swine for 12-72 hours (downtime), and are commonly referred to as “biosecurity protocols”. Despite their widespread acceptance in the industry today, the scientific foundation for the efficacy of such protocols is lacking. Therefore, we attempted to evaluate the ability of contaminated fomites (coveralls and boots) and personnel to transmit PRRSV to susceptible pigs following the use of specific sanitation protocols commonly practiced in the swine industry today.

Materials & Methods

Twenty-four 4-week-old pigs from a PRRSV-naïve source were organized into 6 groups. Group 1 pigs (n=10) were experimentally infected with 2 ml of PRRSV VR-2332 at the concentration of 10^5 TCID₅₀/ml by the intranasal route (Infected group). On day 5, 6, and 7 pi, personnel were exposed to saliva, nasal exudate, feces, and blood of all Infected group pigs and attempts were made to transmit PRRSV to 4 sentinel groups (Groups 2-5, n=3). These groups were organized according to the use of specific sanitation protocols. Group 2 was designated as the Direct Contact group. Following contact in infected Group 1 pigs; the person designated for this group did not change fomites (coverall and boots) or wash hands, prior to contact with sentinel pigs. In contrast, personnel designated for Groups 3-5 were required to complete specific sanitation protocols, including changing fomites and washing hands (Danish system/Group 3); changing fomites, shower, and 12-hour downtime (Standard Protocol/Group 4); changing fomites, shower, and no downtime (Alternative Protocol/Group 5). PRRSV infection status of all sentinel group pigs was monitored for 21 days following the exposure.

Results

Transmission of PRRSV from the Infected group to the Direct Contact group occurred in 2 out of 4 replicates. PRRSV isolated from Direct Contact group pigs was sequenced and found to be homologous to the virus used to infect the Infected group pigs. No transmission occurred between Infected group and sanitation protocol groups including Danish system, Standard Protocol, or Alternative Protocol. PRRSV was detected from contaminated coveralls, boots, and hands of personnel following contact with Infected group pigs. Detected virus was sequenced and found to be homologous to the index virus and positive by swine bioassay. No virus was detected from fomites and personnel (hands, hair, nares, and tonsil) following the sanitation protocols.

Conclusions

Contaminated coveralls, boots and hands of personnel can transmit PRRSV to naïve pigs following the direct contact with infected pigs. Under the conditions set by this study, all sanitation protocols were effective in preventing the transmission of PRRSV by fomites or personnel from infected to naïve pigs. Producers and practitioners should consider changing coveralls, boots, and washing hands between production stages that differ in the PRRSV status on one-site farms, or between buildings and sites within segregated systems.

Aerosols¹⁵

Introduction & Objectives

The role of aerosol transmission of PRRSV is still under debate at this time. Published data indicate that the spread of PRRSV can only occur over very short distances (.46-1 m) under experimental conditions¹⁶⁻¹⁸. However, it is not known whether similar results would be obtained under field conditions, involving large populations of animals and environmental factors. Therefore, it was necessary to conduct the study to assess the possibility for aerosol transmission of PRRSV under field conditions.

Materials & Methods

A total of 210 five-month-old PRRSV-negative pigs were housed in a mechanically ventilated finishing facility consisting of 11 pens. Pen 1 contained 10 pigs (indirect contact controls). Pen 2 remained empty, providing a barrier of 2.5 meters from the remaining pigs in pens 3 to 11. Within pens 3 through 11, 15-16 pigs in each pen were experimentally infected with a field isolate (MN-30100) of PRRSV and 6-7 pigs in each pen served as direct contact controls⁸. On day 5 pi, 2 trailers (A and B) containing 10 five-week-old PRRSV-naïve sentinel pigs were placed along each side of the building. Trailer A was placed 1 meter from the exhaust fans on one side of the building, while trailer B was positioned 30 meters from the fans on the other side. The sentinel pigs remained in the trailers for 72 consecutive hours in order to provide continuous exposure to fan exhaust. Following the exposure period, pigs from each trailer were moved to one of 2 separate buildings located on the same site, 30 and 80 meters respectively, from the infected barn. In the separated buildings, the PRRSV status of the sentinel groups was monitored for 21 days.

Results

Transmission of PRRSV was detected in direct contact control pigs (day 3 pi of index pigs) and indirect contact control pigs (day 7 pi of index pigs) in the facility. Virus isolated from the direct and indirect contact control pigs was sequenced and found to be homologous to the index virus. PRRSV infection was not detected in trailer A and B sentinel pigs. Weather data for the farm area collected during the exposure period suggested that this study was conducted under the conditions thought to support viral survivability (low temperature and high humidity); however, no PRRSV was detected by all-glass impinger from the exhaust air emitted from the infected facility.

Conclusions

While PRRSV may be transmitted over short distances with infected animal air space, aerosol transmission of PRRSV between farms seems to be an infrequent event.

Mosquitoes¹⁹

Introduction & Objectives

Potential transmission routes of PRRSV that have not been explored are insects. Insects have long been known to serve as mechanical or biological vectors of certain swine pathogens; however, currently practiced methods of biosecurity do not regulate the entry of insects into swine herds²⁰. Since PRRSV infection results in prolonged viremia in infected pigs²¹ and blood-borne transmission of PRRSV by contaminated needles has been described earlier, it was hypothesized that insects, particularly hematophagous species such as mosquitoes, may

be vectors of PRRSV. Therefore, we conducted the studies to evaluate the potential for transmission of PRRSV by mosquitoes

A. On-Farm Observation:

Materials & Methods

Approximately 550 mosquitoes were collected at a PRRSV-infected commercial swine farm. Collected mosquitoes were pooled (10-30/sample), homogenized, and tested by PCR, VI, and bioassay.

Results

PRRSV nucleic acid was detected by PCR in 6 out of 22-mosquito homogenate samples (1 sample of PCR-positive, 5 samples of PCR suspect) and PCR-positive sample tested by bioassay and found to be infectious. Detected RNA was sequenced and found to be 100% homologous to the virus isolated from pigs in the farm. All mosquito homogenates were VI-negative.

Conclusions

Homologous infectious PRRSV can be transferred from infected pigs to mosquitoes.

B. Experimental data:

Materials & Methods

A total of 4 replicates were conducted. During each replicate, 300 mosquitoes (100 mosquitoes/day) over the period of day 5, 6, and 7 pi were allowed to feed for 30-60 seconds on a PRRSV-inoculated viremic pig housed in an isolation room. Feeding was interrupted and mosquitoes were manually transferred by small plastic vials, and feed to repletion on a naïve recipient pig in a separate room. Following the cessation of feeding, mosquitoes were immediately placed on dry ice, homogenized, and supernatant tested by PCR, VI, and swine bioassay for PRRSV. Separate personnel (n=3) were designated to handle donor pig, recipient pig, and the transfer of vials. The identical procedure of transferring vials from donor to negative control pig, voiding of mosquitoes, was carried out in each replicate to insure that the transfer process itself was not the source of contamination (protocol control procedure). Additionally, swabs were collected from the exterior surfaces of vials in the recipient pig room and tested by PCR, VI, and swine bioassay for PRRSV to insure that the vials contacted to the recipient pig were not contaminated with PRRSV from the donor pig. PRRSV status of the recipient pig was monitored for 21 days following the exposure.

Results

Transmission from the donor to the recipient pig was demonstrated in 2 of 4 replicates. PRRSV isolated from the recipient pigs was homologous to the virus used to infect the donor pigs. Either PCR or bioassay from mosquito homogenates following feeding on both the donor and recipient pigs in all replicates detected PRRSV. Detected PRRSV was 100% homologous to the index virus. During all replicates, the protocol control pigs remained PRRSV-negative, and PRRSV was not detected from swabs collected from exterior surface of vials.

Conclusions

Mosquitoes can serve as mechanical vectors of PRRSV; however, further studies are needed to evaluate the role of mosquitoes in transmission of PRRSV throughout commercial swine producing areas.

Mechanical transmission of PRRSV by a coordinated sequence of events during cold weather²²

Introduction & Objectives

The purpose of this study was to develop and test a model to assess whether PRRSV could be mechanically transmitted to naïve pigs following a coordinated sequence of events during a period of cold weather. The study was based on the hypothesis that mechanical transmission of PRRSV during periods of cold weather is a frequent event. The model involved situations commonly encountered by swine producers and practitioners during the course of a typical working day, combined with attempts to track the virus using a battery of diagnostic tests, to determine whether contaminated fomites could serve as a source of PRRSV to naïve pigs.

Materials & Methods

The sequence of events that made up the model were as follows:

Cold weather enhanced the survival of PRRSV outside of the host.

Contamination of the exterior of a transport vehicle occurred following exposure to PRRSV on an infected premise.

During the process of cleaning the vehicle at a commercial truck wash, unintentional contamination of footwear led to the introduction of PRRSV into the vehicle's cab.

Long distance transmission of PRRSV onto a second premise occurred via the vehicle and the virus gained entry into a swine facility via contaminated footwear.

Specific environmental factors enhanced the survival of PRRSV within the facility, leading to the contamination of fomites destined for entry into the animal airspace.

Contact with contaminated fomites led to infection of PRRSV-naïve pigs.

Results

As of this writing, the study was under way. Further information will be presented at the Conference.

Conclusions

Results from this study appear to suggest that during optimum conditions for survival of PRRSV outside of the pig, mechanical transmission is a frequent event. These results have also identified new areas of risk (cab of vehicle, farm anteroom, containers, etc) that need further evaluation.

CONCLUSIONS

- Needles can transmit PRRSV to naïve pigs following the vaccination of infected pigs.
- Fomites (coveralls, boots) and hands of personnel can transmit PRRSV to naïve pigs following the direct contact with infected pigs.
- Aerosol transmission of PRRSV over long distances appears to be an infrequent event.

- Mosquitoes can serve as mechanical vectors of PRRSV.
- Mechanical transmission of PRRSV during periods of cold weather is a frequent event.

LITERATURE CITED

1. Christopher-Hennings, J., Nelson, E.A., and Benfield, D. 1998. Identification of porcine reproductive and respiratory syndrome virus in semen and tissues from vasectomized and non-vasectomized boars. *Vet. Pathol.* 35:260-267.
2. Swenson, S.L., Hill, H.T., and Zimmerman, J.J. 1994. Excretion of porcine reproductive and respiratory syndrome virus after experimentally induced infection in boars. *JAVMA.* 204:1943-1948.
3. Dee, S.A., Joo, H.S., Henry, S., Tokach, L., Park, B.K., Molitor, T.W., and Pijoan, C. 1996. Detecting subpopulations after PRRS virus infection in large breeding herds using multiple serologic tests. *Swine Health and Production.* 4:181-184.
4. Dee, S.A. and Joo, H.S. 1994. Clinical investigation of recurrent reproductive failure with PRRS virus in a swine herd. *JAVMA.* 204:1017-1018.
5. Dee, S.A., Joo, H.S., and Pijoan, C. 1994. Controlling the spread of PRRS virus in the breeding herd through management of the gilt pool. *Swine Health and Production.* 3:64-69.
6. Dee, S.A., Molitor, T.W., and Rossow, K.D. 2000. Epidemiological and diagnostic observations following elimination of PRRS virus from a breeding herd of pigs by the test and removal protocol. *Vet. Rec.* 146:211-213.
7. Dee, S.A., Torremorell, M., Rossow, K., Otake, S., and Faaberg, K. 2001. Identification of genetically diverse sequences of PRRSV in a swineherd. *Can. J. Vet. Res.* 65:254-260.
8. Bierk, M.D., Dee, S.A., Rossow, K.D., Collins, J., Guedes, M.I., Pijoan, C., and Molitor, T.W. 2001. A diagnostic investigation of chronic PRRS virus infection in a swine breeding herd. *Vet. Rec.* 2001; 148, 687-690.
9. Bierk, M.D., Dee, S.A., Rossow, K.D., Collins, J., Guedes, M.I., and Molitor, T.W. 2000. Experiences with tonsil biopsy as an ante-mortem diagnostic test for detecting PRRS virus infection in breeding swine. *Journal of Swine Health and Production.* 8: 279-282.
10. Bierk, M.D., Dee, S.A., Rossow, K.D., Otake, S., Collins, J., and Molitor, T.W. 2001. Transmission of PRRS virus from persistently infected sows to contact controls. *Can. J. Vet. Res.* 65:261-266.
11. Batista, L., Dee, S.A., Rossow, K.D., Deen, J., and Pijoan, C. An assessment of PRRV persistence and shedding in a large population of breeding age female swine. *Can. J. Vet. Res.* (Accepted for publication).
12. Dee, S.A., Bierk, M.D., Deen, J., and Molitor, T.W. 2001. An evaluation of Test and Removal for the elimination of PRRS virus from infected breeding herds. *Can. J. Vet. Res.* 65: 22-27.
13. Otake, S., Dee, S.A., Rossow, K.D., Joo, H.S., Deen, J., Molitor, T.W., and Pijoan, C. 2002. Transmission of PRRSV by needles. *Vet. Rec.* 150: 114-115.
14. Otake, S., Dee, S.A., and Rossow, K.D. 2002. Transmission of PRRSV by contaminated fomites (boots and coveralls). *Journal of Swine Health and Production.* 10: 59-65.
15. Otake, S., Dee, S.A., Torremorell, M., Jacobson, L., and Pijoan, C. Evaluation of aerosol transmission of PRRS virus under field conditions. *Vet. Rec.* (Accepted).

16. Wills, R.W., Zimmerman, J.J., Swenson, S.L., Yoon, K.J., Hill, H.T., Bundy, D.S., and McGinely, M.J. 1995. Transmission of PRRSV by direct, close, or indirect contact. *Swine Health Prod.* 5:213-218.
17. Torremorell, M., Pijoan, C., Janni, K., Walker, R., and Joo, H.S. 1997. Airborn transmission of *Actinobacillus pleuropneumoniae* and porcine reproductive and respiratory syndrome virus in nursery pigs. *A.J.V.R.* 58:828-832.
18. Lager, K.M., and Mengeling, W.L. 2001. Experimental aerosol transmission of pseudorabies virus and porcine reproductive and respiratory syndrome virus. The proceedings of 31st annual meeting of American Association of Swine Practitioners, Indianapolis, IN. pp: 409-410.
19. Otake, S., Dee, S.A., Rossow, K.D., Moon, R.D., and Pijoan, C. Transmission of porcine reproductive and respiratory syndrome virus by mosquitoes. *Can. J. Vet. Res.* (Accepted for publication).
20. Stewart, W.C., Carbrey, E.A., Jenney, E.W., Kresse, J.I., Snyder, M.L., and Wessman, S.J. 1975. Transmission of hog cholera virus by mosquitoes. *A.J.V.R.* 36:611-614.
21. Yoon, I.J., Joo, H.S., Christianson, W.T., Morrison, R.B., and Dial, G.D. 1993. Persistent and contact infection in nursery pigs experimentally infected with porcine reproductive and respiratory syndrome (PRRS) virus. *Swine Health and Production.* 1:5-8.
22. Dee, S.A., Deen, J., Rossow, K.D., Mahlum, C., Otake, S., and Joo, H.S. Mechanical transmission of porcine reproductive and respiratory syndrome virus through a coordinated sequence of events during cold weather. *Can. J. Vet. Res.* (Submitted for publication).

CHALLENGES IN SWINE HOUSING AND BEHAVIOUR

BEHAVIOURAL CONSIDERATION IN ANIMAL TRANSPORT DESIGN

**Temple Grandin
Department of Animal Science
Colorado State University**

Taken from: Welfare of Pigs during Transport
<http://www.grandin.com/welfare.pigs.during.transport.html>

The purpose of this paper is to review the most important scientific information on pig welfare during transport and to provide practical information. This paper is divided into five sections of 1) equipment for loading and unloading trucks, 2) handling methods, 3) conditions on the truck, 4) fitness of the animal for transport and 5) incentives to reduce losses.

LOADING AND UNLOADING EQUIPMENT

Non-slip flooring is essential on loading ramps and alley floors. A good finish is to print the pattern of expanded metal into wet concrete. Ideally the ramp angle should not exceed 20 degrees for a non-adjustable ramp and 25 degrees for an adjustable ramp (Grandin, 1987). A pig's heart rate will increase as the angle of a loading ramp increases (Van Patten and Elshof, 1978). Mayes (1978) studied a pig's stride width and found that cleats on ramps must be spaced to fit the normal walking stride of an animal. For 250 lb. (120 kg) market weight pigs, the cleats should be on 8 in. (20 cm) centers. Use 1-inch x 1-inch cleats. Missing cleats must be immediately replaced to prevent leg injuries. Stairsteps work well on concrete ramps. For market weight pigs, they should have a 2 ½ inch (6.5 cm) rise and a 10 inch (25 cm) long tread (Grandin, 1987).

The author has observed that small piglets can get dew claw injuries when they go down a ramp designed for market weight pigs. The animals slip and damage their dewclaws. To prevent injuries to young piglets, small closely spaced cleats are required. In segregated early weaning facilities ramps with small closely spaced cleats must be provided unless the loading and unloading docks are level with the truck. Further information on the design of loading ramps can be found in Grandin (1987, 1990, 2000 and National Pork Board, 2001). Good maintenance of equipment is essential to prevent accidents that can injure either pigs or people.

Pig movement through alleys and chutes can be greatly affected by air movement, shadows and lighting. Pigs have a tendency to move from a darker area towards a brighter area, but they will not approach blinding light. (Grandin, 1982; Van Putten and Elshof, 1978). Adding a lamp or moving a lamp will often facilitate animal movement (Grandin, 1996). Pigs will balk at air blowing in their faces. Pig movement out of the finishing barn can often be improved by opening the curtains to let in daylight and to equalize the air pressure. At night, lights are effective for attracting pigs into trucks or trailers. Pigs will often move up a ramp more easily if they are moved to outside of the building before they encounter the ramp.

HANDLING METHODS

Quiet handling by well-trained people is essential. Handlers should be trained to use behavioral principles of handling such as flight zone and point of balance (Grandin, 1987). Flags, plastic paddles or panels should be used as the primary driving aids. Frequent use of electric prods is detrimental to pig welfare because shocking increases body temperature, heart rate and the incidence of stressor non-ambulatory pigs (Benjamin et al., 2001 and Brundige et al., 1998). Electric prods must not be used as the primary driving aids. When pigs are loaded out of either a segregated weaning facility or a finishing barn it is best to move small groups directly from the home pens to the truck. For finishing pigs it is recommended to move 3 to 6 pigs at a time. For smaller pigs, larger numbers may be moved. Pigs should be moved without piling up. Handling of market weight pigs will be easier if the alley in a finishing building is 36 inches (92 cm) wide. This allows two pigs to walk down the alley side by side.

Both genetics and previous experience will affect the ease of handling of pigs. Piglets that have never walked on concrete may balk and be difficult to move. Moving the animals will be easier if they are given an opportunity to explore the new floor surface prior to being driven over it.

Pigs from certain lean genetic lines may be more excitable and difficult to drive (Grandin, 1997). Shea-Moore (1998) found that high lean pigs were more fearful and explored an open arena less. When they were mixed they had significantly more fights (Buss and Shea-Moore, 1999). More time was required to move lean line pigs down an alley compared to a fatter line of pigs. Observations and work with producers by the author has shown that excitability can be reduced and the pigs will be easier to drive if the producers walk through the pens every day (Grandin 2000). This is especially important for pigs from excitable genetic lines. Grandin (1987) found that walking in the pens or allowing pigs to walk in the aisles produced calmer, less excitable animals. The producer should walk through both grower and finishing pens to teach the pigs to quietly get up and flow around him. Pigs differentiate between a person in the aisle and a person in their pens. British researchers have reported that pigs from certain farms are more difficult to drive (Hunter et al., 1994). Geverink et al. (1998) reports that pigs which have been walked in the aisles during finishing will be easier to drive. Moving the pigs out of the finishing pens a month prior to slaughter also improved their willingness to move (Abbott et al., 1997).

CONDITIONS ON THE TRUCK

Overloading of trucks is a major cause of increased stress and death losses. Severe overloading of trucks results in clear evidence of physical stress (Warriss et al., 1998).

There needs to be a differentiation between a short trip of 2 to 3 hours and a longer trip. Guise et al. (1998) reported that market weight pigs remain standing when a trip is under 3 hours and they lie down for longer trips. The space requirements shown in Table 1 are recommended for short trips during cool weather. Barton et al. (1998) found that for short

trips of under 3 hours during moderate weather, additional space provided no benefits. On longer trips, more space will be required so that all of the pigs will have space to lie down without being on top of each other. During hot weather when the Livestock Weather Safety Index is in the Danger or Emergency Zone load 15 to 20% fewer pigs. For long trips, space allowances recommended by the EC Working Group (1992) should be used. EC space allowances provide approximately 15% more space.

Table 1: Recommended transport space requirements for pigs

Average Weight	Number of hogs per running foot of truck floor (92 inch truck width)	Short trips under 3 hours (during cool weather) Space per pig
50 lbs. (23kg)	5.0	1.53 ft ² (0.14 m ²)
100 lbs. (45 kg)	3.3	2.32 ft ² (0.21 m ²)
150 lbs. (68 kg)	2.06	2.95 ft ² (0.27 m ²)
200 lbs. (90 kg)	2.2	3.50 ft ² (0.32 m ²)
250 lbs. (113 kg)	1.8	4.26 ft ² (0.40 m ²)
300 lbs. (136 kg)	1.6	4.79 ft ² (0.44 m ²)
350 lbs. (158 kg)	1.4	5.48 ft ² (0.51 m ²)
400 lbs. (181 kg)	1.2	6.39 ft ² (0.59 m ²)

Note: For longer trips, increase the space 15 to 20% depending on temperature. On long trips, pigs should have sufficient room to lie down without being on top of each other.

Research has shown that pigs can suffer from motion sickness (Bradshaw et al., 1996). It is probably due to low frequency vibration (Randall, 1992). Feed withdrawal prior to transport will help prevent motion sickness and vomiting during transport. Feed withdrawal 16 to 24 hours prior to stunning will also help prevent carcass contamination and may help reduce PSE (Eikelboom et al., 1990; Warriss, 1993). Longer fasts would definitely be detrimental to welfare. Pigs must be provided with water up until loading and immediately after unloading.

To keep pigs warm in the winter and to prevent frostbite, deep bedding with either straw or shavings is required when the temperature is below 32 degrees F (0 degrees C). When the temperature drops to 10 degrees F, straw is recommended for extra warmth. On aluminum sided trailers, at least half of the ventilation holes should be blocked during winter. During extreme cold, the trailer may have to be lined with wood to prevent the pigs from contacting cold metal.

During the summer when the temperature is over 60 degrees F (16 degrees C), wet shavings or sand should be used. Straw bedding is too hot. At 80 degrees F pigs should be sprinkled with water immediately after loading. Heat builds up rapidly in a stationary vehicle. If a truck

has to stand when the temperature is over 80 degrees F (27 degrees C), the pigs should be wetted. Research on heat stress has shown that death losses increase as temperatures increase (Knowles and Warriss, 2000, Livestock Conservation Institute, 1981). Truck drivers should drive carefully and avoid sudden stops and rapid acceleration.

FITNESS OF THE PIG FOR TRANSPORT

One of the most important factors which determines if a pig is fit for transport is the condition of the pig that is loaded onto the truck. Sows should be marketed when they are still fit for travel. The National Pork Board advises that sows and pigs that are unable to walk should be euthanized on the farm. Stressor pigs which have temporarily become non-ambulatory must be allowed to recover before they are put on a truck. A combination of genetic selection for leaner pigs and poor management has resulted in increased sow mortality (Koketsu, 2000). Producers need to select sound animals with good feet and legs. The author has observed that some sows are lame due to poor leg conformation. Lame animals are more likely to go down and become nonambulatory.

The presence of the stress gene will increase death losses during transport. Murray and Johnson (1998) found that 9.2% of the pigs that were homozygous positive for the stress gene died during transport. Death loss percentages were 0.27% in heterozygous stress gene carriers and 0.05% in pigs that were stress gene free. Fortunately many producers are now selecting pigs that are stress gene free to improve meat quality. A survey of pigs arriving dead on arrival at the slaughter plant indicated that deaths decreased from 0.27% to 0.1% when the stress gene was removed (Holtcamp, 2000). Growth promotants (such as repartitioning agents) must be used with great care to prevent an increase in downer non-ambulatory pigs.

INCENTIVES TO REDUCE LOSSES

People manage the things that they measure. Handling and stunning greatly improved at packing plants when procedures were monitored and measured (Grandin, 1998, 2000). At one plant, death losses were greatly reduced when truck drivers received rewards for low death losses. Financial incentives can be very effective to help prevent losses of pigs during transport and handling. Holding people accountable for losses is a great motivator to prevent losses. Bruises were greatly reduced when people were held financially accountable for them (Grandin, 1981).

CONCLUSION

To maintain an adequate level of animal welfare during transport requires having a fit animal that is carefully managed and handled.

LITERATURE CITED

- Abbott, T.A., Hunter, E.J. Guise, J.H. and Penny, R.H.C. 1997. The effect of experience of handling on pigs willingness to move. *Appl. Anim. Behavior Sci.* 54:371-375.
- Barton-Gade, P. and Christensen, L. 1998. Effect of different stocking densities during transport on welfare and meat quality in Danish slaughter pigs. *Meat Sci.* 48:237-247.
- Benjamin, M.E., Gonyou, H.W., Ivers, D.L., Richardson, L.F., Jones, D.J., Wagner, J.R., Seneriz, R. and Anderson, D.B. 2001. Effect of animal handling method on the incidence of stress response in market swine in a model system. *J. Anim. Sci.* 79:279 (Supl. 1)(Abstract).
- Bradshaw, R.H., Parrott, R.F., Forsling, M.L., Good, J.A., Lloyd, D.M., Rodway, R.G. and Broom, D.M. 1996. Stress and travel sickness in pigs effects of road transport on plasma concentrations of cortisol, beta endorphin, lysine and vasopressin. *Anim. Sci.* 63:507-516.
- Brundige, L., Okeas, T., Doumit, M. and Zanella, A.J. 1998. Loading techniques and their effect on market pigs. *J. Anim. Sci.* 76 (Supl. 1) 99 (Abstract).
- Buss, C.S. and Shea-Moore, M.M. 1999. Behavioral and physiological responses to transportation stress. *J. Anim. Sci.* 77 (Supl. 1) 147 (Abstract).
- Eikelenboom, G., Bolick, A.H. and Sybesman, W. 1990. Effects of feed withdrawal before delivery on pork quality and carcass yield. *Meat Sci.* 29:25-30.
- Geverink, N.A., Kappers, A., Van deBurgwal, E., Labooij, E., Blokhuis, J.H. and Wiegant, V.M. 1998. Effects of regular moving and handling on the behavioral and physiological responses of pigs to preslaughter treatment and consequences for meat quality. *J. Anim. Sci.* 76:2080-2085.
- Grandin, T.. 2000b. Effect of animal welfare audits of slaughter plants by a major fast food company on cattle handling and stunning practices. *J. Am. Vet. Med. Assoc.* 216:848-851.
- Grandin, T. 1998. Objective scoring of animal handling and stunning practices in slaughter plants. *J. Am. Vet. Med. Assoc.* 212:36-39.
- Grandin, T. 1996. Factors that impede animal movement in slaughter plants. *J. Am. Vet. Med. Assoc.* 209:757-759.
- Grandin, T. 1990. Design of loading facilities and holding pens. *Appl. Anim. Behavior Sci.* 28:187-201.
- Grandin, T. 1982. Pig behavior studies applied to slaughter plant design. *Applied Animal Ethology.*
- Grandin, T. 1987. Animal handling. *Vet. Clinics of N. America Food Animal Practice*, Vol. 3, No. 2, pp. 323-338.
- Guise, H.J., Riches, H.L., Hunter, B.J., Jones, T.A., Warriss, P.D. and Kettlewell, P.J. 1998. The effect of stocking density in transit on the carcass quality and welfare of slaughter pigs. *Meat Sci.* 50:439-446.
- Holtcamp, A. 2000. Gut edema: Clinical signs, diagnosis and control. *Am. Assoc. of Swine Practioners Proc.* Pp. 337-339.
- Hunter, E.J., Weeding, C.M., Guise, H.J., Abbott, T.A. and Penny, R.H. 1994. Pig welfare and carcass quality: A comparison of the influence of slaughter handling systems in two abattoirs. *Vet. Rec.* 135:423-425.

- Knowles, T.G. and Warriss, P.D. 000. Stress physiology of animals during transport In: T. Grandin (editor) *Livestock Handling and Transport*, CABI International, Wallingford, Oxon UK. Pp. 385-407.
- Koketsu, Y. 2000. Factors associated with increased sow mortality in North America. *Proceedings of the American Association of Swine Practitioners*. pp. 419-420.
- Livestock Conservation Institute. 1981. (Now National Institute of Animal Agriculture), Bowling Green, Kentucky.
- Mayes, H.F. 1978. Design criteria for livestock loading chutes. *Am. Soc. Ag. Engineers Paper*, 78:6014, St. Joseph, Michigan.
- Murray, A.C. and Johnson, C.P. 1998. Influence of halothane gene on muscle quality and preslaughter death in western Canadian pigs. *Can. J. Anim. Sci.* 78:543-548.
- National Pork Board. 2000. *Trucker Quality Assurance Program*, Des Moines, IA.
- Randall, J.M. 1992. Human subjective response to lorry vibration: Implications for farm animal transport. *J. Agric. Eng. Res.* 52:295-307.
- VanPutten, G. and Elshoff, G. 1978. Observations on the effect of transport on the well being and lean quality of slaughter pigs. *Animal Regulation Studies* 1:247-271.
- Wariss, P.D. 1998. Choosing appropriate spare allowances for slaughter pigs transported by road: A review. *Vet. Rec.* 142:449-454.
- Warriss, P.D. 1993. Ante mortem factors which influence carcass shrinkage and meat quality. *Proc. 39th Int. Congress of Meat Sci. and Technology*, Calgary, Canada, pp. 51-56.
- Pig Transport Audit Form for Welfare and Pork Quality.

CAUSES AND PREVENTION OF TAIL BITING IN GROWING PIGS: A REVIEW OF RECENT RESEARCH

Tina Widowski
Department of Animal and Poultry Science
University of Guelph

INTRODUCTION

The problem of tail biting has probably been around for as long as pigs have been raised indoors. A recent review of the literature cites mention of the problem going back as far as 1896 but reports of tail-biting first appeared in veterinary journals in the 1940's (Schroder-Petersen and Simonsen, 2001). While the causes and "remedies" for tail biting are often discussed in veterinary texts, journals and practical husbandry guides, there really have been very few studies that have systematically investigated the development of tail biting or its underlying behavioural mechanisms. This is probably due to the very nature of tail biting - outbreaks are sporadic and unpredictable- which makes it very difficult to study in a research setting. Consequently, many of our accepted notions for why it occurs, and the measures that can be taken to prevent or alleviate tail biting are based on conventional wisdom or speculation. When tracing back some of these notions through the literature one finds that certain "facts" about the behaviour are based on observations made of a single case study.

Tail-biting has been attributed to a variety of perplexing factors including dietary deficiencies, crowding, poor air quality, uncomfortable environmental temperature (too hot and too cold), lack of bedding or other rootable substrate, floor type, feeding method, insufficient water supply, stray voltage, neon strip lighting, parasite infestation and breed type (Sambraus, 1985; Smith and Penny, 1986). It is considered to be multi-factorial in that some combination of factors is required to set off an outbreak of tail biting. One advisory report by Aherne and Deen (1998) listed over 30 dietary and management adjustments suggested as "cures" for tail biting but noted that the condition can recede spontaneously so that a treatment that seemingly works on one occasion may not work on another.

By far the most common preventative measure for tail biting is the docking of pigs' tails. While this practice does appear to significantly reduce the prevalence of tail biting it certainly does not eliminate the problem. A recent review citing data obtained from European abattoirs suggests that the frequency of pigs diagnosed with bitten tails is increasing (Schroder-Petersen and Simonsen, 2001). Routine procedures such as tail docking are also coming under scrutiny because of animal welfare concerns. In the UK, for example, producers are no longer allowed to routinely dock the tails of pigs without written permission from a veterinarian. These trends are stimulating new research in the area of tail biting in an effort to identify the causes and determine other preventative measures. The objective of this paper is to review some of the approaches that are used to study tail biting and to summarize the results of recent scientific investigations into its causation.

APPROACHES TO STUDYING TAIL BITING

Surveys of abattoirs and farms

A number of studies conducted in the UK have used data from slaughter plants to determine the prevalence and severity of bitten tails and any associations with factors such as gender, season of the year, docking or other carcass damage such as bitten ears. A related approach uses survey questionnaires sent to producers with questions aimed at identifying farm level associations between farm management practices and the occurrence of tail biting. These studies provide a broad picture of the prevalence of the behavior problem and give an indication of some factors associated with it, however, they do not tell us exactly how these factors can cause a pig to chew and bite on their pen-mates' tails. Behavioural studies investigating pigs' motivation for chewing or biting on pen-mates provide additional understanding of how and why the behaviour occurs and insight into how it might be prevented.

Behavioural studies to determine causation

A few early attempts to induce tail biting experimentally were unsuccessful. Therefore, many behavioural studies usually do not involve incidents of tail biting, per se, but instead examine the underlying motivation for chewing, biting or attraction to blood or other stimuli.

When studying animal motivation, behavioural scientists consider how the combination of internal factors and external stimuli interact to cause an animal to perform a particular behaviour at a particular time. Internal factors might include such things as an animal's genetic predisposition to engage in certain types of behaviour, hormone levels, physiological changes or emotional states such as fear or frustration. External stimuli include visual, olfactory (odour) or taste cues that animals find attractive (or repulsive) leading them to direct behaviour at particular objects in their environment. The animal's housing environment and management practices can alter both the internal states and external stimuli that motivate behaviour. For a complete understanding of why an animal performs a particular behaviour, scientists attempt to identify what the various motivational factors are and their relative importance in stimulating behaviour.

David Fraser (1987a, 1987b) was one of the first investigators to examine factors that may lead to tail biting in this way. He classified the tail-biting behaviour occurring in two stages. The first stage is the pre-injury stage before any wound on the tail is present. This stage might involve normal exploratory behaviour and mutual chewing or biting on pen-mates bodies that can lead to injury. The second stage occurs after a tail becomes injured and is bleeding. In this second stage both the behaviour of the recipient and the wounded tail result in very different external stimuli, which can cause the behaviour to escalate.

Fraser developed a model to study pigs' tendencies to chew using a cotton braid rope that could be soaked in blood or other substances. Other investigators have adopted Fraser's tail-model to study various factors that may lead to tail biting. But is chewing at a rope tail model really predictive of tail biting behaviour? Breuer et al. (2000) recently investigated whether

the use of a rope chew test was valid measure of pigs' tendencies to direct harmful behaviour at pen-mates. They subjected pigs to a rope chew test at 4 weeks of age and also measured the frequencies and durations of nosing and biting the ears and tails of other pigs from videotapes made of pigs in groups in their home pens. They found that pig-directed behaviour in the home pen was positively correlated with rope directed behaviour during the tests and concluded that pigs that perform a high level of rope directed behaviour may be more likely to perform harmful social behavior in their resident pens. Their results suggest that using rope "tail models" is a valid method for investigating the tendencies of pigs to engage in tail biting.

In other studies, investigators have measured the effects of various factors on pigs' tendencies to direct rooting or chewing on objects (Day et al., 1995; 1996) or on pen-mates bodies (Beattie et al., 1996; 2001) in order to identify behavioural mechanisms that may be related to the pre-injury stage of tail biting. One Danish group is examining what they call "Tail-In-Mouth" (TIM) behaviour in younger pigs and have suggested that TIM may be a precursor for the damaging tail biting that occurs in older pigs (Schroder-Petersen et al, 2000, 2001).

The many factors that are said to be associated with tail biting can be classified into genetic, environmental/husbandry and dietary. Genetic factors include breed or line differences, but also might involve inherent sex differences. Factors falling into the environment/husbandry category are housing conditions such as crowding, lack of rooting substrate or uncomfortable temperatures thought to cause "stress". Dietary factors involve nutrient deficiencies (which are probably pretty uncommon these days) but might also include salt or minerals that are thought alter behaviour. So what have the various scientific investigations taught us about the factors that may lead to tail biting?

THE NATURE OF PIGS AND TAIL BITING

All of us who know pigs can attest to the fact that the creatures are built to root, and chew and to explore the environment with their mouths and snouts. A large part of this rooting and chewing behaviour may be associated with natural feeding and foraging motivation (Day et al., 1996). Some is probably associated with the pig's natural tendency to explore their environment and their group mates (Feddes and Fraser, 1994). Pigs also tend to be rather aggressive animals, and engage in intense fighting when establishing their social hierarchy or when competing for a limited resource such as food or water. So where does tail biting fit in? Tail biting is generally not considered an aggressive behaviour in that it involves different motor patterns and signals than those used in aggressive interactions or fighting, and the recipients are generally thought not to respond. The most common behavioural hypothesis for tail biting is that it involves normal behaviour, such as foraging and exploration that becomes redirected or misdirected to the tails of pen-mates when something in the environment is lacking (Schroder-Petersen and Simonsen, 2001). This redirected behaviour may intensify when pigs become stressed or frustrated. It is sometimes suggested that tail biting occurs when there is competition for resources such as feeder space or lying areas. Whether the behaviour occurs when pigs are actually fighting to get access to the resource, or in another context when a pig is frustrated because it is prevented from obtaining the resource is unclear.

It may be that the underlying behavioural mechanism for tail biting differs depending on the situation.

GENETIC EFFECTS ON TAIL-BITING

While it is common to see mention of genetics in relation to tail biting (Sambraus, 1985), this is one area that we know very little about. Fraser (1987a) found large individual differences in pigs' tendencies to chew on plain or blood soaked tail models and this observation is supported by some of the more recent work using tail models (Breuer et al., 2001, Jankevicius and Widowski, 2001b). Some pigs chew on the models almost continuously during the tests while others hardly touch the models. Individual differences have also been observed in pigs engaging in other types of oral/nasal pig directed behaviour (i.e. belly-nosing) but most observations related to actual tail biting incidents are anecdotal. Although it has been suggested that some genotypes may be "less irritable than others" and therefore less likely to perform tail biting (Aherne and Deen, 1998), there are no controlled genetic comparisons to be found in the literature.

SEX DIFFERENCES AND BITTEN TAILS

Results from several surveys conducted at abattoirs in the UK have shown that there is a significant link between gender and the prevalence and severity of bitten tails on pig carcasses, with males being much more likely to have bitten tails than females. Comparisons of the percentages of male versus female carcasses with bitten tails were 15.7 % of castrated males and 7.7% of females (Penny and Hill, 1974), and 4.58 % of boars versus 3.37% of gilts (Hunter et al, 1999). Lee and Veary (1993 as cited in Schroder-Peterson and Simonsen, 2001) found that not only were males more likely to have bitten tails, the severity of tail wounds were greater in males. Data used in these various studies were collected on populations of both docked and undocked pigs but the effect of sex appears to be consistent in both groups.

While carcass data indicate a consistent trend in sex differences and tail biting few studies have addressed why this sex difference may occur. Nor is it known whether same sex or mixed sex penning has an effect on tail biting. In one survey of management practices on 450 farms, pigs in single sex pens were more likely to be bitten than those on farms using mixed sex groupings (Hunter et al., 2001). In contrast, "Tail-in-mouth" behaviour was found to be greater in mixed-sex pens than in pens with only barrows or gilts (Schroder-Peterson et al, 2000) but only 3 groups of pigs per penning system were observed in this study. An early study focussing on ear and tail directed behaviour of pigs, indicated no effect of sex on pigs' tendencies to be either the perpetrators or the recipients of biting behaviour (Blackshaw, 1981).

At this point the reasons for the sex difference in bitten tails are purely speculative. All of the abattoir surveys were conducted in the UK and therefore include some data from both castrated and intact males. It has been suggested that gilts are more active than barrows and therefore gilts may be more likely to be the tail biters, and barrows easier targets, when they

are housed in mixed-sex pens. However this does not explain the high prevalence of tail-bitten males coming from single-sex pens (Hunter et al., 2001). It has been suggested that penning groups of young intact boars together can result in higher levels of aggression, but whether this would result in an increase of tail-biting is not known.

NUTRITIONAL FACTORS AND THE TASTE FOR SALT OR BLOOD

Many of the earliest discussions on tail biting suggested that dietary deficiencies contributed to the problem. Fraser et al (1991) outlined three ways in which diet and nutrition could affect a pig's motivation to bite tails. One is that many of the neurotransmitters and hormones that control behaviour are derived from amino acid precursors and therefore dietary deficiencies or imbalances could potentially lead to alterations in behaviour. Fraser also pointed out that a pig's dissatisfaction with the diet may lead to increased restlessness and foraging behaviour that could result in tail-biting if pigs redirected that behaviour to the bodies of their pen-mates. It has been demonstrated that feed deprivation in growing pigs does in fact decrease the amount of time spent lying and increases the amount of rooting and foraging directed at woodbark/foraging substrate in controlled tests (Day et al., 1995). The third reason Fraser suggested was that dietary deficiency might cause a specific appetite for some nutrient that is available in blood making it more attractive if the second stage of tail biting occurs. A specific appetite refers to animal's tendency to seek out and ingest a particular nutrient that may be deficient in the body but that might be present in the environment. Sodium appetite, for example, is a state of increased motivation to seek out and ingest salty substances in the environment.

Using a blood-treated tail model Fraser and his colleagues found that pigs fed mineral (1987b) and protein deficient diets (1991) directed significantly more chewing at the blood treated model than pigs fed control diets. However more recent studies do not support Fraser's findings. McIntyre and Edwards (2001) found that chewing directed at blood-treated or plain tail models were not different among pigs fed either a low protein, low energy diet or control diet over a 6 week period. In another study, Beattie et al. (2001) found that feeding pigs a salt deficient diet for 2 weeks did not lead to an increase in chewing directed at rope models treated with sodium chloride, but they did not offer a blood-treated model in this study. However, they did find that the pigs were more active and engaged in more rooting behaviour during the period of salt deficiency.

Other nutritional factors have been suggested as causes or cures for tail biting. It has been suggested that feeding a high energy, low fibre diet might stimulate tail biting, but one experimental attempt to induce the behaviour in this way was unsuccessful (Ewbank, 1973). Dietary magnesium supplements, thought to have an "anti-stress effect" has also been suggested (Smith and Penny, 1986). However the one study in the literature examining the effects of magnesium supplementation and space allocation on the behaviour of pigs showed no effect of adding magnesium (Krider et al., 1975).

STRESS AND THE TASTE FOR SALT OR BLOOD?

One of the common remedies suggested for reducing tail biting is the addition of salt or potassium to the diet (Smith and Penny, 1986; Aherne and Deen, 1998). Presumably the logic behind this stems from some of the earlier work on salt and mineral deficiencies and the pig's attraction to blood. Although it is logical that dietary deficiencies might increase exploratory chewing or a taste for blood, it is less clear how environmental stressors may elicit this behaviour. Interestingly, a variety of physical and environmental stressors such as crowding, restraint and immobilization, cold stress and exposure to social intruders have been shown to stimulate a sodium appetite in mice, rats and rabbits (Denton et al., 1999). One model of the stress response that has been widely used is the injection of adrenocorticotrophic hormone (ACTH), one of the many hormones released during stress. In mice, rats, rabbits and sheep treatment with ACTH causes a pronounced sodium appetite. Fraser (1987) suggested that if pigs show a similar response to stress, an appetite for salt could increase their attraction to blood and contribute to tail biting. This is one area that we have been exploring recently in my laboratory.

In our first study, we adopted the traditional method of measuring sodium appetite that has been used in other species, offering salt solutions and measuring ingestion of those solutions (Jankevicius and Widowski, 2001a). Growing pigs (45 kg) were offered different concentrations of sodium chloride and potassium chloride solutions and their intakes were measured before, during and after a 5-day period of ACTH injections. During the injection period, the pigs significantly increased their water and feed intakes and had elevated salivary cortisol, indicating that they were responding physiologically to the hormone injections. However, they did not increase their intake of sodium solutions. In fact, some of the pigs that were drinking the more dilute salt solutions during the pre-treatment period decreased sodium intake during the injection period.

We thought that perhaps offering salt in solution was not an appropriate vehicle for delivering salt to pigs. Therefore we conducted a second study in which pigs were treated with ACTH and offered rope tail models soaked in whole pig's blood, a salt solution having the same salt content as blood or plain water (Jankevicius and Widowski, 2001b). As in the first study, pigs did not show an increased attraction to blood or the salty tail during the period of ACTH injections. Overall, the activity of the pigs and their chewing behaviour directed at the rope models decreased during treatment. Results of both of these studies indicate that pigs do not develop a sodium appetite or attraction to blood in response to the stress hormone ACTH. However it should be noted that ACTH release is only one of the many physiological responses to stress and may not be the appropriate model for studying whether pigs develop a stress-induced sodium appetite.

PIG'S ATTRACTION TO BLOOD

Fraser's early study (1987) using blood-treated tail models indicated that pigs are strongly attracted to blood flavoured models compared to plain rope "tails". But what is it about blood that is so attractive to pigs? McIntyre et al (2001) compared the preferences of growing pigs

fed standard diets to rope models treated in whole blood, the cellular fraction of blood, the protein plasma fraction of blood or Na Cl solution. They found that pigs preferred to chew on models treated in whole blood or sodium solution and were not attracted to the other fractions of blood. In our ACTH trials, pigs showed a significant preference for blood-treated tails compared to NaCl or water treated models, regardless of hormone treatment (Jankevicius and Widowski, 2001b).

In all of the studies involving blood soaked tails, the colour and appearance of the tail models are considerably different depending on what they are treated with. Pigs might simply be attracted to the tail that is darker in colour. To rule out the effect of colour or appearance on pig's attraction to blood-treated models, we treated tail models with red food dye as well as blood, salt or water and used a colourmetric system used for meat studies to closely match the colours of the tails treated in the different substances. When all tail models were similar in colour pigs still showed a strong preference for tail treated with blood + food dye, compared to salt solution + food dye or simple food dye. Together these studies indicate that pigs are using some olfactory or taste cues to discriminate among the tails. Our studies suggest that it is not the salt content of blood that is attracting pigs to the models, at least not when they are fed diets that meet their nutritional requirements. On the other hand, McIntyre's study suggests that pigs are attracted to salty tail models, but they used a much higher concentration of salt solution to treat the tail models.

Overall, the body of recent research suggests that salt isn't that attractive to pigs and that a taste for salt is not contributing to the development of tail biting. In addition, Beattie and Weatherup (2000) found that supranutritional salt supplementation did not reduce the frequency of nosing other pigs or tail biting compared to pigs fed a control diet. It is reasonable to conclude that there is no benefit to adding salt to the feed or by providing salt-treated objects to the pen in order to curb tail biting when pigs are fed a nutrient sufficient diet.

EFFECTS OF MANAGEMENT FACTORS

Chambers et al (1995) surveyed management practices on 47 farms in the UK to identify those associated with producer reports of tail biting. Tail biting was reported to have occurred on 66 percent of the farms surveyed. From this sample, reports of tail biting appeared to differ with provision of bedding, slatted floors and methods of feeding. Tail biting was less likely to occur on farms at which straw was provided and when pigs were fed manually rather than via automatic systems. There were no associations with pen size, number of pigs per pen, stocking density, or type of ventilation system. These results should be viewed with some caution considering the relatively small number of farms sampled and the large number of variables considered.

Hunter et al (2001) followed up an abattoir survey (Hunter et al 1999) with a questionnaire sent to producers with questions relating to housing type, straw provision, ventilation, mixed or single sex grouping and feeding methods. Data were collected from 450 farms representing 27, 870 pigs sampled at the abattoir. Of units included in the study, 18.8% provided deep

straw, 29.9% light straw, 3.6% a mix of deep and light straw and 41.4% no straw. As this study was conducted in the UK, natural ventilation systems were most common, accounting for 53.4% of the units surveyed. Provision of straw significantly affected probability of tail biting. For both docked and undocked pigs, tail biting was lowest in the systems with light straw and highest in the units where no straw was provided. Natural ventilation also reduced the probability of tail biting but in most naturally ventilated units, straw was also provided. Feeding level (restricted, to appetite or ad lib) did not affect the probability of bitten tails. Method of feed delivery only affected the probability of bitten tails in undocked pigs. Probability of tail biting was highest in pigs fed pellets, (versus meal or liquid feeding) and in pigs fed on floor, or in single-spaced feeders (versus double or multi space feeders).

Specific climatic factors

In their review, Schroder-Petersen and Simonson (2001) noted that although both indoor climate and season have been suggested to lead to tail biting the scientific evidence for this is inconsistent and contradictory. Depending on the study, tail biting has been observed to be greater when indoor temperature was below 17°C, greater when indoor temperature was above 20°C, greater at 35 °C compared to 25 °C, and greater at 23 °C than at 28 °C. Seasonal effects based on abattoir studies have been reported to be highest during summer months in one report and highest during winter months in another.

Ventilation is also claimed to affect tail biting but nearly all of the evidence for this is based on case study or anecdotal report and the survey data are inconsistent (Chambers et al, 1995; Hunter et al, 2001). Reasons given for why poor ventilation might elicit tail biting include both poor air quality and draft. There have been no studies specifically addressing air quality on pigs' tendencies to engage in harmful behaviour. While subjecting pigs to cold draft has been shown to stimulate fighting and ear lesions, there is little direct evidence on the tendency for pigs to bite tails. One area that we are currently addressing in my laboratory is whether drafty conditions in different environmental temperatures can stimulate chewing on rope tail-models in growing pigs.

Substrate for rooting and chewing

Both of the UK farm survey studies reviewed here (Chambers et al., 1995; Hunter et al., 2001) indicated that regular provision of straw significantly reduced the probability of observing tail biting on farms. The benefits derived from straw may relate to its effects on thermal comfort, or the recreational and nutritional opportunities straw provides. Results from a number of behavioural studies measuring pigs' tendencies to direct rooting and chewing at other pigs have shown that provision of straw or some other rootable/chewable substrate is an effective means of directing harmful behaviour away from other pig's bodies. In housing systems that do not allow for use of straw, providing objects or small amounts of substrate that pigs can root or chew can be effective. Feddes and Fraser (1994) demonstrated that the type of "enrichment" object can significantly affect pigs' attraction to it, pigs directed much more chewing at objects that were "destructible" and that they could more easily grasp and chew on. Recent work by Beattie et al. (1996, 2001) has shown that suspending a tray filled

with mushroom compost in pens with fully slatted floors can significantly reduce nosing and tail biting behaviour.

CONCLUSIONS

- Results from abattoir surveys indicate that bitten tails are more common in males than in females but the behavioral mechanisms for this are currently unknown.
- In pigs receiving adequate diets, there appears to be no benefit of adding salt or other nutritional supplements to the diet for reducing tail biting.
- Provision of straw or other rootable/chewable substrates appears to be the most effective means of reducing pig-directed behaviour that can lead to tail biting.
- Further research is needed to determine how environmental stressors such as thermal discomfort or air quality and how genetics increase pigs' tendencies to engage in biting behaviour.

LITERATURE CITED

- Aherne, F. J. Deen, 1998. Tail biting problems linger in many swine production systems. *International Pigletter*. 18:7-12.
- Beattie, V.E., N. Walker, I.A. Sneddon, 1996. An investigation of the effect of environmental enrichment and space allowance on the behaviour and production of growing pigs. *Appl. Anim. Beh. Sci.* 48:151-158.
- Beattie, V.E., I.A. Sneddon, N. Walker, R.N. Weatherup, 2001. Environmental enrichment of intensive pig housing using spent mushroom compost. *Anim. Sci.* 72:35-42
- Beattie, V. , R.N. Weatherup, 2000. The effects of increased dietary salt concentration on performance and behaviour of finishing pigs. *Proc. Brit. Soc. Anim. Sci.*
- Beattie, V.E., et al. 2001. The effect of salt deficiency on the behaviour of finishing pigs in a tail chew test. (Personal communication).
- Blackshaw, J.K., 1981. Some persistent behavioural deviations in weaned domestic pigs: persistent inguinal nose thrusting, and tail and ear biting. *Anim. Prod.* 33:325-332.
- Breuer, K. B., V.E. Beattie, et al., 2001. Validation and development of a behavioural test to predict the predisposition of growing pigs to perform harmful social behaviour such as tail biting. *Proc. Brit. Soc. Anim. Sci.*
- Chambers, C., L. Powell, E. Wilson, L.E. Green, 1995. A postal survey of tail biting in pigs in south west England. *Vet. Rec.* 136: 147-148.
- Day, J.E.L., I. Kyriazakis, A.B. Lawrence, 1995. The effect of food deprivation on the expression of foraging and exploratory behaviour in the growing pig. *Appl. Animal Behav. Science* 42:193-206.
- Day, J.E.L., I. Kyriazakis, A.B. Lawrence, 1996. An investigation into the causation of chewing behaviour in growing pigs: the role of exploration and feeding motivation. *Appl. Anim. Behav. Sci.* 48:47-59.
- Denton, D. A., J.R. Blair-West et al., 1999. Effect of adrenocorticotrophic hormone on sodium appetite in mice. *Amer. J. Physiol.* 277 (Regul. Integr. Comp. Physiol. 46): R1033-R1044.

- Ewbank, R. 1973. Abnormal behaviour and pig nutrition. An unsuccessful attempt to induce tail biting by feeding a high energy, low fibre vegetable protein ration. *Brit. Vet. J.* 129:366- 369.
- Feddes, J.J.R., D. Fraser, 1994. Non-nutritive chewing by pigs: implications for tail-biting and behavioral enrichment. *Trans ASAE* 37:947-950
- Fraser, D. 1987a. Attraction to blood as a factor in tail-biting by pigs. *Appl. Anim. Behav. Sci.* 17:61-68.
- Fraser, D. 1987b. Mineral-deficient diets and the pig's attraction to blood: implications for tail-biting. *Can. J. Anim. Sci.* 67:909-918.
- Fraser, D, D. Bernon, R.O. Ball, 1991. Enhanced attraction to blood by pigs with inadequate protein supplementation. *Can. J. Anim. Sci.* 71:611-619.
- Hunter, E.J., T.A. Jones, et al., 1999. Tail biting in pigs 1: The prevalence at six UK abattoirs and the relationship of tail biting with docking, sex and other carcass damage. *The Pig J.* 43: 18-32.
- Hunter, E.J., T.A. Jones, et al., 2001. The relationship between tail biting in pigs, docking procedure and other management practices. *Vet. J.* 161: 72-79.
- Jankevicius, M.L, T.M. Widowski, 2001a. The effect of ACTH on salt appetite in growing pigs. *Proc. 35th Cong. ISAE, (Eds.) J. Garner, J. Mench, S. Heekin. Center for Animal Welfare, Davis, CA.*
- Jankevicius, M.L, T.M. Widowski, 2001b. The effect of ACTH on pigs' attraction to salt or blood flavoured tail models. *Proc. Can. Soc. Anim. Sci. AIC2001, p. v29*
- Krider, J.L., J.L. Albright, et al. 1975. Magnesium supplementation, space and docking effects on swine performance and behaviour. *J. Animal Science* 40:1027-1033.
- McIntyre, J., S.A. Edwards, 2001. An investigation into the effect of different protein and energy intakes on the tail chewing behaviour of growing pigs. (personal communication).
- McIntyre, J, Beattie, V. E., et al., 2001. The chewing behaviour of growing pigs presented with tail models soaked in different fractions of blood, as a test for tail-biting predisposition. *Proc. Brit. Soc. Anim. Sci.*
- Penny, R.H. F.W.G. Hill, 1974. Observations of some conditions in pigs at the abattoir with particular reference to tail biting. *Vet. Rec.* 94: 174-180.
- Sambras, H.H., 1985. Mouth-based anomolous syndromes. In: *Ethology of Farm Animals, World Animal Science, A5, (Ed.) A. Fraser Elsevier, Amsterdam.* pp. 391-422.
- Schroder-Petersen, D.L., H.B. Simonsen, 2001. Tail biting in pigs. *Vet. J.* 162: 196-210.
- Schroder-Petersen, D.L., H.B. Simonsen, L.G. Lawson, 2000. "Tail-in-mouth" behaviour among weaned pigs in relation to sex, age weight and group composition. *Proc. 34th Intl. Cong. ISAE, (Eds.) A. Ramos, L.C.P. Machado, M.J. Hotzel, Universidade Federal de Santa Carolina, Florianopolis, Brazil.*
- Schroder-Petersen, D.L., H.B. Simonsen, L.G. Lawson, 2001. The motivation for performing "Tail in mouth" (TIM) behaviour in weaner pigs expressed by posture and behaviour immediately before and after TIM. *Proc. 35th Cong. ISAE, (Eds.) J. Garner, J. Mench, S. Heekin. Center for Animal Welfare, Davis, CA.*
- Smith, W.J. R.H.C. Penny, 1986. Behavioral problems, including vices and cannibalism. In: *Leman, A. D et al. (Eds.) Diseases of swine, 6th ed. Ames, Iowa: Iowa State University Press; 1986.*

ELECTRICITY DEREGULATION

Ron MacDonald and C.L. Gibb

**Agviro, Inc.
Guelph, Ontario**

INTRODUCTION

May 1, 2002 is the target deadline for deregulation of the electricity market in Ontario. As a result, Ontario farms will have the opportunity to choose their electricity supplier in much the same way natural gas and even long distance phone plans can be purchased from various retailers (ON, 2002). As always, there is a “buyer beware” consideration to this open market.

The problems seen in California and to a lesser extent, Alberta, under a deregulated electricity market largely were due to rapid growth, no incentives to add generation or distribution capacity and a cap on electricity prices (Vogel, 2000). Ontario appears to be well prepared for the near future with adequate capacity and a reasonably good distribution system in place that is connected to other US and Canadian suppliers.

Going from an electricity market largely monopolized by Ontario Hydro to an open market place with a variety of retailers/suppliers all offering different pricing plans might be daunting. This discussion will attempt to shed some light on what deregulation is and its effect upon your swine operation.

MARKET STRUCTURE: PAST AND FUTURE

Deregulation will not affect the regulatory component of the electricity industry; in fact, electricity retailers will be faced with more regulations regarding the sale of electricity in Ontario than ever before. The market structure, however, will change.

Under the old system (Figure 1), Ontario Hydro was almost exclusively the only supplier/retailer of electricity to farm customers in Ontario. The amount of energy used was billed at a fixed rate per kWh. This fixed rate included other costs such as generation, transmission and billing to name a few.

Under the new deregulated system (Figure 2), the only charge that is deregulated is the energy or kWh charge. All other costs are regulated and will be priced separately and added to the monthly bill based on consumption and other local delivery costs which have yet to be determined.

Figure 1: Old System

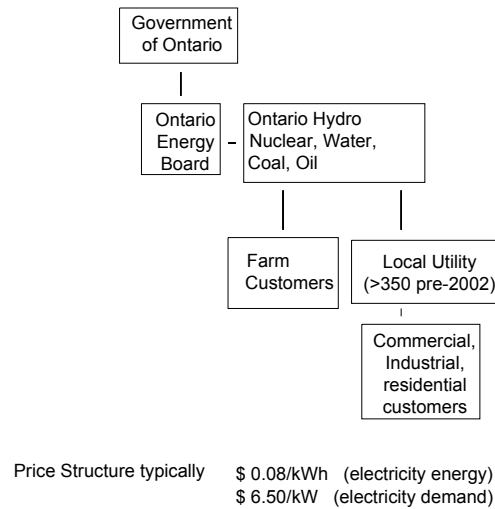
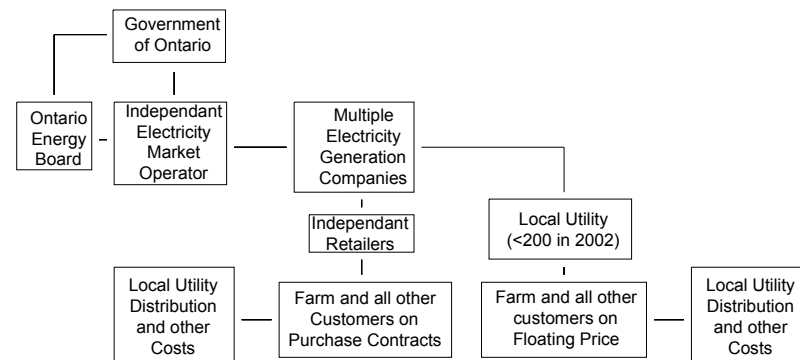


Fig 2: New System



Demand (kW) = \$9.00/kW

\$ 0.0430/kWh (1) (electricity) from utility on Retailer

\$ 0.0100/kWh (2) (transmission)

\$ 0.0300/kWh (2) (distribution access)

\$??? (2) (Utility access charges T.B.D.)

\$ 0.009/kWh (stranded debt)

0.092/kWh Total

(1) Contracts price from retailers currently are \$ 0.0545/kWh - 3 years

\$ 0.0595/kWh - 5 years

(2) Note: Prices shown will vary by utility

How will deregulation affect most Ontario farms?

- Electricity rates will change. In the short term however, they will not change by much, one way or the other.
- Billing will be more confusing. Instead of the basic kWh (energy) or kW (energy demand) charge (note, only large farms of 400 amp service or more pay a demand charge), there will be charges for kWh, kW, transmission, distribution and fees associated with the privatization of Ontario's electricity system.
- Most businesses that are large users of electricity will get an "Interval meter" that will provide hour-hour billing based on the spot price. This meter will gather information on lows and highs and load profiles, demand and power factor. At the present, it is unknown how all the data will be collected and made available to the end user.
- You will be able to choose your electricity supplier. Farms can choose to buy from a retailer on a "fixed term and price contract" or choose to remain with the "Default" supplier. See the section following for more details on these choices.

Electricity Retailers and Default Supplier

Retailers

The main retailers so far are:

- Ontario Hydro Energy Co.: retails electricity throughout Ontario
- Toronto Hydro Energy Services: retails electricity mainly in the GTA
- Ontario Power Generation (OPG): retails to large customers only
- Direct Energy: retails electricity throughout Ontario

Information about these and other retailers, and gas and electricity prices is available at www.energysshop.com. You can sign up with retailers on line via this site. You also can go to a retailer's site and get contract copies.

If you sign a contract, the current fixed contract price for energy is 5.95 cents/kWh for 5 years or 5.45 cents/kWh for 3 years. As of May 1, the anticipated energy price will be about 4.0 cents/kWh and is expected to remain at this limit for at least 2 years.

Default Supplier

The "Default" supplier for most consumers is their current supplier. For most farms, Hydro One Networks (the equivalent of the old "Ontario Hydro") will be the regulated distribution utility. It is the "default supplier" and cannot offer contracts. The cost for electricity is a floating price; therefore, Hydro One will bill on its cost to buy on the spot market. As a result, your bill will vary throughout the year.

For most locations where a PUC has supplied power, it will be the default supplier; for example, Listowel PUC (unless you have signed on with another retailer). In the case of the PUC, it can either build up a “variance account” (not likely as it is very expensive) where it credits or debits the individual customers regularly; or spot price pass through (more likely).

Understanding Your Farm’s Energy Use

One of the mysteries of deregulation is its impact on what you will have to pay for the electricity you use. Three components come into play. The first is your farm’s load profile. The second is your supplier’s load profile. The final component, what you are charged, depends on whether or not you have a fixed or a floating rate.

Figure 3 shows a typical electrical load profile for a fan ventilated finisher facility over 11 days. There is very little variation on a diurnal (24 hour) basis. The number of amps increases early in the day as loads are added, then decreases at night as equipment turns off.

Figure 3: Finisher Unit Load Profile

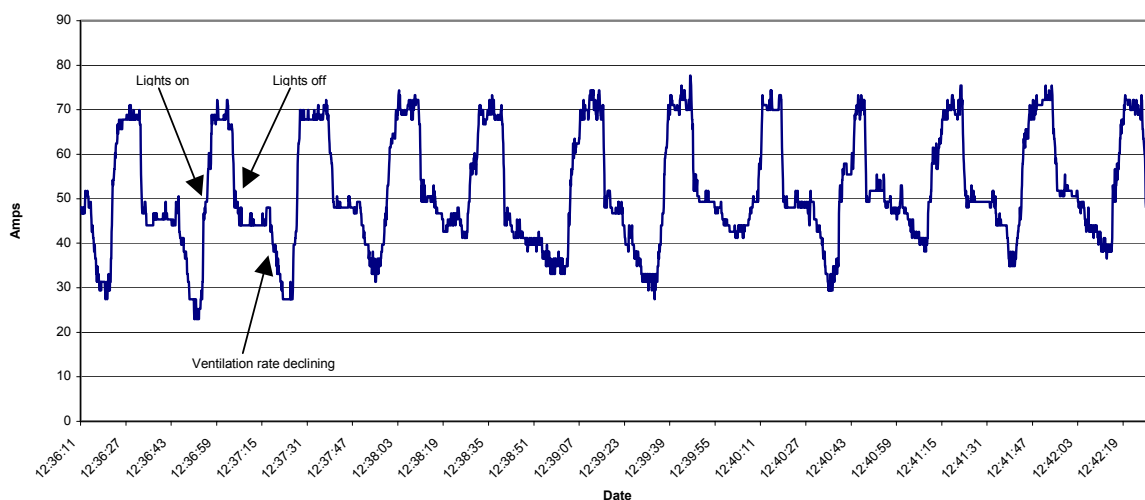


Figure 4 compares the supplier’s electrical load on a 24 hour basis to a swine finisher barn. A finisher barn’s load profile is very similar to the supplier’s load. If the supplier’s load peaks remained constant every day of the year, then the pricing structure would be very consistent as well. However, the increases in peak demand due to weather (cooling on the hottest days in summer, heating on the coldest days in winter), often require additional suppliers to meet these peaks. These short term suppliers need to cover large costs over a very short duration; hence, the peak price changes, as shown in Figure 5.

Figure 4: System Demand vs Finisher

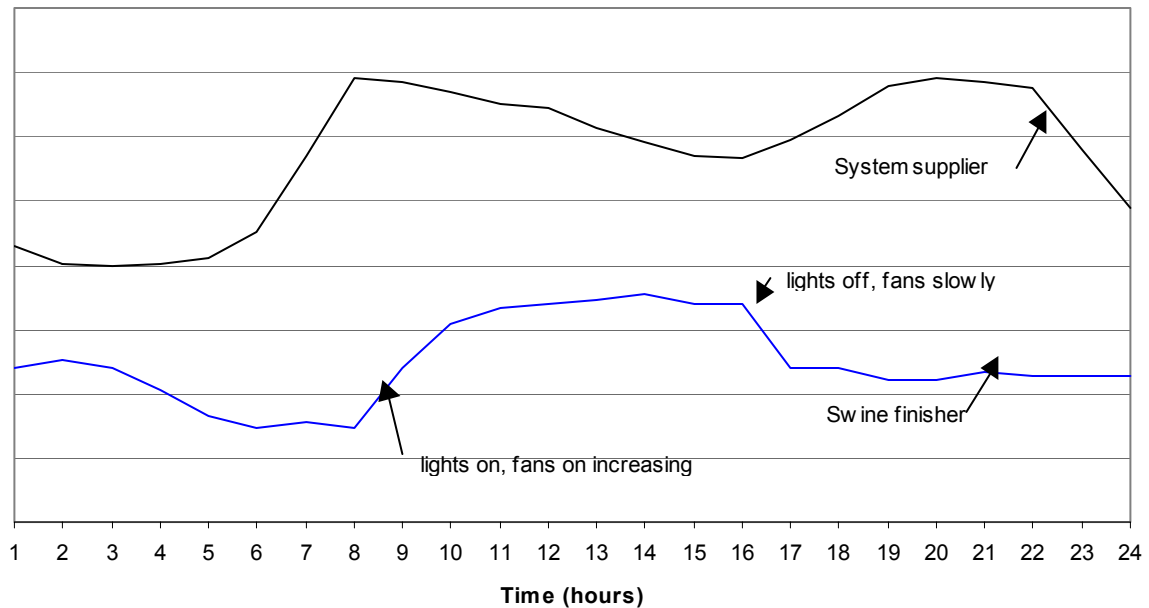
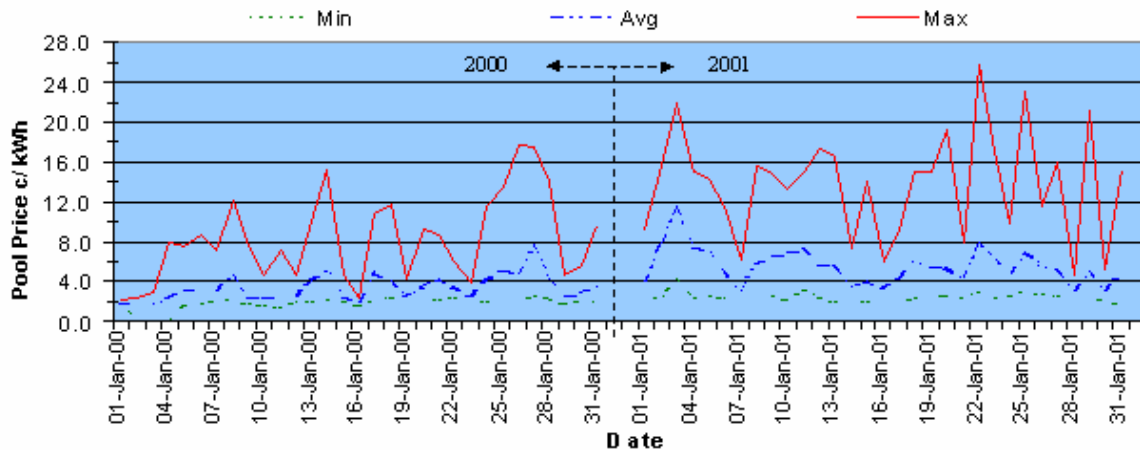


Figure 5 shows the effect on prices in a deregulated market in the US as of January 2001. The maximum and average prices increased after deregulation; however, the minimum price remained the same. January 22 2001's electricity prices ranged from about \$0.24 kWh to \$0.03/kWh with an average of about \$0.08/kWh (US\$). The average and maximum prices were short term only and dropped over the next two days.

Figure 5: Price Structure in a Deregulated North East USA Market Place, 2000-2001



If you stay with your current ‘default’ supplier, the rates will vary year round according to demand and pricing. They can be expected to rise in very hot and very cold weather, while remaining lowest during fall and spring. On average, your rates should be close to what they currently are in the short term.

Opportunities Under Deregulation

For most farms, the opportunities are limited. Unless electricity requirements are very large (over 5 Megawatts) and very steady, not much can be done in terms of purchasing agreements or contracts. Hydro One Networks will be the “default supplier” for most farms and cannot offer contracts. The cost for electricity is a floating price; therefore, it will bill on its cost to purchase on the spot market.

If you investigate a fixed duration and price contract, be aware that many other costs are excluded as stated earlier. These costs might include kW, power factor, stranded debt surcharge, distribution, transmission, as well as other local charges that have yet to be determined.

Distribution charges are set by the Ontario Energy Board and vary by area. For example, recent estimates were about \$0.014/kWh in Mississauga and as much as \$0.028/kWh for rural areas.

Check the web site www.oeb.gov.on.ca for these charges by location. They are not yet all settled. Be aware that this web site is not easy to navigate.

In the future, retailers may offer an option whereby they negotiate a rate with a large group of energy users, if it is beneficial. Under this rate structure, one bill will be sent to the entire group. This option appears unlikely right now.

A supplier/retailer might offer a good deal for a steady load that is on for 24 hours/day, 7 days/week. However, all farms are profile loads (Figure 4); in other words, they follow the supplier’s daily/seasonal load profile. Profile loads tend to be costly and not well suited to this form of rate structure.

While the opportunity to obtain savings through a contract with a retailer appears minimal, a farm energy audit may reveal potential for savings. The three main energy consumers on the farm include heating (particularly creep heating in farrow units), ventilation fans and lighting. On-farm feed generally is not as big a power consumer as many think, but should still be evaluated, particularly when motors can be scheduled to operate in off-peak times to keep the demand (kW) charge down. By conducting an energy audit, the opportunity for savings might be realized.

SUMMARY

In summary, the rate for electricity in Ontario is expected to be lower than retailers are currently offering and to remain fairly stable into the near future. However, where it goes after the first year or two depends on which forecast you believe.

Be aware that the final price for electricity billed to the farm may be much higher than the contract appears to indicate. Farms are advised to make no movement to sign any contracts until a clearer picture emerges of all the prices. All contracts should clearly indicate all the prices that can and will be included to preclude surprises.

LITERATURE CITED

- Ontario Government. Spring 2002. "Electricity: Plugging Into The Future." Ontario Government Report. Toronto, Ontario.
- Cambridge Hydro. Fall 2001. "Rate Structure Information Sheet." Cambridge, Ontario.
- Henderson, Graham. October, 2001. "Deregulation of Ontario Electricity Marketplace." Presentation to Professional Engineers Ontario, Guelph, Ontario.
- Vogel, Nancy. December 9, 2000. "How State's Consumers Lost With Electricity Deregulation." Los Angeles Times Los Angeles, California.

EMERGING OPPORTUNITIES AND CHALLENGES

CHANGING PRODUCTION REQUIREMENTS

**Bernard Peet
Pork Industry Consultant
Lacombe, AB**

ABSTRACT

In the past the pork industry has responded to economic and market pressures by reducing the cost of pork in real terms and providing a wide range of quality products. Over the next decade we will see an increasing focus on meeting consumer demands in the areas of food safety, animal welfare and the environment, mirroring the trends that have been seen in Europe over the last 15 years. This will necessitate some changes to production practices and the development of credible “farm to plate” quality assurance schemes. Such changes will best be applied by business structures which involve integration, cooperation, or alliances between producers, processors and the retail level. This will result in the development of dedicated supply chains with defined production and quality standards, supplying branded, added value or convenience products to the consumer. Business models which result in a value chain, where participants work together to maximize the profit in the chain, will replace the traditional, antagonistic relationships between producer, processor and retailer.

INTRODUCTION

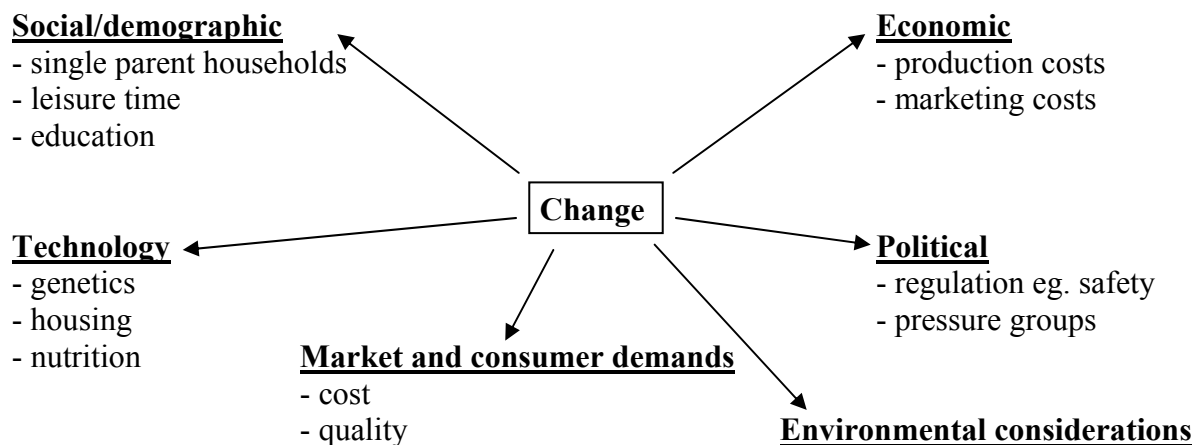
The pork production and processing industries have responded to a wide range of internal and external influences and pressures during their move from the immediate post-war period to the modern, intensive and efficient systems we see today. Although these changes have primarily been cost and volume driven and pork has effectively been a commodity market, the pressures for change are now increasingly related to factors such as product quality, food safety and environmental impact. At the same time, rationalization and concentration in the worldwide industry, including the development of integrated systems, has occurred. These structural changes may be seen as a threat to independent producers, indeed the development of large scale production systems has certainly hastened the demise of traditional family farms in many countries. In this paper I will look at the factors that drive change in the pork industry and focus particularly on the areas of consumer demands and structural change. I will consider how these will influence *how* we produce pigs and *who* will produce the pigs.

DRIVERS OF CHANGE

All businesses are influenced by a wide range of factors ranging from economic to political (Fig 1). Management of the business makes decisions on how to respond to these influences which affect how their products are produced, their cost of production and their attractiveness to potential customers. The importance of the many factors changes over time and will not be the same in different countries or in different market segments within the same country. For

example, animal welfare is not an issue in poorer countries, where cost of food is the major driver. However, in affluent societies, there may be a market for organic pork sold at a large premium.

Figure 1: Drivers of change in the global pork industry



Companies that respond correctly to these drivers succeed and grow, those that don't may fail. There are countless examples of once-successful companies that fell by the wayside because they did not adapt to a changing environment. In an increasingly global economy, if a domestic company does not meet consumer demand then a company from overseas will. How does all this affect the pork industry and help us identify what we should be doing? A brief look at where we have come from will start to answer this question.

HISTORICAL PERSPECTIVE

After a long period of food shortages during World War II, for many countries increasing the availability of food was a priority during the late 1940's and right through the 1950's. Governments encouraged agriculture to apply technology, increase output and reduce cost to the consumer. In most western countries, this process of continuous improvement continued without question until the 1980's. The choice and quality of food products available increased while the price dropped. The proportion of disposable income spent on food fell dramatically which meant that consumers became more demanding and quality oriented. Prior to the 1980's, few people had questioned the way in which food had been produced and the impact of intensification on food safety, the environment or animal welfare. But, at about that time, the beginnings of what we now call "consumer issues" or "consumer concerns" were surfacing in Europe and have had major consequences for the pork production industry there.

Structurally, the pork industry in both Europe and North America had also changed in the 30-40 years after the war. Farm size increased and the number of producers went down. In most cases this happened in a gradual way, but in the early 80's, the USA saw the start of a massive structural upheaval brought about because traditional US hog producers had failed to keep up with technological developments. The integrators, often poultry integrators, saw the opportunity to leapfrog 30 years in terms of genetics, housing and nutrition, slashing production costs. Now, only twenty years later, integrators account for about 30% of US hog slaughterings. This process has not happened so rapidly in Europe and Canada because producers kept up with improvements in technology more successfully. However, it is still going on and because the change is not as rapid, many producers have failed to recognize how it will impact their business. In Canada, large scale production companies and integrated systems like Maple Leaf, are successful not only due to their ability to reduce production costs but because they are able to address market demands more effectively, for example through added value, convenience or branded products.

In the next 10 years, my view is that the two most important considerations in the Canadian industry will be the impact of consumer demands in both domestic and export markets and how the industry will be structured to meet that demand, in particular the role of the independent producer. With regard to consumer issues there are many lessons we can learn from Europe, similarly the USA has valuable models for the survival of independent producers and the Danish industry can also provide useful information.

CONSUMER ISSUES IN EUROPE

Background and relevance to Canada

In Europe, consumers have become more discerning and more concerned about the food that they eat, creating the need for reassurance about the systems which produce food. Concern has been heightened by a series of "food scares" both in Britain – Salmonella in eggs, BSE, E Coli 0157 – and in other countries such as Denmark which had an outbreak of Salmonella food poisoning caused by pork in the early 90's. Most consumers have very little knowledge of farming or food production practices – in many industrialized nations only 1.5% of the population works in agriculture. This has added to the "fear factor" and fuelled a belief that intensive livestock are produced under horrific conditions and fed large amounts of antibiotics and hormones. The media, particularly the tabloid press, has exploited these concerns ruthlessly, especially in Britain, but also in Denmark and Germany. National governments and the EU have introduced ever tighter legislation in the areas of food safety, animal welfare and the environment especially from about 1990 onwards. At the same time participants in the food chain – primary producers, food processors and retailers – have introduced Quality Assurance systems to provide the reassurance customers have demanded. Some of these have been driven forwards by the retailers, others by the production and processing sectors.

Many of the areas relating to pig production that have seen great change in Europe over the last 10-15 years such as sow housing, welfare standards, the use of antibiotic growth promoters, Salmonella control and traceability, are now emerging as issues in North America.

As a recent immigrant from Britain I can see similarities between the situation in Canada now and that in Europe in the mid 80's to early 90's. Many in the industry believe it is inevitable that we move in the same direction with regard to production practices and quality assurance. If so, can we learn some valuable lessons from the experience in Europe? Canada, as a world exporter of pork also has to consider whether, in order to export pork to Europe, it will have to be produced under European conditions. Also, key competitors in other markets, such as the Danes, have a highly sophisticated quality assurance program. If Canada does not develop equivalent systems, will it be excluded from certain markets?

How change has occurred

Changes to production methods have come about in a number of ways:

Legislation: In countries such as Britain, Germany, Denmark and Sweden, pressure groups such as animal welfare organizations have successfully campaigned for, and got, legislation to ban the use of sow stalls. Some of these groups, such as Britain's Compassion in World Farming have huge budgets and are very influential.

Retailer demands: Retailers are seen as the conscience of their customers in that they make decisions about food standards on the customer's behalf. The consumer does not expect to purchase food from the retailer that makes them ill and there is a great deal of trust placed in Europe's major retailers. When this was threatened by food scares, retailers responded extremely quickly, and publicly, to allay those fears. Similarly, consumers expect the pork or chicken they buy to have been produced under humane conditions. Changing expectations in terms of production conditions have led retailers to, in turn, demand change from primary producers. Some producers view the retailer's approach as dictatorial but then the word "customer" is missing from many farmers' vocabularies.

Consumer pressure: The dynamics of consumer attitudes, perceptions and buying preferences is complex. "Consumers" are not one body, but can be categorized according to their degree of concern about farming practices and how it influences their buying decisions. A small percentage of consumers is vocal in relaying their concerns to retailers and politicians, having a proportionately greater influence on the process of change. In order to make rational decisions about how to respond to perceived consumer concerns, participants in the food chain must fully understand consumer psychology. This requires detailed consumer research on a continuing basis to identify trends in attitude, beliefs and knowledge. It may be expensive to satisfy the perceived demands of 10% of consumers if 90% are unwilling to pay for enhanced welfare or product quality.

QUALITY ASSURANCE SCHEMES

European Quality Assurance Schemes

I have already noted that systems of Quality Assurance grew in response to consumer demands and concerns. Many European countries have QA schemes for pork, either industry

wide as in Denmark, Britain and the Netherlands, branded meat quality programs such as “Land-juwel” or EGO in Germany or very specific standards for the production of products such as Parma hams in Italy. Depending on the need, these include elements relating to production methods, transport, lairage, slaughtering and meat processing.

1. In Britain the first pig industry scheme was the Scottish Pig Industry Initiative which started in the late 80's as a means of differentiating Scottish pork – this still operates today. A similar scheme was established for England and Wales in the early 90's, although it has undergone a series of name and organizational changes. Assured British Pigs and associated schemes for transport and processing now cover all areas of the chain from the farm through to processing methods. In the mid 90's the farm assurance scheme was fairly basic and the major retailers developed their own production standards for suppliers. The Farm Assured British Pigs scheme, as it was then, responded by creating new standards which embraced almost all the areas where the retailers wanted change. This effectively created a set of unified baseline standards and removed the need for retailers to pursue their own schemes other than for specialist products such as “outdoor reared” pork. In 1994, the Royal Society for the Protection of Animals (RSPCA) launched its own QA scheme, Freedom Food, with enhanced welfare standards, with pork and other livestock products sold with the Freedom Food logo by most major retailers. There are now 3000 farmer members in the scheme, 500 of them pig producers. All the British schemes are audited by national certification bodies.
2. Denmark, as Europe's largest pork exporter, has had quality control systems in place for many years, mainly related to product quality. Due to the integrated nature of the industry, once standards are defined, they are applied rigidly by everyone. In the late 80's, as food safety concerns increased, they launched their “Microbiological Action Plan” and then in 1992 the Meat Safety Assurance Scheme which was specifically for the important UK bacon market. This was revised and extended to include the Salmonella Control Program and pig welfare component, becoming the Danish Quality Guarantee in 1996. The system now included almost every aspect of the food chain but lacked detailed farm assurance standards. At this time, the British scheme had just become much more comprehensive and the Danes came under pressure from British producers and retailers to meet the same farm standards. In 1999, by which time the UK had phased out sow stalls, this pressure reached the point where Denmark had to respond. It developed a new set of farm standards embodied in the “Contract for UK Production”, broadly equivalent to the British ones including the requirement for group sow housing. Denmark also has specific quality standards for other important export markets such as Germany and Japan.
3. The Netherlands evolved its own QA scheme over the same period as in Britain and Denmark. Called IKB – Integrated Chain Control – it was developed in the mid 80's and introduced fully in 1992. It covers production standards, meat safety, traceability and product quality. Processors representing 97% of total capacity are members and 90% of all pigs slaughtered are covered by the scheme. The Netherlands had 28.8% of the UK bacon market (136,669 tonnes) in 2000 and the Danes 21.2% or 100,129 tonnes. While the Danes target the premium end of the market, the Dutch primarily sell on price.

However, this is changing, so that Quality Control is becoming a more important tool in adding value and ensuring consistent quality.

Features of a good QA system

A recent report by Britain's Farm Animal Welfare Council, a government advisory body, on the animal welfare implications of farm assurance schemes¹ said that "the basic tenets of Farm Assurance are credibility, transparency and traceability". It also noted that "methods of audit and assessment are critical to the consumer's trust" and that the body carrying out these functions should be both competent and independent. The British and Danish schemes are accredited under two European Standards and use independent evaluators. Independent accreditation is therefore the first requirement of a good scheme. Second, clearly defined audit procedures are required. This starts with clear, unambiguous standards, but at the same time over-prescriptive standards are undesirable as they stifle creativity and create antipathy amongst producers. In order to deliver the transparency and rigor of inspection which lead to credibility a scheme should have independent on-farm assessors, independent auditing of the system and random checking. It should also have well-defined procedures for non-compliance, for example suspension or removal from the scheme.

Integrated schemes – "from farm to plate" – deliver comprehensive reassurance to consumers for pork and other food items. They also avoid the confusion of several schemes within the food chain and allow an identifying mark to be used at the point of sale.

Lessons from Europe

The process of developing QA schemes and changing production practices in order to satisfy retailer and consumer demands in Europe has not been a smooth one because of the differing views and interests of the food chain participants. Here are some of the lessons I think we have learned:

1. Understand consumer attitudes in detail – what they know about production practices and which aspects concern them – and take this into account when developing QA schemes.
2. Work together with processors and retailers on standards. Find out what they want now and are likely to want in future. Agree upon standards and time scales so that everyone can support them and, if necessary, defend them, especially from animal welfare pressure groups.
3. Be pro-active with your food chain partners in developing QA systems and improving standards, otherwise change may be forced upon you.
4. Phase in agreed changes over a period of time so that producers know in advance what is required, especially if this involves changes to facilities.
5. Move towards using group housing for sows if building a new barn or remodeling – this will increase marketing opportunities in future. There is enough experience to draw on in

Europe to ensure that group systems are neither more expensive or less productive than stalls.

6. Use the scheme to identify the product to consumers and increase confidence by use of a “quality mark” – link this to advertising and promotion.
7. Don’t expect a premium for the product. Industry integrated schemes set the baseline for product quality
8. Sell the benefits of the system effectively to producers who often don’t understand the market beyond the farm gate – better liaison between producers, processors and retailers helps in this respect.
9. Don’t give the consumer too much detail about production practices unless they ask specifically. I know I mentioned transparency but people do not want to know about tail docking and castration – they need broad reassurance that gives them a nice warm feeling about eating pork.

How the CQA Scheme should develop

The CQA scheme primarily addresses food safety issues which is the primary area of concern for Canadian consumers and those in export markets such as Japan. However, it has some shortcomings even within its limited area of coverage (mainly that validation is too infrequent and it is not independently audited) that needs to be rectified. To stay ahead of future demand, the scheme should gradually be extended to other aspects of production and further down the pork chain, covering areas such as:

- Treatment of sick, injured and disadvantaged pigs
- Other welfare-related areas: housing, feed and water, management
- Environmental management
- Transport standards
- Lairage and slaughter
- Traceability

If the industry reads the market (ie the consumer) correctly and is pro-active both in the area of production systems and customer reassurance, many of the mistakes which have been made in Europe can be avoided. Improved Quality Assurance will also be of huge benefit in export markets.

STRUCTURAL CHANGE - INTEGRATION, COOPERATION AND VALUE CHAINS

Despite its technical efficiency, the pig production sector has long been extremely weak in the area of marketing. Pigs, like other primary agricultural products, are a commodity, with price driven by supply and demand and the producer being a weak seller. When prices are high, the

processor suffers, when they are low the producer suffers but rarely does the retailer suffer. Producers compete with each other and the smaller and less efficient ones are swallowed up by those that are bigger and more efficient. Similarly with the processors – they compete for pigs when they are short, driving up prices, in order to maintain their throughput and of course some fail to survive. This economic nonsense is perpetuated by existing structures within the industry, notably the marketing boards and groups. It is an antagonistic “no-one wins” situation that is going to change rapidly in the next 10 years.

What are the structures that will emerge?

1. Vertical integration – where production, processing and retail product are all carried out by the same company eg. Smithfield in the USA.
2. Vertical coordination – where production and processing is in separate ownership but closely linked by a long term arrangement.
3. Alliances between producer groups and a processor – again a long term arrangement.

The structures that have developed are based on two maxims:

- There’s only one profit in producing a pig!
- Each sector of the pork chain can add value to the other.

Vertically integrated companies have, in theory, the biggest advantage in this respect - they get the whole margin from farm to retail level and they can focus on adding value to and increasing profit throughout the pork chain not just in one sector.

These new business structures create value chains where the different parts of the pork chain work together to maximize the profit in the whole chain. This requires openness about costs and margins between the participants. Members of the chain work together to service an end market, either retail or export. To meet market requirements and maximize the margin from doing so requires very good communication between the parties involved. It may also mean changes to production methods, for example part of the requirement for a specific market could be the use of a Duroc boar or implementation of a Salmonella control and monitoring scheme. Such changes are made purely to meet this market and any increased costs involved can then be recovered and distributed fairly to the appropriate level in the chain.

One of the biggest advantages of a value chain is that the participants can not only share the overall margin more equitably but they can also work together to reduce price risk. The use of “window contracts” protects producers from receiving a price below the cost of production and protect the processor from paying too much when the open market is short of pigs. Both parties benefit but the average price paid or received is the same as the market over the long term.

Another outcome of dedicated supply chains is that they can produce a branded retail product to a determined set of standards with full traceability. It is likely that these systems will develop their own quality assurance systems with standards well above the baseline provided by the national scheme.

Producers will in future lose the option of being totally independent in the way that many are now because the current structure of much of the industry is unsustainable. One option is to become part of a vertically coordinated system such as the Maple Leaf Signature Program. This long term contract provides protection from low prices but requires the producer to use Maple Leaf's feed and breeding stock to achieve consistency in the end product. This type of arrangement will be attractive to some producers and will certainly provide security even though a small amount of independence is lost.

Another alternative is for independent producers to get together and form an alliance with a processor which allows them to focus on providing the quality of carcass that the processor requires. The producer group can also employ specialist management to help improve efficiency and reduce costs, for example by central purchasing of inputs such as feed. There are many examples of such groups in the USA where competition from the integrators is much greater. Producers had to get organized and increase efficiency to survive and also to gain some marketing power. In Alberta, I work with a group called Rocky Mountain Pork which has 13 independent producers with over 10,000 sows. RMP's management company hold an exclusive long term contract with Olymel in Red Deer which is based on cost of production. This "window" contract is for a minimum of 5 years and up to 10 years. Group management focuses on two areas:

- Improving the quality of hogs supplied in order to add value to both the producer and Olymel
- Providing a range of management and technical services aimed at reducing cost of production.

This value chain arrangement will eventually extend to Olymel's customers and the group aims to grow to 25,000 sows over the next 3 years. It provides a model for similar groups in other parts of the country.

CONCLUSIONS

During the current decade, I believe the two biggest changes we will see in Canada are related to meeting consumer requirements or concerns and major changes in the relationships between those involved in the pork chain. Producers will need to respond to the consumer, which will inevitably require some change in production practices. It will also need much more robust Quality Assurance Schemes to provide consumers with reassurance about the food they eat. These changes will increasingly be delivered by a more coordinated and integrated production chain, either through vertical integration, vertical coordination or alliances between producer groups, processors and possibly retailers. Coordination or cooperation not only results in reduced cost throughout the chain and greater competitiveness, but is more responsive to the market. Value chains, or dedicated supply chains will increasingly apply well defined production standards backed up by credible quality assurance to meet changing consumer requirements.

SWINE RESEARCH AT GUELPH: EXPLORING ALTERNATIVES TO ANTIBIOTICS

Bob Friendship
Department of Population Medicine
University of Guelph

ABSTRACT

The era of antibiotics in livestock feed for growth promotion and control of enteric disease may be coming to an end. In order to prepare for this possible development, researchers at the University of Guelph have been exploring a wide range of possible alternative approaches. These include genetic selection for disease resistance, genetic modification so that animals produce antimicrobial factors, and other methods of immune stimulation. As well, we are studying ways to modify the diet that encourages beneficial bacteria and discourages pathogens, and additions to the diet of beneficial bacteria or immunoglobulins to provide passive protection.

This paper examines specific work relating to alternative approaches to control of post-weaning *E. coli* diarrhea. Techniques that have been used include probiotics, prebiotics, egg-yolk antibody products, and vaccines. Generally, none of these techniques have been shown to be effective to date demonstrating that this is a complex and difficult problem.

INTRODUCTION

There is growing pressure on the livestock industry to reduce the use of antimicrobial drugs - the practice of using antibiotics at low levels in the feed for growth promotion is particularly under scrutiny. The greatest benefit of antibiotics when used as a means of improving feed efficiency and promoting growth, occurs in the nursery period and therefore, it is not surprising that surveys of drug use on Ontario pig farms have revealed that almost all pigs are fed antibiotics during the immediate post-weaning period (Dunlop et al, 1998).

The post-weaning period is a time at which the pig is particularly vulnerable to disease, especially enteric bacterial infections. A survey of about 500 Ontario pig farms (Dewey et al, 2000) that categorized herds into those with high death loss (>3%) and low death loss (<1%) found that the disease problem with the highest prevalence on the high mortality farms was *E. coli* (94% of herds). Further investigation of Ontario nurseries with Post-Weaning *E. coli* Diarrhea (PWD) found antibiotic use to be quite high in nursery operations with *E. coli* problems (Amezcuca et al, 2001).

Commonly, six or more different antimicrobial drugs are used during the nursery period on farms where PWD is a problem and antibiotic resistance has been shown to be a concern. The K88 *E. coli* strains isolated from these Ontario herds show multiple antibiotic resistance

including some resistance developing to relatively new antibiotics such as apramycin (Amezcuca et al, 2001).

The example of post-weaning *E. coli* diarrhea in Ontario nurseries illustrates the need to develop alternative therapeutic approaches. Over time, resistance will develop so that these drugs will not be effective, but it is possible that before that happens regulations will change so that the use of antibiotics might be greatly restricted. If either scenario comes to pass, how will this disease (or other diseases like this) be handled?

In our survey of herds with PWD, we were unable to identify management or other risk factors which could explain why certain herds have problems. This suggests that this problem can not be easily solved by simple changes to husbandry or feeding practices. Many of the herds instituted control measures that consisted of multiple treatments making it difficult to assess whether one particular measure had any impact. Common control measures used on Ontario farms with PWD include: antibiotics in feed and water and by injection, acidifiers in water and/or feed, high levels (> 2,000 ppm of zinc oxide in feed, prebiotics and/or probiotics in feed, immunoglobulins in feed (spray dried porcine plasma or chicken egg-yolk antibodies), vaccines (oral live bacteria or killed intramuscular bacterins).

RESEARCH SUMMARY

We have attempted to investigate some of these alternatives to antibiotics with respect to controlling post-weaning *E. coli* diarrhea. Our approach has been to try field trials on commercial farms where the disease is a consistent problem, as well, we have developed an experimental model where pigs are challenged with a controlled amount of *E. coli* organisms.

In each case, during a field trial, antibiotics and zinc oxide are removed from the feed and pigs are randomly allocated to a control group without treatment and a treated group. Generally, the level of diarrhea observed in both the treated and control groups have been similar and typically worse than before the antibiotics and zinc were removed.

Table 1: Results of K88 (F4) *E. coli* vaccination with killed autogenous and a live attenuated vaccine in a herd with endemic post-weaning diarrhea

	Treatment		
	Control	Injectable Vaccine	Oral Live Vaccine
Number of pigs	113	130	124
Pigs with diarrhea (%)	10.5	7.7	14.2

One explanation for the lack of success might be that more than *E. coli* alone is present on these farms, possibly viruses and other bacteria contribute to the treatment failure. Therefore,

evaluation of each treatment in a controlled laboratory environment was undertaken. Pigs were assigned to treatment and control groups and then given 5ml of a broth containing a known amount of K88+ *E. coli*. Signs of diarrhea and illness were observed in some of the pigs as early as 6 hours after oral challenge with the *E. coli*. To date, we have not observed an advantage to using intra-muscular vaccines, chicken egg-yolk antibody products, prebiotics (fructose oligosaccharides) or probiotics.

Table 2: The incidence of mortality and diarrhea in weaned pigs receiving either a control diet or a diet containing egg-yolk antibodies (Chernysheva et al, 2002)

	Farm 1 (n=204)		Farm 2 (n = 235)	
	Control	Treatment	Control	Treatment
Number of pigs	101	103	109	126
Mortality	5	5	3	4
Diarrhea	57	61	24	46

Interestingly, one of the most promising studies of growth performance in newly-weaned piglets was an evaluation of a herb extract containing cinnamon, thyme, and oregano (Radford et al, 2002). During the first week following early weaning, growth performance was improved as a result of adding 0.5% and 0.75% of the herbal extract product to the non-medicated diet. This resulted in higher body weights at 21 days post-weaning for those two treatments, as compared to the non-medicated control diet (0% diet).

Table 3: Growth performance of newly-weaned piglets receiving herbal extract (n=162)

	Inclusion level of commercial herb product			
	0%	0.25%	0.5%	0.75%
Weaning weight (kg)	5.30	5.37	5.46	5.40
Weight at 21 days (kg)	7.99	8.19	8.84	8.32

Researchers at Guelph have looked at the value of dietary supplementation of different organic acids as an alternative to the use of antibiotics in the diets of early-weaned pigs (Borysenko et al, 2001). Various diets were evaluated: a control diet (containing lincomycin 44 at 1 kg/tonne of feed), a negative control without antibiotic, and a ration with lactic acid, a ration with fumaric acid and a diet with formic acid (containing 0.2% of each acid). There were no differences between treatment groups with regards to visceral organ growth, feed conversion efficiency, white blood cell counts, and diarrhea scores.

CONCLUSIONS

What this demonstrates is that there are no simple solutions to this problem. In the past, if the pig gut was overwhelmed by a particular pathogenic bacteria, we simply used a product that killed the disease-causing micro-organisms and probably much of the other flora as well (much like using “Roundup” to solve a weed problem). The challenge we face in a future that may not include antibiotics is to develop a healthy gut micro-flora that is not reliant on broad spectrum antibiotics to keep the disease causing bacteria in check. We need to figure out what normal or healthy intestinal flora are and what aspects of the diet encourage the growth of these beneficial bacteria and discourage the proliferation and overgrowth of the disease causing bacteria like K88+*E. Coli*. This approach may include the addition of beneficial bacteria in the diet, the use of phages (virus to kill bacteria), methods to simulate gut immunity, and dietary manipulation to encourage certain bacteria and discourage others. Our work will primarily focus on probiotics and prebiotics to accomplish these goals.

The following definitions are offered to explain what is meant by these terms and where our research is focused.

PROBIOTICS

Definition. A term used to refer to preparations of live micro-organisms that are added to feed to improve the health of the host by beneficially influencing the indigenous microbes.

Application in Swine. The most widespread use of probiotics in swine is for the control of bacterial gastro-intestinal disease in young growing pigs, particularly *Salmonellosis* and *Colibacillosis* (*E. Coli*). The bacteria most commonly used as probiotics are *Lactobacilli*, but some work has been done using *Enterococcus faecium* and *Bifidobacterium sp.* It is generally thought that administration of the probiotics about the time of weaning when the piglet gut is immature and the permanent bacterial population has not been fully established is the most appropriate period to attempt to influence the microbial flora of the intestine. Probiotics mainly act in the small intestine.

Research Needs. The concept of probiotics is not new and yet has not been carefully evaluated. There is a need for the selection of strains of bacteria that are efficacious in the control of specific pig disease and there is a need to develop feeding programs that complement the use of probiotics and encourage a healthy gut micro flora.

PREBIOTICS

Definition. A term used to refer to non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improving the health of the host.

Application in Swine. The main focus of work has been to reduce the negative effects of bacterial diseases of the pig’s colon, such as swine dysentery colonic *Spirochetosis*, and *Salmonellosis*, by indirectly encouraging the growth of bacteria considered to be associated

with a healthy gut, primarily *Lactobacilli* and Bifidobacteria. Generally, prebiotics have also led to a change in metabolic activity of the intestinal flora causing an increase in carbohydrate fermentation and a decrease in protein degradation and fermentation. Carbohydrate fermentation generally results in harmless or even beneficial products, whereas protein fermentation results in production of potentially harmful products.

Research Needs. It is unclear whether prebiotics are complementary to the use of probiotics and a great deal of work is needed to determine optimums inclusion, overall efficacy, and which prebiotics work best under various circumstances.

LITERATURE CITED

- Amezcuca, M.D.R. 2001. Post-weaning diarrhea and mortality caused by *Escherichia coli* - Investigation of risk factors and control methods. MSc Thesis, University of Guelph.
- Borysenko, M., Fan, M.Z., Archbold, T., Atkinson, J.L., Dewey, C.E. 2001. Dietary supplementation of different organic acids as an alternative to the use of antibiotics in the diets of early-weaned pigs. Ontario Swine Research Review, p. 15 .
- Chernysheva, L., Friendship, R., Gyles, C. 2002. Does feeding of specific chicken egg antibodies control post-weaning *E. coli* diarrhea? Proc. Amer. Assoc. Swine Vet., Kansas City, pp 315-317.
- Dewey, C.E., Johnston, T., Oldfield, L., Whiting, T. 2000. The impact of disease on nursery pig production. Workshop #7, Amer. Assoc. Swine Practitioners, Indianapolis. , pp 3-11.
- Dunlop, R.H., McEwen, S.A., Meek, A.H., Friendship, R.M., Clarke, R.C., Black, W.D. 1998. Antimicrobial drug use and related management practices among Ontario swine producers. Can.Vet. J. 39: 87-96.
- Radford, M., Jeaurond, E., Schumann, B., Clunies, M., and deLange, C. 2002. Supplementation of diets with herb extract enhances growth performance in newly-weaned piglets. Ontario Swine Research Review, pp 37.

UNDERSTANDING THE SPREAD OF RESPIRATORY DISEASE IN NURSERY PIGS

Cate Dewey
Department of Population Medicine
University of Guelph

ABSTRACT

Blood samples were taken from 21 sows and their piglets on two farms. The pigs were sampled at 1, 3, 5, 7, 9, and 11 weeks of age. The serum was tested for antibodies against Porcine Reproductive and Respiratory Syndrome virus (PRRS), *Mycoplasma hyopneumonia* and swine influenza virus (SIV). On both farms, PRRS and mycoplasma were active in the nursery but SIV was not spreading through the barn. Inconsistent vaccination of sows and gilts lead to variable maternal antibody levels in the nursing pigs. This resulted in the spread of PRRS beginning the week after weaning. The spread of PRRS through the nursery was very rapid when the pigs were 5 to 7 weeks of age. The mycoplasma vaccine was not optimally effective when it was given to pigs that were less than 3 weeks of age. This is likely due to the interference with the maternal antibodies. Serological profiling of pigs for respiratory disease can be used to determine the effectiveness of the current vaccination program and to understand the spread of diseases through a group of pigs. Using this information, the producer can make informed decisions about the use of antimicrobials to control disease and vaccinations to prevent disease.

INTRODUCTION

Nursery pigs in Ontario are often exposed to Porcine Reproductive and Respiratory Syndrome virus (PRRS) and *Mycoplasma hyopneumonia*. There has been concern about swine influenza virus (SIV) over the past few years in both nursery and grower/finisher pigs. When pigs are infected with multiple respiratory pathogens, they have significantly more severe clinical disease than those exposed to only one pathogen at a time. The resulting disease is worse than the simple combination of the two diseases. Therefore it is important to understand when loss of maternal antibody protection occurs for these diseases and when the disease begins to spread through the nursery barns. Using this information, we can determine when to institute disease control measures.

Society is pushing the livestock industries to raise animals without in-feed antibiotics. The primary reason for this is the rise in antibiotic-resistant bacteria affecting the human population. Although there are many causes of these drug-resistant bacterial infections, one concern is the use of antimicrobials in food-producing animals. This concern has lead several European countries to restrict the use of in-feed antibiotics used for pigs.

Producers in North America are taking a pro-active stance in response to what has happened elsewhere and are investigating the possible ramifications of similar changes to our swine industry. Several important initiatives have begun. Producers are increasing their knowledge of antimicrobials through the Ontario Swine Medicines course and the Canadian Pork Quality program. Producers with their veterinarians are actively evaluating the use of antimicrobials on their production units. This will ensure that antimicrobials are used in the most effective manner.

There are many Ontario researchers currently working on the best approach to raising nursery pigs without antimicrobials, or with reduced levels of antimicrobials. The purpose of this project was to understand the spread of respiratory disease in nursery pigs through the use of serological profiling of pigs on commercial farms.

METHODS

Two commercial production units volunteered to cooperate in this study. On each farm, blood samples were taken from 21 sows in the farrowing room and five pigs from each of their litters. The pigs were bled every other week until they were 12 weeks old. The serum from these pigs and sows was tested by Animal Health Laboratory of the University of Guelph for antibodies against the PRRS virus (IDEXX ELISA), Mycoplasma hyopneumonia (DACO ELISA) and Swine Influenza virus (HI). These results were graphed to show the number of pigs that were positive for these diseases at one week of age, determine when they lost their colostral immunity and when they became actively infected in the nursery.

On farm 1, we conducted a vaccine trial. Within each litter, pigs were assigned to be vaccinated against Mycoplasma hyopneumonia using the Inglevac9 M hyo, Boehringer-Ingelheim vaccine. The pigs were randomly assigned to be vaccinated at 2, 3 or 4 weeks of age or were left as unvaccinated controls. Half of the control pigs were vaccinated against PRRS at weaning (3 weeks of age) and the other half were left as unvaccinated controls. All of the pigs that received the mycoplasma vaccine also received the PRRS vaccine.

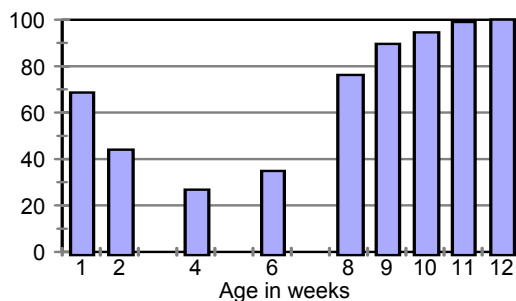
RESULTS AND DISCUSSION

Porcine Reproductive and Respiratory Virus

For this study we designated a PRRS positive SP ratio to be one that was at least 0.4. In farm 1, 29% of the sows had positive SP ratios for PRRS virus and none had SP ratios of more than 2.5. In the first week of life, 69% of nursing piglets had positive titres. This shows that sows can concentrate the antibodies in the colostrum for the protection of their piglets. By 4 weeks of life, only 27% of the pigs still had positive PRRS SP ratios.

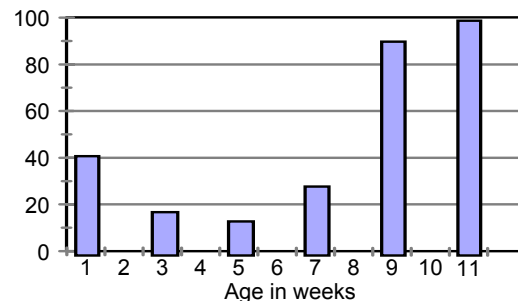
Farm 1: PRRS

Percent of Positive pigs



Farm 2: PRRS

Percent of Positive pigs



Active PRRSV infection (S/P ratio >2.5) was observed in 7% of the nursery pigs. The average age of pigs with active PRRSV infection was 55 days. The youngest pig to show active infection was 33 days of age while the oldest pig was 62 days of age. Four of the pigs with these high SP ratios were further tested to determine whether or not they were infected with the vaccine virus or the wild strain of the virus. We recovered virus from only two of these pigs. In one pig, the virus appeared to be similar to the vaccine and the other was infected with an intermediate strain. The serum results indicated that 5.9% of the pigs that did not receive PRRSV vaccine were actively infected in the nursery while 8.2% of the PRRSV vaccinated pigs became actively infected. This shows that the use of the PRRSV vaccine did not prevent active PRRSV infection in the nursery. Pigs that received the M hyopneumoniae vaccine at 3 or 4 weeks of age were less likely to develop an active PRRSV infection than those that received the vaccine at 2 weeks of age or not at all. This may have been due to high maternal antibody levels in the 2-week old pigs interfering with the development of an active immune response to the M hyopneumoniae vaccine.

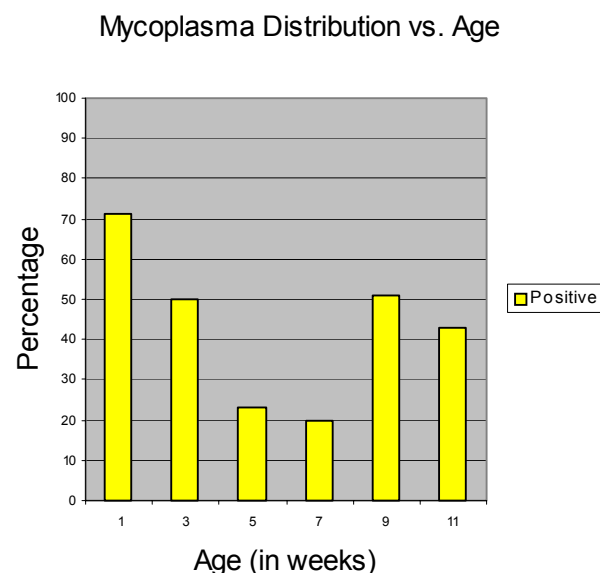
On farm 2, 40% of the sows had positive SP ratios for the PRRS virus and none had SP ratios of more than 2.5. In the first week of life, 41% of nursing piglets had positive titres. At three weeks of age, only 19% of pigs had a positive titre. It also shows that the PRRS antibody from the colostrum does not last a very long time. By five weeks, only 13% of the pigs were positive. This means that most of the pigs were susceptible to get PRRS. Of the pigs that were positive for PRRS, three of these pigs were still losing antibody from the colostrums, but 11 pigs had increasing levels of antibodies. These 11 pigs were infected with the PRRS virus when they were 3 weeks old. The producers were not vaccinating these pigs against PRRS, but were vaccinating the sows at weaning. However, there was an indication that these pigs were becoming positive for PRRS while they were nursing or shortly after weaning. Further examination of the SP ratios by parity revealed a difference in the ratio by parity. Only 39% of the gilts had a positive titre. The gilts with negative ratios had values of 0.000 to 0.23. In the sows, the negative values ranged from 0.000 to 0.35. The gilts with positive ratios had values of 0.58 to 1.72. The sows with positive ratios went as high as 0.79. Follow-up discussion with this producer included a review of the vaccination protocol. The producer was going to establish a system to ensure that the vaccination was being given to all sows and gilts.

For a disease to spread from one pig to another we have to have a pig shedding the virus and we need another pig that is susceptible to infection. When these nursery pigs were 5 weeks old, 85% of them were susceptible to infection because they had no antibody against the PRRS virus. We wanted to know how fast the disease spread through the nursery pigs. From 5 weeks to 7 weeks of age, 60% of the negative pigs developed antibodies to PRRS. From then on, the disease spread very quickly through the group of nursery pigs. Between 7 weeks and 9 weeks of age, 88% of the negative pigs became positive. By the time the pigs were 11 weeks old, 99% of the pigs had antibodies against PRRS virus. This means that the disease spread rapidly through the group when the pigs were 5 to 9 weeks old. Clinically this group of pigs became ill at 4 weeks of age and the most severe illness was seen when the pigs were 7 to 8 weeks old.

Mycoplasma hyopneumonia

On farm 1, there were 52.4% of the sows positive for antibodies to M hyopneumoniae (optical density of specimen <50% of the optical density of control). When the first blood sample was taken from the piglets at an average age of 5 days, 53.7% were positive for M hyopneumoniae antibodies. When the second sample was taken at an average of 18 days of age, only 25.8% of the pigs still tested positive for M hyopneumoniae antibodies. This shows that the pigs had begun to lose their passive immunity by the time the second blood sample was taken.

On farm 2, 78% of the sows were positive for antibodies to M hyopneumonia (mycoplasma). During the first week of life, 71% of the piglets had a positive titre for mycoplasma. The piglets were vaccinated at 16 days of age. When they were five weeks of age, only 23% of the pigs were positive for mycoplasma antibodies. It seems as though the pigs were not responding to this first vaccination. It is likely that the maternal antibodies were too high at the time of vaccination. Although this was the most convenient time to give the vaccine, it was probably the wrong time for the pigs in this herd. The pigs experienced a cough beginning at four weeks of age and then becoming most severe at 6 to 8 weeks of age. It appeared that the active spread of PRRS virus in the nursery barn in combination with the in-effective mycoplasma vaccination protocol, resulted in pneumonia in these pigs. It was recommended on this farm that the pigs be vaccinated against mycoplasma when they were at least three weeks of age, so that the maternal antibody was lower at the time of vaccination. It was also suggested that when the sows and gilts were uniformly vaccinated against PRRS, there would be less PRRS shedding in the nursery. This will likely reduce the problems due to mycoplasma as well.



Swine Influenza Virus

Swine influenza did not appear to play an important role in the clinical problems in either herd. In farm 1, 85.7% of the sows were positive for SIV (HI test titre >1:8). Although some pigs still had a positive titre at 11 weeks of age, these were pigs that were born to sows with high titres. These pigs were still losing their maternal immunity.

On farm 2, 57% of the sows had positive SIV titres. However, 82% of the sows were positive but none of the gilts were positive. Although SIV did not seem to cause a problem in this nursery barn, it is interesting to see the difference in titres between sows and gilts. Titres last a long time in adult and growing pigs.

CONCLUSIONS

Inconsistent vaccination of sows and gilts against PRRS virus can lead to active PRRS infections in both the nursing and nursery pigs. Maternal antibody against the PRRS virus only lasts a few weeks and this leaves nursery pigs prone to infection if the virus is circulating in the nursery. Mycoplasma vaccination may be ineffective if given to pigs with a high maternal antibody titre. It is important that this vaccination is not given to pigs less than three weeks of age if the sow has antibodies that are passed to the pig in the colostrum. It is expected that this will be true on most farms in Ontario. Swine influenza virus did not cause a problem in the pigs on these two farms. The antibodies received in the colostrum last a long time - even past 11 weeks of age.

Serological testing was used to understand the spread of infection in this group of nursery pigs. Although I have only presented the PRRS results, the samples collected can be tested for most infectious diseases. Examples of these would include PRRS, Mycoplasma and swine influenza virus. The samples can be collected on the same pigs over time as was done in this study, or by taking samples from at least 10 pigs from each age group all on the same day. Although following one group of pigs over time may provide more accurate information, it is very time consuming and it takes a long time to obtain the results. By sampling all pigs in one day, the producer and veterinarian will get the same information if most groups of nursery pigs have a similar disease pattern. The results of the tests can be used to establish vaccination protocols and to determine the best time to use pulse medication in the nursery barn. Serological monitoring is a cost-effective component of a herd health management program.

ACKNOWLEDGMENTS

I appreciate the financial support of Ontario Pork, Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario Agri-Food Industry, Agriculture and Agri-Food Canada and the cooperation of the participating producers and veterinarians. This project involved work from many people including Dr. Robert Friendship, Beth Young, Heather Gunn, Susan Fink, Tom Rosendal, Dr. Angel deGrau, Dr. Zvonimir Poljak, Kevin Vilaca, Nicol Janecko, Karen Richardson, Olga Mizak and Bryan Bloomfield.

WELFARE DRIVERS OF PRODUCTION PRACTICES: WHERE IS THE ANIMAL SECTOR GOING?

Temple Grandin
Department of Animal Science
Colorado State University

Paper presented at National Institute of Animal Agriculture, April 4, 2001

Taken from: Corporations Can be Agents of Great Improvements in Animal Welfare and Food Safety and the Need for Minimum Decent Standards
<http://www.grandin.com/welfare/corporation.agents.html>

In 1996 I conducted a survey for the USDA in handling and stunning practices in 24 federally inspected plants in 10 different states. Ten beef packing plants were surveyed. Out of these 10 plants only 3 of them (30%) were able to stun 95% or more of the cattle with a single shot (Grandin, 1997a). Four plants (40%) did poorly due to poor maintenance of stunning equipment. There was much evidence of a lack of management supervision in the stunning room. In three beef plants (30%) there was severe abuse of cattle. There was excessive use of electric prods, paralyzing bulls with electricity to hold them still and shoving downed, crippled cows with a forklift (Grandin, 1997a). Conditions improved greatly when McDonald's Corporation started their plant auditing program.

MCDONALD'S AUDITS

In 1999 McDonald's Corporation started auditing handling and stunning practices in the plants that supply them with beef. They used a scoring system that I developed for the American Meat Institute (Grandin 1997b) and I trained the HACCP food safety auditors from their grinder suppliers to do handling and stunning audits. The results of the McDonald's audits clearly showed huge improvements (Grandin 2000). Now 90% of the plants were able to stun 95% or more of the cattle with a single shot (www.grandin.com, www.mcdonalds.com). Most of the very abusive behavior of employees has stopped and in many plants electric prod use has been reduced or eliminated. Electric prods have been replaced with other driving aids such as flags. The year 2000 audits clearly indicated that the improvements have been maintained.

I have been working in the meat industry for more than 25 years and I saw more improvements in 1999 than I have seen in my entire career. I have designed handling facilities and have consulted on animal handling for most of the major meat companies. During 1999 I visited 27 pork and beef plants to conduct McDonald's audits and train auditors. The good news is that the vast majority of plants did not have to make expensive capital improvements to pass the audits. Small changes such as installation of a non-slip floor grating in a stunning box or changing lighting to reduce the frequency of animals balking and backing up were often the only equipment changes needed (Grandin 1998c, 2000b). Over half of all the improvements were brought about by motivating management to actively supervise handling

and stunning. There were also benefits in reduced bruises, less PSE (pale, soft and exudative pork) and fewer gaps in the production line.

The industry became serious about improving handling and stunning after McDonald removed one large plant from the approved supplier list and suspended several others for varying lengths of time. Both McDonalds and Wendys are conducting audits of handling and stunning. During my travels in the U.S. I have observed that the cleanliness of meat plants is better in plants that are audited by McDonalds or Wendys compared to plants that are not audited. Audits by restaurant companies have raised both food safety and animal welfare standards.

HANDLING AND STUNNING AUDIT PROCEDURES

The American Meat Institute guidelines use a critical control point approach for objectively scoring handling and stunning. This objective method provides more uniform results between different auditors than welfare audits that contain no hard data. Depending on the size of plants, 50 to 100 cattle or pigs are scored on the following variables:

1. Percentage of animals stunned correctly on the first attempt.
2. Percentage of animals that remain insensible and unconscious on the bleed rail. Fail if less than 100%.
3. Percentage of cattle that vocalize (moo or bellow) during movement through the chutes and stunning. Vocalization is a measure of distress or aversive events such as being prodded with an electric prod or missed stuns (Dunn 1990, Grandin 1998b, 2001, Warriss et al., 1994, Watts and Stookey, 1998 and White et al., 1995).
4. Percentage of animals prodded with an electric prod.
5. Percentage of animals that slip or fall.

Each variable is scored on a yes/no basis for each animal. The auditors also walk through the yards and unloading area and note problems with poor maintenance, overcrowded holding pens, slick floors, etc. A good auditing system should have a combination of hard data scores and a more subjective “walk through” evaluation. The American Meat Institute has conducted training seminars on handling, stunning, and implementing the guidelines during the last three years.

THIRD PARTY AUDITING

Currently each restaurant company is conducting their own audits for both food safety and animal welfare. In other countries, auditing companies have been formed to perform the audits so that a plant is not inundated with auditors from many different companies. Third party auditing will evolve. Currently, I have compiled data from the last two years of McDonald's audits and have published a summary of the results which presents an overall state of the industry. Individual plant names are kept confidential (www.grandin.com). During 2000 and 2001 I have continued to work with several companies to train auditors. To keep

this auditing system calibrated, I plan to pick several meat plant names at random from their restaurant supplier lists for audits that I will conduct. I favor random choice of these calibration plants so that my knowledge of the industry does not influence where I go.

WHAT WOULD THE PUBLIC THINK?

Being a practical person I base standards of animal treatment on what would the general public accept. I have taken many non-meat industry people to a well run slaughter plant and most people found it was acceptable. It is essential to fully explain disturbing sights such as stunned animal movement. It is important that the visitor has the opportunity to watch cattle going up the ramp for at least 15 minutes so that they see that the cattle remain calm. Producers need to ask themselves what would the public think? How would ten people picked at random from an airport or bus station react to animal rearing, transport or slaughter practices?

My background in working with animals is in cattle and pigs. When I visited a large egg layer operation and saw old hens that had reached the end of their productive life, I was horrified. Egg layers bred for maximum egg production and the most efficient feed conversion were nervous wrecks that had beaten off half their feathers by constant flapping against the cage. Half naked hens are not going to be acceptable to most people. This operation would fail the people from the airport or bus station test.

I showed a picture of the half naked spent hens to over 100 undergraduate students in animal science and biology classes. Before the slide was shown I asked the students to vote for one of the following categories: 1) totally ok, 2) somewhat disturbed or 3) totally grossed out. The students voted two-thirds somewhat disturbed and one-third totally grossed out. One girl raised her hand and said, "I worked at layer farms, those are good spent hens." Only one biology student thought the spent hens were totally ok. When I showed the pictures I was careful not to bias the students. I explained the voting categories while I was showing a slide of nice looking young hens in a battery cage.

Some egg producers got rid of old hens by suffocating them in plastic bags or dumpsters. The more I learned about the egg industry the more disgusted I got. Some of the practices that had become "normal" for this industry were overt cruelty. Bad had become normal. Egg producers had become desensitized to suffering.

There is a point there economics alone must not be the sole justification for an animal production practice. When the egg producers asked me if I wanted cheap eggs I replied, "Would you want to buy a shirt if it was \$5 cheaper and made by child slaves?" Hens are not human but research clearly shows that they feel pain and can suffer.

Need for Balanced Approach

Fraser (2001) states that some scientists who defend animal practices tend to gloss over the ethical issues. He provides the example of North and Bell (1990) which is a textbook on egg

production. This book fails to address the ethical concerns of the death losses which occur when feed deprivation is used to force molt hens. Fraser (2001) is a very thoughtful and objective article which discusses the need to obtain accurate information and to stop simplistic polarized views on both sides of welfare and environmental issues. Below is the abstract of Fraser's paper.

"A growing popular literature has created a "New Perception" of animal agriculture by depicting commercial animal production as 1) detrimental to animal welfare, 2) controlled by corporate interests, 3) motivated by profit rather than by traditional animal care values, 4) causing increased world hunger, 5) producing unhealthy food and 6) harming the environment. Agricultural organizations have often responded with public relations material promoting a very positive image of animal agriculture and denying all six of the critics' claims. The public, faced with these two highly simplistic and contradictory images, needs knowledgeable research and analysis to serve as a basis for public policy and individual choice. Scientists and ethicists could provide such analysis. In some cases, however, scientists and ethicists have themselves produced misleading, polarized, or simplistic accounts of animal agriculture. The problems in such accounts include the repetition of unreliable information from advocacy sources, use of unwarranted generalizations, simplistic analysis of complex issues, and glossing over the ethical problems. The New Perception debate raises important and complex ethical issues; in order to provide useful guidance, both scientists and ethicists must consider these issues as research problems that are worthy of genuine investigation and analysis." (Fraser 2001)

Minimum Decent Standards

Throwing live hens in the garbage is a practice that the vast majority of the public would condemn. I predict that animal welfare standards will evolve into two categories - a minimum decent standard for large scale commercial use and higher welfare standards for niche markets with higher income consumers. Throwing live hens in the trash violates most people's idea of minimum decent standards. It is my opinion that the new McDonald's standards for egg laying hens are a minimum decent standard that the egg industry really needed. Previously each hen was provided with the space equal to a half of sheet of paper. The new space standard for caged layers provides enough space for all the hens to roost at one time and feed deprivation to induce molting is banned.

An example of a higher welfare standard for hens would be free range hens. The acceptable ratings published in the American Meat Institute guidelines is another example of a minimum decent standard. Minimum decent standards need to be implemented worldwide.

THE SOW STALL QUESTION

Whereas throwing live hens in the trash or beating an animal are clear-cut violations of most people's idea of a minimum decent standard the issue of sow stalls is less clear-cut. I conducted informal conversations with airline passengers who sat beside me on the subject of sow gestation stalls. People are disturbed by the fact that the sow cannot turn around. A

typical comment was it just “does not seem right.” Each passenger was shown photos of gestation stalls and pictures of pigs housed in groups on a concrete slotted floor. Most people thought that the pigs on the concrete slotted floor were acceptable. Opinions on the gestation stalls were: 1/3 (no opinion); 1/3 (mildly opposed) and 1/3 (very opposed to the stalls) which prevented the sow from turning around.

There are many issues where decisions will have to be made to determine what will be acceptable for a minimum decent standard. Science can provide many answers, but ethics must also be considered. It is my opinion that an animal not being able to turn around for most of her life is not going to be acceptable to the public.

Barnett et al. (2001) provides an excellent review of the scientific literature on welfare of sows in different housing systems. This paper has over 200 references. They conclude that “the consequences for welfare of housing pigs in stalls for varying durations should be evaluated. Because stalls housing is a controversial issue from the view of public perception, but may have reproductive and welfare advantages, housing in stalls for a defined period that is considerably less than the period of gestation may be a reasonable compromise.” The main criticism I have of Barnett et al. (2001) is that genetic factors on behaviors such as aggression are not reviewed. Indoor group housing systems are likely to have greater success if less aggressive types of pigs are used. The author has observed that different genetic lines of group housed sows in the same building will have different amounts of injuries and abnormal behavior such as belly rubbing and ear sucking. Large groups of over a hundred sows may help reduce aggression. The author has observed that large groups of over a hundred finishing pigs, which have been mixed from different pens, engage in relatively little fighting. After the pigs arrive at the packing plant, they usually lie down quickly. There is a need for research on genetic factors. However, practical experience has shown that group housing systems will be more successful if pig genetics is taken into consideration.

SUMMARY

- Corporate purchasing power has been used to greatly improve conditions for animals.
- The American Meat Institute guidelines are being successfully used to objectively score conditions in slaughter plants by McDonald’s and Wendy’s. A good auditing system uses a combination of objective scores and subjective measures.
- Animal welfare standards will evolve into two categories:
 - Minimum decent standards which would be acceptable to most members of the public. Examples – McDonald’s laying hen guidelines and American Meat Industry guidelines at the acceptable level.
 - Higher welfare standards for niche markets with higher income consumers such as free range hens.
- Improving welfare during handling, slaughter and transport is a win-win situation, where there is often an economic advantage. A combination of audits and incentive programs can be used to reduce damage to animals.
- Implementing minimum decent standards for animal production may have economic costs and reasonable economic costs should be considered a cost of doing business. Both

scientific data and ethical concerns should be used to make decisions about animal housing.

LITERATURE CITED

- Barnett, J.D., et al., 2001. A review of welfare issues for sows and piglets in relation to housing. *Australian J. Agric. Res.* 52:1-28.
- Dunn, C.S. 1990. Stress reactions of cattle undergoing ritual slaughter using two methods of restraint. *Vet. Rec.* 126:522-525.
- Fraser, D. 2001. The "New Perception" of animal agriculture: legless cows, featherless chickens and a need for genuine analysis. *J. Anim. Sci.* 79:634-641.
- Grandin, T. 1997a. Survey of handling and stunning in federally inspected beef, pork, veal and sheep slaughter plants. ARS Research Project No. 13602-32000-002-08G. United States Dept. of Agriculture, Washington, D.C.
- Grandin, T. 1997b. Good management practices for animal handling and stunning. American Meat Institute, Washington, D.C.
- Grandin, T. 1998a. Objective scoring of animal handling and stunning practices in slaughter plants. *J. AM. Vet. Med. Assoc.* 212:36-93.
- Grandin, T. 1998b. The feasibility of using vocalization scoring as an indicator of poor welfare during slaughter. *Appl. Anim. Behav. Sci.* 56:121-128.
- Grandin, T. 1998c. Solving livestock handling problems in slaughter plants. In: Gregory, N.G. (ed) *Animal welfare and meat science*. CAB International, Wallingford, U.K.
- Grandin, T. 1998c. Solving livestock handling problems in slaughter plants. In: Gregory, N.G. (ed.) *Animal welfare and meat science*. CAB International, Wallingford, U.K.
- Grandin, T. 2000a. Effect of animal welfare audits of slaughter plants by a major fast food company on cattle handling and stunning practices. *J. Am. Vet. Med. Assoc.* 216:848-851.
- Grandin, T. (editor). 2000b. *Livestock handling and transport*, 2nd edition. CAB International, Wallingford, Oxon, U.K.
- Grandin, T. 2001. Cattle vocalizations are associated with handling and equipment problems in beef slaughter plants. *Appl. Anim. Behav. Sci.* 71:191-201.
- North, M.O. and D.D. Bell. 1990. *Commercial Chicken Production Manual*. 4th Edition, Van Nostrand Reinhold, New York.
- Warriss, P.D., S.N. Brown, S.J. and M. Adams. 1994. Relationship between subjective and objective assessment of stress at slaughter and meat quality in pigs. *Meat Sci.* 38:329-340.
- Watts, M. and J.M. Stookey. 1998. Effects of restraint and branding on rates and acoustic parameters of vocalization in beef cattle. *Appl. Anim. Behav. Sci.* 62:125-135.
- White, R.G., J.A. deShazer, and C.J. Trassir. 1995. Vocalization and physiological responses of pigs during castration with and without a local anesthetic. *J. Anim. Sci.* 73:381-386.

FACING THE CHALLENGES

PREMIUM PORK CANADA - FACING THE FUTURE

**Herman Lansink and Brian Simpson
Premium Pork
Lucan, Ontario**

SUMMARY

Premium Pork is the fastest growing pork producer in Canada. Its focus is on excellence in pork production and on meeting customer demand for large quantities of consistent, high quality pork products at a competitive price. Risk management is a key component of its strategy to achieve long-term stability. It is committed to further growth of its business, which is likely to include production of branded pork products.

THE ORGANIZATION

Premium Pork was initiated in 1997 as an integrated swine business founded on partnerships and alliances. The organization is committed to producing the highest quality pork by using the most effective, up-to-date production methods in an environmentally conscious manner.

Since its initiation, it has grown to include twelve 2500 sow units, six 1500 sow units, an AI boar stud, and has more than 300,000 pigs on feed. Most pigs are finished in Iowa and some in Indiana, in a 50/50 partnership with Prairie States Management. It is anticipated that another eleven 2500 sow units will be added to the system over the next two years.

STRATEGIES FOR SUCCESS

Premium Pork recognizes that its employees are the key to its success. Training and education, access to advanced production technologies, good pig genetics, a comprehensive bonus system, family, and community involvement all contribute to a highly motivated and successful staff.

Its strategy for further growth is based on industry trends, including increased consumer awareness about food safety, animal welfare and the environment, the consumer's changing need for different types of pork products, and consolidation of the packing and retail industry.

Means to address these industry trends include innovation, diversity in pork production strategies and pork products, achieving high production standards, and involvement in the industry. Premium Pork is continually exploring alternative manure management technologies, such as AMMTO, and wetlands, as well as open penning for gestating sows, to accommodate animal welfare and environmental concerns. Nutrient management plans are developed for all sites. We are pursuing HACCP approval and compliance with ISO 14001. Biosecurity is a high priority for Premium Pork, involving perimeter fencing and restricted

access to the facilities, tight protocols for entry of people and delivery of animals, feed and other materials. Premium Pork is actively involved in the Ontario Pork Industry Council, Ontario Pork Congress, and the Ontario Farm Animal Council.

We feel that packers want to form alliances with large production systems that can provide consistent quality and efficient quantities of uniform product. Since no expansion is expected in Ontario and US packing capacity, market price will be driven by supply of consistent quality hogs and versus shackle space demand. The current industry expansion will cause a downturn in market price in late 2002 and 2003, which we are preparing for by production and sales contracts.

FACING THE FUTURE

Bob Hunsberger
Progressive Pork Producers Co-Operative Inc.

ORIGINS OF THE PROJECT

Progressive Pork Producers Co-Operative (3P) was formed for the sole purpose of vertically integrating the hog farming members to the next stages of the pork supply chain. Those stages are hog slaughter and fresh pork preparation. The seeds of the concept were planted at an Ontario Pork annual meeting in the mid 1980's, with a discussion about a producer-operated kill and chill plant. Subsequently, Ontario Pork commissioned a study of the possibilities and concluded that the project was not feasible under that banner. However the concept did not die and in 1993 Progressive Pork Producers Co-Operative Inc. was formed with the intent of finding a suitable entry venue into the hog slaughter and processing business.

Many people found the concept of an integrated system alluring and initially the Co-op had about 500 members. Those 500 members produced about 1,000,000 hogs annually. When members were asked to commit funds to take the idea forward, some dropped out. Many, however, agreed to commit money through a check-off to fund the development of the plan.

With funds from a member check-off, 3P began an intensive study of the potential of various types and sizes of plants. The initial study looked at the costs and efficiencies of a 1,000,000 hog per year plant. As the plan evolved, it became clear that members would need to provide the equity component of the financing package. That represented a significant financial commitment by members and again some dropped out. By this time, the members' production was about 600,000 to 700,000 hogs annually. Our analysis still indicated, that was a feasible size.

The culmination of the project came in 2001 when the opportunity to buy Conestoga Meat Packers was presented. That deal was completed last year when Progressive Pork Producers Inc. purchased the shares of Conestoga Meat Packers Inc. Progressive Pork Producers is now structured as a new generation co-operative.

The plan now is to kill all of the hogs produced by the 173 members and market the meat as fresh pork.

WHY WOULD PORK PRODUCERS DO THIS?

Meat packing is a volatile, high-risk business but it is offsetting vs. the risk of hog farming. The question of why hog farmers would want to take the risk of vertically integrating into meat packing is complex and multi-dimensional. However, the primary reason centers on the question of whether our future as smaller, independent farmers is more predictable with or

without the integration. In order to assess that, we looked at the state of the pork industry in North America. Our conclusions were:

- Demand for the product is declining.
- Supply chain relationships, across segments, are poor.
- Supply chain segments are internally fragmented.
- Vertical markets have failed.
- Most of the North American industry is vertically integrated or aligned.
- The most profitable business in the industry is the most integrated.

Factors Contributing to Vertical Integration

- Vertical market failure – the market becomes so risky and unreliable that it is impossible to make coherent business plans and the contracts designed to overcome that risk become difficult to create and administer.
- Unequal distribution of market power.
- Integration can raise barriers to entry and allow price discrimination across segments.
- Independents are pulling out of adjacent stages of the supply chain.

Characteristics of a Failed Market

- A small number of buyers and sellers.
- High asset specificity, durability and intensity.
- Frequent transactions.

CHALLENGES FOR THE FUTURE

- Operate a new generation co-operative efficiently and effectively.
- Show farmers how their pigs affect the marketability of the product.
- Sell the product profitably.

OBJECTIVES

Through the last ten years, the gross returns per hog have ranged from \$235 to \$30. That volatility is unacceptable for any logical business planner. This project set out to address ways of managing and mitigating that risk. The lives of our members are based on their businesses. Their families' future hangs on successful and stable production. The final membership of the Co-op is comprised of these people....firmly committed members who were willing to risk their capital and agree to provide a consistent supply of high quality hogs. From the beginning of this project, members have been told that their payments would be based on the market value of their pigs. The intent, therefore, is to pursue markets for high quality hogs where the production and control system can be a part of the process. Farmers have traditionally bought branded products (seed grains, herbicides, machinery, feed) and

combined them to produce a commodity. That commodity is then sold to a buyer who takes it apart and produces branded products. 3P believes that how the pigs are grown can be part of the brand.

Pork is the most widely consumed meat in the world. In spite of declining demand, we believe that there is an ongoing market for pork. 3P members intend to face the future by sharing production and processing information, mitigating risk by participating in both sides of the business and by being driven by the customer demand for fresh pork products from integrated, family-based businesses.

UNDERSTANDING THE RETAIL SECTOR: TOWARDS TRACEABILITY IN THE MEAT PRODUCTION CHAIN¹

Brian Buhr
Department of Applied Economics
University of Minnesota

ABSTRACT

The traditional food supply chain is arranged as a complex array of producers, handlers, processors, manufacturers, distributors and retailers. As the food supply chain grew in complexity over time, little emphasis was placed on preserving information regarding the origin of raw materials and their transformation, often by multiple handlers, into consumer ready products. The 1990's saw an explosion of the desire for information beyond the retailer, as many foods' final traits are increasingly determined and controllable at the production or even genetic level. Often these traits are not readily observable to the final consumer and labeling or other assurances are necessary to provide this information to the final consumer. Further demands for traceability have arisen from concerns about food safety and more recently bio-terrorism. In both cases the primary economic objective of traceability is to appropriately capture value or assign costs. So far, the North American food system has relatively limited traceability of food products, particularly animal products. Meanwhile, several European countries have implemented animal product identification mechanisms. Historically, these were managed by costly batch processing methods that are not likely to be implemented in the large-scale, throughput-oriented supply chain in the U.S. However, the advent of information technology including electronic scanning devices and the Internet offer promising technological solutions for maintaining large-scale supply chain efficiency while maintaining product identity. In 2001, case studies including several European meat and poultry supply chains were completed. The objective was to identify incentives for adopting supply chain traceability, to understand the economic costs and benefits of these existing traceability systems and to assess their potential for application in North American meat and poultry supply chains. This paper focuses primarily on the economic issues identified and uses illustrations from the case studies to underpin these results.

INTRODUCTION

Food safety issues in meat and livestock have come to the forefront in recent years with high profile incidences of contamination by *e. coli*, BSE, dioxin, hormones and antibiotics all contributing to a desire to find ways to improve quality control systems in the meat supply chain. In the U.S., the primary large-scale response has been to implement HACCP programs from slaughter to retail. However, in the case of BSE or hormone and antibiotic residue, the need for quality control programs extends farther back to feeding and management practices

¹ For those interested in more details than space permits in this paper, a complete description and analysis of the cases is available from the author (formal publications are in progress, but it's too early at this stage to formally cite them). Simply send an e-mail with your request to Brian Buhr at bbuhr@appec.umn.edu.

on the farm or even feed manufacturing. Extending this to include the use of genetically modified feed ingredients, product integrity must be controlled at the crop production stage of the supply chain. As a result, there are increasing calls for meat supply chain traceability initiatives along with identity preservation of genetically modified crop products.

A few recent economic studies have addressed the physical or market side of the traceability issue. Liddell and Bailey (2000) examine the broader market implications of traceability by ranking the relative development of traceability systems in the U.S. to other competing countries in world markets. They suggest the U.S. lags behind in areas of both food safety and quality control, particularly when compared to European suppliers such as Denmark and the U.K. However, there is no information in the report regarding the actual types of quality control systems in place or their economic potential. Hooker, Nayga and Siebert (1999) examine the food safety activities in the beef industry and primarily focus on the results of surveys regarding the ability to implement food safety practices, including traceable supply chains. Most processors in the U.S. and Australia viewed it as feasible, but the particulars of how it might be implemented or the economic costs of implementation are not directly addressed. Bullock, Desquilbet and Nitsi (2000) consider the costs of identity preservation and segmentation of grains, but construct their economic results from an economic engineering perspective with no hard information on actual costs and potential benefits of implementation. Maltsbarger and Kalaitzandonakes (2000) take a similar approach with regard to grains and Hobbs (1996) develops an economic engineering approach to implementation of traceability in beef processing. Missing from all the previous work is a look into the actual economics and practices necessary to implement traceability.

Five European organizations were chosen for this investigation. Participants included a poultry production system (Label Rouge/Challans, France); an egg production system (KAT/Wiesengold, Germany), a salmon production system (Intentia/Nutreco, Norway), a veal production system (The VanDrie Group, The Netherlands) and a lamb, pork and beef supply chain (Scase-Intentia/Gilde, Norway). In examining these systems several supporting organizations were also visited, including the Poultry Livestock and Meat Board in The Netherlands, several governmental agencies in France, and Carrefour supermarkets in France. This enabled us to discuss the implications with other participants with whom the focal organizations interact. There are several other firms implementing traceability schemes in the E.U. such as Pingo Poultry (Nutreco), Danske Slagterier (Denmark) and Beltrace (Belgium). Our selection included those willing to graciously open their systems to our visits. The objectives of the site visits were to document the supply chain production protocols, examine alternative forms of governance structures for supply chain traceability and document methods of electronic traceability. This paper, however, focuses on the economic incentives and implications of adopting traceability in their supply chains. This includes a diverse set of issues, which I believe require careful consideration as similar systems are adapted to North American meat and poultry supply chains.

TRACEABILITY SYSTEMS ARCHITECTURE

The general concept of traceability as implemented by the case study participants included

three components – 1) management of the physical supply chain, 2) management of the parallel information system to maintain traceability and 3) organizational structures to manage and implement the production and information systems. This section provides a description of these aspects. For the most part this section is ‘fact’ base with little discussion of the implications, but sets the stage for the economic issues raised.

Physical Production Systems

In all cases we visited, the traceability systems extended from the feed manufacturing process through retail. Also, each case had unique production protocols that supported the development of particular consumer product attributes such as organic production, group housing, free range or antibiotic free. All were also clearly focused on the joint issue of food safety. The production protocols typically stipulated production inputs such as feeds, health treatments, and animal rearing methods (e.g., non-cage, group housing, free-range) and genetics. Production protocols were enforced at all stages of the production process. In many cases the key implication of this was the need to manage the production modules as batch processing systems to maintain product integrity. This “batch” system also improved the efficiency of the information system by creating larger lots to be tracked, rather than tracking individual animals. Still, all systems were able to trace individual animals or products as well. In cases where the supply chain members were independent but cooperatively organized, group boards usually established the protocols. In the vertically owned and contracted cases, protocols were simply mandated by management and implemented at the production level. Most operations were of relatively small scale, compared to North American production standards. For example poultry farms we visited had a maximum of 4,300 chickens per farm and the processing plant (mid-sized by their standards) slaughtered approximately 2,000 birds per hour.

Logistics management in production becomes a key enabler of traceability. Animal supplies, slaughter times and locations, feed deliveries and other aspects were all tightly coordinated because the supply chains were relatively closed. Animals must be identified when they are born, carefully tracked as they are moved between farms and then tracked at slaughter if they are to be identified by the final product. The most intensive points of logistics were at aggregation/dispersion points for inputs (e.g., feed plants with ingredient inputs and packing plants where carcasses are disassembled). Batch integrity quickly becomes an important production management tool by reducing the sheer number of observations (e.g., animals vs. pens vs. barns vs. farms). The more individual elements (e.g. animals) that could be treated identically the greater ease in managing production protocols. Hence, production methods often fit the scale of barns. It’s very much analogous to all-in-all-out production management already common in the swine industry in this regard.

Information Systems

Information systems we observed ranged from relying heavily on paper and personal computers to fully web-integrated traceability systems. However, it is clear that all will evolve to incorporate the Internet in some form because of its inherent merits for creating large and centrally managed databases. There are two key components to the information

systems: the computer databases and applications themselves and the information hardware necessary to collect and record data. Weigh scales with data ports, visual carcass grading technologies which enabled capture of key carcass parameters, water monitoring devices for measuring mixing ratios of calf-milk replacer are all examples of data collection devices which greatly enhance the ability to capture production information which can be part of the traceability information system. These lower the costs of collection, improve accuracy and avoid the error of human input. At this point, processing plants (feed and meat/egg) had a much higher level of automated data collection hardware than did farms. This was particularly true in cases where the farms were mostly independent from the rest of the chain.

In addition to measurement devices, there must be methods to physically identify products. Interestingly, the everyday barcode was still the primary vehicle for labeling products. Two firms (Gilde and VanDrie) had experimented with implantable and radio frequency id's (RFID's), but found they were unreliable compared to inexpensive barcodes. The primary problem with implantable chips is that they migrated in the animal so they were difficult to find (and more importantly may have carried a food safety risk in themselves) and RFID's had production line difficulties in getting them to read properly. At farms, much of the information was still captured via human data entry from paper reports, and multiple copies of paper reports were kept on file at other participants locations or at enabling agencies.

As mentioned the information systems varied from personal computer based databases in the case of Challans (they are moving to web-based databases) to state of the art web-based systems illustrated by Gilde/Intentia/Scase, VanDrie and KAT. The personal computer based systems are very similar to existing swine record systems but included information on all stages of the supply chain. The obvious drawback of this is that while it was functional for maintaining traceability it was nowhere near real-time and not physically or remotely accessible by someone not on the computer. So while they did have traceability, it was not very transparent to those external to the system. The state of the art systems were real-time and transparent to anyone. In the cases of KAT and VanDrie they had consumer focused websites where the consumer could take the code number from their egg or package of veal, enter it into a website and actually see the farms and plants where the product originated and a limited set of information of the production protocols, any quality assurance tests which had been done and their results. For an illustration, visit VanDrie's customer website at <http://www.vealvision.com>.

The overarching goal for much of the computer industry and IT is the development of standardized system architectures including databases and interfaces. This systems compatibility has dramatic spillover benefits for traceability and business management as well. From our observations it appears that the system that is in the front-running position is a combination of enterprise resource planning systems combined with corporate level intranet modules which then interface with web-based information systems for transmitting data to other partners in the supply chain. Enterprise resource planning systems (ERP's) basically serve the role of capturing and managing operations and management data. For example, VanDrie had an ERP for its' feed manufacturing plant which was specific to feed processing. This ERP analyzed real-time ration formulation and then captured the data of the final batch that could then later be used to support traceability. This has the advantage of being highly

customized to the particular application (in this case milk replacer blending), but is secure because there is not outside access to the system. A subset of this data was uploaded to the VanDrie corporate intranet which simply is a server (database) which links computers within their operations (feed, farm, slaughter). The feed ingredient identification and any tests that were relevant to the farms or the slaughterer were uploaded to this intranet, making it available for tracing information. Similar activities are done at each stage of the production process (e.g., farms had veterinary certification and treatment records, the slaughter plant had carcass information, etc.). Of this universe of data from all stages of operation, only the subsets necessary for confirmation of traceability to outside parties (e.g., ear tag identification numbers, test results, prices, etc.) were added to the Internet database.

The merits of this information system are considerable in that it captures the efficiency of production management systems (ERPs), while enabling efficient transmission of information to upstream and downstream participants in the chain while maintaining security for the entity. The KAT organization and Gilde/Scase managed very similar information systems from an architectural standpoint. Clearly, the more efficiently data can be captured for input into the system the more valuable it becomes, so bridging the physical world and the digital world is an extremely important component of traceability. Note also that in many cases, the networked traceability systems doubled as sales planning systems. In the cases of Gilde, Label Rouge, and VanDrie, they all had mechanisms for retailers to place orders directly into their system and even provide pricing information so that the price labels could be directly applied at the plant. This has tremendous potential for creating dual traceability and supply chain management benefits.

One of the most striking insights from the traceability systems we observed is that while their goal seemed to revolve around a desire to improve information and create the ability to trace and preserve identity, there were two significant spillovers. First, it enabled dramatically improved collection of data about production processes which was then used for production management decisions, and secondly, it naturally led to improved supply chain coordination for other purposes such as pricing, ordering and aligning supply and demand. Much of the theme of the rest of the paper will include the theme that potentially the greatest impact of traceability is not the success of preserving the identity for products, but actually these spillovers into the areas of production management and supply chain management.

ECONOMIC TRADE-OFFS IN TRACEABILITY

Branding, Consumer Demand and Traceability

When we asked our case participants why they adopted traceability, the first response in every case was: “consumers demanded to know where their food came from and how it was produced.” Why consumers wanted to know this clearly had to do with historical food safety issues such as dioxin contamination, BSE in cattle, radiation contamination as well as increased demand for organic products or free range products. However, the participants consistently co-mingled these other product attributes with traceability. So, it was impossible to say whether consumers actually demanded traceability or if they actually demanded other product attributes (e.g., organic poultry) or some combination which is most likely. When we

speak of traceability in the physical sense of the control mechanisms and information systems to accomplish identity preservation, we also need to differentiate between this and HACCP procedures which also improve food safety. A prime example is the potential substitution of irradiation for traceability. What value does traceability have when irradiation breaks the chain of pathogens to that point? Traceability by itself may only improve food safety by enforcing truth telling and possibly by improving information on processes which contribute or detract from food safety.

In this context, branding can be thought of as a traditional form of traceability. By labeling it clearly identifies the seller to the buyer. This has two benefits: it allows the buyer to capture the value of their particular product by differentiating it to the consumer and it enforces truth telling or a form of reputational traceability in the sense the company and its' brand are held accountable for delivering what they say they will deliver – in the present case a safe and wholesome food product. Case study participants often viewed traceability as supporting branding by increasing consumer confidence in the production process. However, this could be obtained through effective control mechanisms without traceability in place. It also implies a potential failure in branding in that consumers do not trust the assurances provided by brands but seek to have the ability to examine those assurances themselves. Therefore, the current argument is that firms, and especially firms with consumer brands seek traceability to support their brand by tracking their suppliers. This is a very important distinction – consumers probably really don't care how their food got "safe", but they will penalize those with unsafe products. The branded firm will seek to push those penalties back to suppliers who might be the actual cause of any problems. Similarly, from a value perspective of firms in the supply chain without consumer brands, they are seeking to capture value from the downstream firm with the consumer brand. Hence, I argue that while traceability is often packaged as a consumer demand issue – it is at its' heart an intra-firm allocation issue. To the extent consumers view this as superior is likely a psychological benefit (not to minimize the fact this can have important marketing value). In the same sense, brands are eroded by 'mistakes', traceability will be eroded as a consumer value as there are 'mistakes' and may perhaps be more severely penalized for mistakes because of the implied integrity of traceability.

Food Safety and Value Capture

All participants illustrated concerns regarding mitigating costs and improving food safety and capturing the value of product attributes which were often categorized as credence attributes. Credence attributes are simply those attributes which are only verified by assurances of the seller, many animal welfare issues (battery cages, free range, group housing, etc.) are undifferentiable to the consumer but for the claims and assurances of those using these production methods. This is in contrast to physical attributes (e.g., the color of the meat) which is easily observable and verified by the consumer. While capturing value through traceability is a one sided coin – firms benefit if they can capture value they have contributed to the final product, food safety is a two sided coin – on one hand creating superior food safety can be a value added attribute, at the same time it can result in high costs if not accomplished – hence having positive and negative consequences. Value capture is relatively straightforward and so emphasis in this paper is focused on the food safety issue.

The food safety implications of traceability are quite interesting. First, though it must again be emphasized that food safety issues for the firm can be controlled through HACCP processors or technologies (e.g., steam pasteurization, irradiation, worker and production line hygiene, etc.), while traceability largely involves information about these processes or products. Traceability has two components in its economic effects on food safety (1) it assists in identifying the origin of the food safety problem and (2) it likely reduces the costs of containing a food safety problem if it occurs. Navobi, the calf-milk replacer manufacturer, provided an excellent example of this point. Their veterinary services identified a salmonella problem in routine on farm testing. They immediately sampled feed batches at the farm and also were able through traceability databases to identify all possible other farms using feed from the same batches and which ingredients and their sources had gone into the suspected feed batches. Therefore, they were also immediately able to go back to plant records to cross-check feed testing which had occurred prior to its sale. They found that no feed was contaminated and that the salmonella had been introduced by other means on the farm. Without traceability they would have recalled all suspected feed immediately to reduce the risk of cross contamination to other farms, and likely wouldn't have been able to identify as quickly that the contamination had occurred on the farm versus at the manufacturing plant. They did an ex post assessment of the cost savings from traceability and estimated in this single instance it saved them over \$100,000 in recalls and recovery costs. What this example illustrates is that the value of traceability likely depends on the overall risk of contamination and the costs of testing or controlling for that risk, and also the overall potential costs for recall. The costs for recall also depend on how widely the product is distributed upon its release. In a relatively closed system such as VanDrie's feed manufacturing and calf feeding, the potential recall costs are small compared to potential recall costs for ground beef which can be distributed very widely and can even be used as ingredients in other manufactured food products. Proper valuation of traceability in any instance depends on the following issues 1) the accuracy of testing and sampling procedures for detecting contamination 2) the costs of sampling and testing or control (HACCP) procedures 3) the dispersion of the product once it leaves the control of the firm 4) the probability of contamination itself 5) the costs of recall and 6) any potential costs in terms of liability and reputational damage. What traceability likely contributes to these issues is that it reduces the costs of recovering from a food safety outbreak and to some extent may reduce the probability of outbreak by improving information within the process and enabling communication and identification of potential issues more quickly and efficiently among participants. To simplify this logic, think of it as the proverbial "ounce of prevention and a pound of cure". You can prevent outbreaks and food safety issues through preventative measures such as improved sampling, testing procedures and technologies, or you can reduce the "pounds" or costs of compensating should an incident occur. This recognizes the fact that given the biological nature of food safety issues, there is no "zero risk" state and that traceability has a contribution to make in improving response (hence lowering human health implications and costs) and helping improve communication.

The previous discussion ignores the "allocation" problem. The current issue with many food safety issues is that the restaurant or grocery store who last handles the product before consumption is the initial focal point for identifying the problem and also for resolving it and potentially bearing the liability costs. Similar allocation problems may exist at all stages of

the chain. In this case, traceability plays an important role in both allocating costs once an outbreak may have occurred, but probably also inherently improves it because firms are more likely to implement control procedures knowing that their probability of being held liable and identified are much greater. This is a similar argument on the value-added side of the issue.

Retailers and Traceability

Although our focus during the case visits was not on retailers; given the consumer, branding, value added, food safety and logistics issues involved in traceability it's not surprising that retailers are the nexus where traceability comes together. In particular, grocers and even restaurants view fresh meat and produce as the final strategic niche in which they can differentiate themselves to consumers (vs. WalMartization). However, retailers find themselves in a strategic conundrum in the nexus between food safety, value added and traceability. On the positive side, traceability enhances their ability to offer value added products such as improved safety or organic products as it helps them assure that the attributes claimed are accurate. Also, traceability naturally fits into major retail initiatives of ECR (efficient consumer response) and CPFR (continuous planning, forecasting and replenishment) where information systems and standardization for logistics are critical to success and an area in which meat products (with variable weights and cutting differences) largely defy systems applied to dry goods. As we'll see shortly for the rest of the production chain, traceability also enables retailers to avoid the "liability by association" problems they face in anonymous supply chains. The negative side is that traceability, if left to manufacturers and producers, leads to more value and more responsibility being shifted to the manufacturers and suppliers. In all the traceability cases we observed the manufacturer or producer branded the product and assured traceability using a case ready product. This is positive for retailers' logistics management and in store processing and fabrication and liability perspective. But it potentially destroys their ability to strategically differentiate themselves from competitors who will carry the same brands, traceability claims and products provided by manufacturers. In fact from a manufacturer's perspective the broader the retail base the better. So, retailers move more towards WalMart's competitive advantage of simply selling shelf space and least cost logistics management with traceability shifted to manufacturers. What is retail's response? What will likely emerge are "store or chain" based traceability systems where closely aligned production systems originate at the retailer and are linked through the manufacturer to producers. This is the only mechanism by which stores can maintain strategic competitiveness in this arena and explains why Marks & Spencer has aggressively promoted traceability in the UK and is also an incentive for Safeway foods in the U.S. to have invested in Future Beef with a concept of supply chain traceability.

Firm Specific Production Economics

As implied in earlier discussions, traceability often has production benefits from improved information and control of production even though traceability has generally been couched as a supply chain management issue. In large part this stems from the incorporation of ERP systems at the firm level that inherently improved data collection, as well as analysis, diagnosis and response of potential production issues.

Perhaps Gilde Norge, the Norwegian slaughtering plant, provided the best illustration. In implementing traceability, they incorporated a visual grading system. In this system, the carcass is photographed on the line and a computer program immediately uses the image to construct parameters on the size of the carcass. This information is instantaneously compared to previous carcass yields from similar carcasses already in the database. This information is passed to terminals along the line, which show appropriate cuts to be made in subsequent fabrication to maximize the yields of the carcass. As the carcass is fabricated data is captured on the actual yields of the fabricated cuts and compared to the predicted values prior to fabrication. This ongoing real-time analysis of carcass cutouts aids in quality control and improves yields. In fact, at the end of each week the workers on the line are evaluated based on the data collected on their cutting efficiency and abilities to meet expected cutout yields with actual yields. They attributed this continuous improvement as adding 5-10% to their final meat yields.

Similarly, in all cases, strict controls on feed use and scheduling of delivery of animals naturally led to improved production management for growth efficiency and certainly enabled benchmarking of farms within the production system as was the case with Label Rouge in Challans. Each grower received a quarterly report of their relative efficiency compared to other growers within the syndicate.

Traceability has a multifaceted economic impact on firms and the supply chain. The key point is that there are potentially real economic cost and management benefits at the firm level at the same time that it improves coordination and allocation of values and costs in the supply chain. At this point, we have successfully identified the key tradeoffs. Further empirical work needs to be done to provide a clearer picture of whether traceability has net benefits to firms and the supply chain.

Governance and Structural Change Issues

Traceability in general has implications for the structure of the supply chain and how firms organize. In general, there are two aspects of this governance and structure 1) the organization and structure of the firms themselves and 2) the organization of the controlling agencies and auditing firms. In all of the cases we observed the chains incorporating traceability were very tightly coordinated. The VanDrie group and Nutreco were completely vertically integrated except for growers which were sometimes contract growers and sometimes owned production units. Gilde and Wiesengold were cooperatives, but growers were tightly coordinated through contractual membership into the supply chain. Lable Rouge was organized as “syndicates” with feed companies, growers and plants pre-approved for membership, but products within the syndicate could be transferred among alternative members. In all cases we observed the overall production chains were relatively small compared to North American commercial production standards. The key issue with size and structure is the scale compatibility between stages of production which enables traceability. In other words, it generally took a relatively small number of growers to satisfy the demands of processing plants or to absorb the supply of feed plants. The primary scale incompatibilities in the North American supply chain may very well be that our processing plants and feed manufacturing plants are of such a scale that it presents coordination problems with the large number of

growers needed to manage traceability in the supply chain. Obviously, the fewer operations which need to be traced the more easily traceability can be implemented. In fact, VanDrie had difficulty coordinating their conventional beef operations for traceability because it required over 500 growers versus the 100 growers who were supplying their veal operations. One hypothesis is that traceability may have diseconomies of scale in that it is more cost efficient and operationally efficient on a smaller scale than non-traceable commodity production.

In the case of Label Rouge and Wiesengold, there were “control agencies”. The control agencies (KAT in the case of Wiesengold and Sylac in the case of Challans/Label Rouge) were responsible for managing records, establishing production protocols and standards, arranging for auditing and maintaining the databases supporting traceability. In other cases, the controls were internal. Auditing agencies were always external to avoid conflict of interest in application of production standards and traceability. Label Rouge also had extensive government involvement in managing the system. The Ministry of Agriculture and the Ministry of Finance had roles in developing and approving standards, establishing labeling requirements, and in preventing fraud. No other system had direct government involvement although government policies on traceability and food safety often influenced their decision to implement traceability or how it was implemented. KAT as an independent controlling agency offers a good example of how production protocols and participation is managed. KAT was developed by the European Poultry, Egg and Game Association. It developed the traceability information system and also manages the control processes and data collection. However, outside auditing agencies perform system checks to assure compliance with their protocols. Members such as Wiesengold propose standards (such as feeding, medication, and other production protocols) which distinguish their supply chain. Producer members can then approve or reject these standards. Once approved, all members are audited, including processors, farms and feed suppliers if appropriate. Audits are often done on a monthly, quarterly or annual basis or around production flows of the system such as when animals are ready for slaughter or when new animals are brought into the system. Members pay a fee for the audits and for being members of the control group. Members who do not comply are removed from the system. This is very important as they recognize their vulnerability to lapses in quality control.

It will generally be true that intensive traceability as we observed would require very tightly coordinated supply chains. How this coordination is achieved will also be important. The cooperative forms all recognized two potential problems 1) it was difficult to get membership buy-in to new protocols which may require increased investment since the members were otherwise autonomous 2) the first issue may affect their ability to be responsive to changing demands or new innovations. It appears that full integration has merits in both of these instances, where protocols can be updated and enforced at will. Secondly, it is clear that traceability has implications for size compatibility among participants in the supply chain. It appears that very large plants with a large number of suppliers or buyers will have difficulty managing traceability – it is simply a numbers game and as numbers increase logistics and control become more expensive. Information technologies are successful at reducing the costs of managing large numbers of records, but the requirement of control, auditing and verification is still largely a hands on process which gets more costly as scale increases.

Given the politically charged notion of “independence” at least in the U.S. agricultural sector, it is our contention that traceability at this point probably favors vertically integrated operations. Canada may have a slight advantage in their history of cooperative marketing boards and pooling similar to what is observed frequently in Europe.

Public Policy and Public Health

2001 was a horrific year for conducting case studies in Europe. When we proposed the research, we were focused on what now appear trivial issues of supply chain efficiency and the role of information systems. As the year progressed, the outbreak of foot and mouth disease in the UK, the events of September 11, and subsequent anthrax terrorism in the U.S. had a direct bearing on our ability to do the research, but also on the implications of our research. Traceability has direct implications on the ability to contain both natural outbreaks of devastating diseases such as foot and mouth disease, but also on the ability to respond to and contain potential food borne bio-terrorism events. While much of this paper considers the implications on firms, in this new world, traceability is a public health and policy issue. Since we did not specifically consider the issues of the public costs of disease outbreaks (e.g., in the UK, the military was involved in quarantine, containment and clean up and disposal) it's difficult to estimate what the potential benefits of animal identification and tracking systems might be but it's safe to say from the UK experience that they total in the millions. Similarly, with bio-terrorism, the rapid identification and sourcing of pathogens can potentially save lives and even assist in bringing culprits to justice. At this point, suffice it to say traceability will be a component of public policy regarding food safety and health. The important question is again “how much traceability is enough”. Animal identification and tracking would seem to be a minimal set of traceability. Again, the interesting trade-off in the meat chain is the fact that there are intervention strategies such as irradiation which may have more merit than traceability. However, these tradeoffs need to be examined. Developing national systems on the order of the VanDrie Group's intensity would likely be extremely burdensome from a cost perspective. Similarly, doing nothing likely exposes us to extreme public health and economic risks. Interestingly, the U.S. was opposed to the EU regulations requiring animal identification and tracking which became mandatory in January 2002 in August of last year because the U.S. felt it represented a trade barrier. Now, similar identification is being proposed in U.S. legislation (H.R. 3448).

CONCLUSIONS

This paper has raised several issues which require further empirical investigation. However, the data from our visits also provides some guidance for some relatively confident conclusions. First, it is clear that electronic information systems greatly improve the potential for identify preservation, management of the supply chain and firm level management. Second, it is very likely that traceability will lead to more closely coordinated supply chains. Whether these can be cooperatively managed or if vertical ownership is more efficient is an empirical question. Third, traceability can improve the allocation of economic values, but the empirical question is does integration do the same thing and to what extent does integration become more valuable because of traceability and the ability to increase the control of a

broader asset base. Fourth, it is very likely that new government policies as adopted in Europe will mandate or require some form of traceability. Finally, producers must begin to consider how they can capture and control their own information to improve the value of traceability for their own situation.

Given recent events, the relevant question is actually one of “how much traceability is *enough* traceability?” For example, without any additional investment in the U.S. meat supply chains, animals likely can be traced from packing plants back to individual finishing farms by using existing business documents such as invoices, shipping or weight tickets and other similar documentation. Lot or batch numbers can also be used to trace most meat products back to plant of origin and even with a reasonable level of confidence to the date they were manufactured and therefore narrow the window of possible sources of contamination. Is that enough? Would we also like to be able to trace the feed batches? Would we also like to know before actual entrance into the meat chain what other farms may have been supplied this feed? This is the central policy and business issue in traceability, particularly when considering food safety issues. How much is enough depends on the costs of tracing products, the potential costs if a contaminating event occurs and the potential costs of recall or discovery if a contaminating event occurs. These costs in turn are affected by the likelihood of a food safety event occurring and also the ability to control this likelihood given quality control strategies (e.g., feed testing at the farm) and the ability to intervene (e.g., irradiating for biological pathogens). This complex set of trade-offs is basically what defines how much is enough. So far, relatively little information exists on the empirical value of these trade-offs.

LITERATURE CITED

- Bullock, D. S., M. Desquilbet and E.I. Nitsi. 2000. “The Economics of Non-GMO Segregation and Identity Preservation. Department of Agricultural and Consumer Economics, University of Illinois, Urbana, Illinois. November 2000.
- Hobbs, J. 1996. “A Transaction Cost Analysis of Quality, Traceability and Animal Welfare Issues in UK Beef Retailing.” *British Food Journal* 98:16-26.
- Hooker, N.H., R.M. Nayga Jr., and J.W. Siebert. 1999. “Assessing the Economics of Food Safety Activities: Studies of Beef Slaughter and Meat Processing.” Faculty Paper Series, FP99-4 of The Department of Agricultural Economics, Texas A&M, University, College Station, Texas.
- Liddell, S. and D. Bailey. 2000. “Market Opportunities and Threats to the U.S. Pork Industry Posed by Traceability Systems. Department of Economics, Utah State University, Logan, Utah.
- Maltsbarger, Richard and Nicholas Kalaitzandonakes. 2000. “Direct and Hidden Costs in Identity Preserved Supply Chains.” *AgBioForum* 3:236-242.

BREAK-OUT SESSIONS

“CONQUERING CHALLENGES”

PRACTICAL TIPS AND GUIDELINES FOR THE HANDLING AND TRANSPORT OF MARKET HOGS

Temple Grandin, Colorado State University

Tina Widowski, University of Guelph

Penny Lawlis, Ontario Ministry of Agriculture, Food and Rural Affairs

INTRODUCTION

Animal handling and welfare is becoming an increasingly important issue to consumers and major meat buyers. Good handling and humane treatment of pigs during transport and slaughter ensures a product that is acceptable to consumers, not only in terms of quality meat that is free of defects, but also in the assurance that the animals that provide the meat are well cared for. In the big picture, humane handling doesn't only involve the hogs that are shipped to the plant but also includes the treatment of those animals that are compromised and unfit for transport. The objectives of this session are to review some practical tips and guidelines that producers can use to ensure good handling of market hogs and compromised animals. This includes practical tips and troubleshooting for the care, moving and loading of finishing pigs, an overview of the Recommended Codes of Practice for Transportation and guidelines for decision-making about transporting compromised pigs

HANDLING PIGS FOR OPTIMUM PERFORMANCE ON THE FARM AND IN THE SLAUGHTER PLANT

(excerpt from <http://www.grandin.com/references/handle.pigs.performance.html>, Grandin, 1999)

Tips for Moving and Loading Finishing Pigs on the Farm

1. When loading finishing pigs, move very small groups of 5 to 6 at a time.
2. Do not store large groups of finishing pigs in an alley or holding pen. This will lead to damage caused by fighting. It is best to take each small group of pigs immediately from the finishing pen to the truck.
3. New finishing buildings should have a 3-foot (1 m) wide alley. This is wide enough to allow 2 pigs to walk down it side by side. If a building has a 2-foot (.75 m) alley, only three pigs should be moved at a time.
4. Do not overload the trucks. Overloaded trucks, especially during hot weather, are a major cause of high death losses.
5. Do not allow pigs to stand in a fully loaded truck, get moving immediately. Heat builds up rapidly in a stationery vehicle.

6. In winter, use straw for bedding. In extremely cold weather, straw provides the best insulation and helps prevent frostbite. Observations in packing plants indicate that trucks with inadequate bedding are more likely to contain frost bitten pigs.
7. When there is high heat and humidity, it is best to transport pigs very early in the morning and at night. Stocking density should be reduced.
8. Schedule trucks so that pigs can be unloaded promptly at the packing plant.
9. Minimize the use of electric prods. Electric prods should not be used in the finishing barn.
10. Calm pigs are easier to sort and separate than excited pigs. Pigs are easier to sort if the handler moves slowly and deliberately and separates the desired pigs from the group on the first attempt. Excited pigs stick together and are more difficult to separate.
11. If pigs refuse to leave the finishing building, try shutting off the ventilation or reversing it. Pigs often balk if air is blowing in their faces as they exit the building.
12. To make pigs flow more easily out the door of a finishing building, attach plywood to the last 16 feet (5 m) of pen near the door. This will prevent pigs which are being driven out of the building from seeing or touching pigs which are in pens near the door. After loading, the plywood should be removed because it will interfere with ventilation flow through the pens.

At the Packing Plant

Practical experience has shown that improving handling at the packing plant and reducing electric prod usage will improve meat quality. Below are some tips for improving handling in packing plants which will help maintain pork quality and reduce PSE.

1. Rest pigs prior to moving to the stunning chute for 2 to 4 hours. Slaughtering pigs immediately after unloading will have a detrimental effect on pork quality.
2. Use sprinklers during hot weather.
3. Staging areas which lead to the stunning chute crowd pen should be filled only half full. Fill the crowd pen only half full and DO NOT push the crowd gate tight up against the pigs. They need room to turn.
4. If pigs balk and refuse to go up the single file chute or constantly back out of the chutes, look for distractions that cause balking. Some of the things that cause balking are: air blowing in the faces of approaching pigs, shiny reflections on metal, puddles, a chain hanging in the chute, restrainer entrance too dark, seeing people up ahead and moving objects. Removing distractions and improving lighting will reduce balking. Light up the

restrainer and chute entrances with lamps. Animals will not go into a dark place. The lamps must not shine directly into the faces of approaching pigs.

5. Electric prods should be eliminated in the yards and staging area. Pigs moved with electric prods have higher heartrates than pigs moved with a panel. In the stunning chute an electric prod may be needed on an occasional stubborn pig. Some other tool should be in the person's hand as the primary tool for moving the animals. The electric prod should only be picked up when it is needed. To reduce use it should not be constantly in the person's hands. In a survey that Grandin author conducted for the USDA, it was possible to greatly reduce electric prod usage. In two plants which had excessive use of electric prods 44% of the pigs were electrically prodded. After handlers were instructed to fill the crowd pen only half full and tap the pigs first, the percentage of pigs which were electrically prodded dropped to 15%. Handlers were able to keep up with the line when electric prod usage was reduced. It is important to eliminate distractions which cause balking. At another plant, it was impossible to reduce electric prodding when the sun was out due to harsh shadows. When a cloud covered the sun the pigs moved easily. To solve this problem, the roof over the crowd pen had to be extended to block high contrasts of light and dark at the stunning chute entrance. In plants where pigs are stunned in groups on the floor, electric prods should be totally eliminated.
6. Monitoring of squealing levels is a simple way to monitor stress levels during handling. When pigs are quiet stress levels will be lower. Vocalization (squealing) is highly correlated with physiological stress levels and poor pork quality. In a slaughter plant an easy way to measure squealing is to count the number of stun cycles where the entire handling area is quiet. As each pig is stunned; score on a yes/no basis - "room quiet" or "heard a squeal". From this you can calculate the percentage of time the room is quiet.

RECOMMENDED CODE OF PRACTICE FOR THE CARE AND HANDLING OF FARM ANIMALS: TRANSPORTATION

In 2001, the Canadian Agri-food Research Council published the Transportation Codes of Practice. The voluntary code is "intended for use as a guide and educational tool in promoting sound animal transportation and welfare practices". The guide contains practical information that transporters and producers can use to assess and improve facilities and practices with regard to animal transportation. The code covers general considerations for all transported livestock as well as specific recommendations for different species and classes.

Specific recommendations for the handling and transport of pigs included in the code:

- step heights and ramp slopes for loading and unloading facilities
- minimum space allowances for different sizes of pigs in transit
- recommendations for handling, loading and unloading
- care and protection during hot weather transit
- care and protection during cold weather transit
- special considerations for boars

- special considerations for iso-weaned pigs

The Code is available from the Canadian Food Inspection Agency, Animal Health and Production Division, and on the internet at www.carc-crac.ca.

GUIDELINES FOR TRANSPORTING COMPROMISED PIGS

The Ontario Humane Transportation Working Group [Members: Ontario Farm Animal Council (OFAC) Canadian Food Inspection Agency (CFIA), Ontario Society for the Prevention of Cruelty to Animals (OSPCA) and Ontario Veterinary Medical Association (OVMA)] has developed practical guidelines that producers can use to determine when an animal is not fit for transport and what actions to take if that happens.

- The Guidelines include the signs and health conditions of animals that are at risk during transport, including pigs that can be transported with special provisions.
- The Guidelines help to identify non-ambulatory pigs that should not be transported.
- Regulation 732/94 of the Livestock and Livestock Products Act provides special care for non-ambulatory animals. A non-ambulatory animal is defined as "any animal that due to age, injury, metabolic or systemic disease, etc., is unable to raise itself without assistance to a standing and walking state" (source: Ontario Veterinary Medical Association). "Downer" and "downed animal" are terms used in reference to a non-ambulatory animal.
All non-ambulatory animals require a veterinary certificate.
- The Guidelines help to determine when to call a veterinarian.
- The Guidelines help to determine when to euthanize.

The Guidelines are available in a pamphlet that can be obtained from OFAC, OMAFRA or Ontario Pork.

Further information on proper handling of non-ambulatory livestock can also found be in OFAC's "Preventing and Handling Non-Ambulatory Livestock on the Farm" brochure at <http://www.ofac.org/ambulat.html>.

INDOOR AIR QUALITY IN PIG BUILDINGS: WHY IS IT IMPORTANT AND HOW IS IT MANAGED?

Stéphane Lemay¹, L. Chénard¹ and Ron MacDonald²

¹Prairie Swine Centre Inc., Saskatoon, SK

²Agviro Inc., Guelph, ON

ABSTRACT

From the first second of our lives, we need to breath fresh air. It is vital! Wherever we go, including our working place, we must have access to clean air supply. For pork producers and workers, barn environment has to provide them with fresh air to breath. Many of today's modern production facilities have the proper equipment required to control building air temperature under extreme cold conditions and also maintain a fairly comfortable environment during hot days. But considering that the majority of those systems are strictly controlled by the room air temperature, controlling the air quality in pig barns is still a good challenge. The goal of this presentation is to make producers and barn workers aware of the importance of keeping good air quality levels in their barn. This paper reviews the most important airborne contaminants present in a swine building and what should be the maximum concentration for each of those contaminants to ensure worker health and safety. Some health risks are discussed in the case where those limits are being exceeded. Various options are discussed to limit contaminant exposure in a barn environment.

WHAT DO WE MEAN BY AIR QUALITY?

First of all, it is critical to define the meaning of air quality. Under clean conditions, ambient air contains nearly constant amounts of nitrogen (78% by volume), oxygen (21%), and argon (0.9%), with varying amounts of carbon dioxide (about 0.03 %; ASHRAE 1999). Also included are trace amounts of hydrogen, neon, krypton, helium, ozone, and xenon, in addition to varying amounts of water vapour and small quantities of microscopic and submicroscopic solid matter called permanent atmospheric impurities (ASHRAE, 1993). This definition of ambient air under clean conditions could be considered as "normal air". Any other constituent than those listed is usually considered a contaminant.

The air quality is a characterization of the air content compared to its normal composition under clean conditions. In other words, the air quality is an assessment of how many contaminants (particulates, vapours) are present in addition of the various gases constituting normal, clean air. The more contaminants present in the air, the lower the air quality is.

CONTAMINANT CONCENTRATIONS MEASURED IN PIG BUILDINGS

Air contaminants in pig barns include dust particles, various gases and micro-organisms often referred to as "bioaerosols". Dust is generated from feed, bedding, dried manure, skin debris

and building materials (Maghirang et al., 1995). Gases are predominantly produced directly by animals and excreta while micro-organisms are released from animals and dirty surfaces (Hartung, 1993). The most important gases are carbon dioxide (CO₂), ammonia (NH₃), hydrogen sulphide (H₂S), methane (CH₄), nitrous oxide (N₂O) and some trace gases (aldehydes, amines, aromatics, organic acids, sulphur compounds; Hartung and Phillips 1994). Carbon dioxide is mainly produced by pig respiration while ammonia is released through the bacterial and enzymatic decomposition of nitrogen compounds contained in the excreta, especially in the urine.

Bioaerosols include bacteria, endotoxins, and molds. Gram positive bacteria make up to 72% of the bacterial isolates in dust from a grower-finisher pig building (Butera et al., 1991). Twenty two species of bacteria and fungi were isolated from dust collected from a room housing pigs compared to only six species from a similar room without pigs (Martin et al., 1996). Based on those previous studies, barn ambient air includes a large variety of micro-organisms in suspension.

Recently, a comprehensive research project documented air quality in 329 buildings in Europe (Takai et al. 1998; Groot Koerkamp et al. 1998; Seedorf 1998). Overall, mean inhalable and respirable dust concentrations were 2.19 and 0.23 mg/m³ in pig buildings and mean ammonia concentrations varied from 5 to 18 ppm. Daily mean inhalable endotoxin concentrations were 114.6, 186.5 and 135.1 ng/m³ for sows, weaners and grower-finisher sections, respectively. The indoor concentration of total bacteria averaged 5.1 log CFU/m³ in pig buildings. Cormier et al. (1990) found that the predominant micro-organisms in farrowing and growing-finishing units were bacteria (up to 1.25 x 10⁶ CFU/m³) with an important fraction in the respirable size range (up to 0.5 x 10⁶ CFU /m³). They concluded that air of swine confinement buildings is highly contaminated with bacteria, yeast and moulds at a level up to 1200 times higher than so called “normal air”. Similar studies realised at the University of Saskatchewan have shown similar high levels of contaminants in pig and poultry buildings throughout the Prairies.

In general terms, total dust mass concentration in swine buildings will stay between 2.0 and 3.0 mg/m³ in various sections of the barn and over the year. Dust fractions also need to be characterized based on particle size as particles of different sizes have different impacts on humans. Generally speaking, dust particles having an aerodynamic diameter larger than 0.5 µm (1 µm is 1 million times smaller than a meter) are defined as inhalable dust because they can be inhaled by the upper respiratory tract of a person. A large portion of those particles will stay trapped in the nose or the throat. Respirable dust particles that have an aerodynamic diameter between 0.5 and 5.0 µm will travel deeper into a person’s respiratory system. Being so small, those particles can transport micro-organisms or gas molecules very deep into the lungs and have a combined impact as lungs are exposed to more than one contaminant type. Therefore, reducing large dust particles in the air will not always reduce the amount of airborne small particles. For example, putting oil into pig diets reduces large dust particles but it may increase respirable dust. In this case, the barn looks cleaner however the air is not safer for worker lungs.

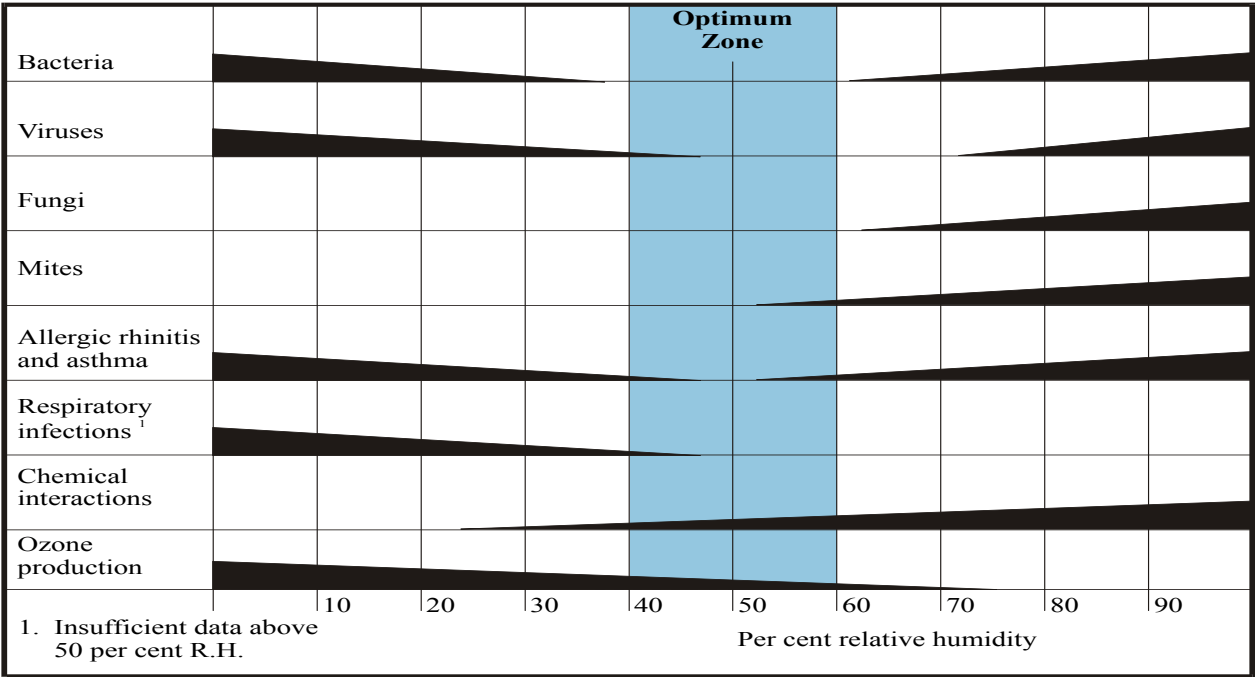
Carbon dioxide concentration may exceed 4000 ppm under winter conditions but will normally be lower than 1000 ppm in summer time. The same trend can be observed with

ammonia. Its concentration can be between 20 and 30 ppm under winter conditions but it is much lower during the summer.

Under normal barn management when the pits are emptied frequently, the concentration of hydrogen sulphide, methane and other gases will be very low from a human safety perspective. Hydrogen sulphide is mainly released when pig manure that has been stored under anaerobic conditions and is agitated in any way. Methane will be produced when liquid manure kept in storage for a long time is maintained in anaerobic conditions. Therefore, it is only under specific manure management conditions that those gases will be released and measured at high concentrations.

Relative humidity, although not a contaminant in itself, is a very easily measured component in the air that can be used to determine if there are other potential contaminants. Figure 1 shows the optimum range for relative humidity considering the growth and viability of various micro-organisms. This optimum zone is not going to be same for different building types.

Figure 1: Relative humidity and concentrations of selected air contaminants for human building occupancy



E.M. Sterling, Criteria for Human Exposure to Humidity in Occupied Buildings, 1985 ASHRAE

EXPOSURE LIMITS AND HEALTH RISKS

Different exposure limits have been defined to provide guidelines and protection to workers. Until now, for gases, these exposure limits are the same regardless of the work place and type

of activities. As occupational health and safety is under provincial jurisdiction, the limits may vary slightly within the country. The values and information presented here for gases are provided by the Canadian Centre for Occupational Health and Safety (CHEMINFO, 2000).

Table 1 presents the exposure limits for gases that are most commonly present in swine buildings and can present a threat to human and animal health. The vapour density of gases relative to air (value is 1) is also presented. Gases with a vapour density higher than 1 will have a tendency to stay concentrated at floor level, under the slat, or at the bottom of enclosed areas thus replacing oxygen when their concentration is high (ex: carbon dioxide and hydrogen sulphide). The limits are given for three different exposure levels to provide enough information to the workers and give insight on levels that should not be exceeded in order to provide a safe working environment. If those threshold levels are exceeded, measures have to be taken to improve the air quality or personally protect the worker.

Table 1: Exposure limits of various gases found in swine buildings (CHEMINFO, 2000)

Gas	Symbol	Vapour density (relative to air)	TWA* (ppm)	STEL [†] (ppm)	IDLH [‡] (ppm)
Ammonia	NH ₃	0.60	25	35	300
Carbon dioxide	CO ₂	1.52	5,000	30,000	40,000
Carbon monoxide	CO	0.97	35	200	1,200
Hydrogen sulphide	H ₂ S	1.19	10	15	100
Methane	CH ₄	0.56	Simple asphyxiant at high concentrations [§] (not toxic below 50,000 ppm)		

* TWA: time weighted average for an 8-hour day and 40-hour work week exposure.

[†] STEL: short-term exposure limit (generally 15 min. during an 8 hour shift only if no other measurable exposure occurs).

[‡] IDLH: immediately dangerous to life or health, level defined so worker can still react and escape from a given contaminated environment in case of failure of the respiratory protective equipment or engineering procedure.

[§] Becomes flammable at and above 50,000 ppm and is highly explosive.

Table 2 provides the gas odour and appearance of various gases and health effects associated with them and the conditions that can present a risk on health and safety of workers. The symptoms resulting from exposure to a given gas are presented for their corresponding concentration range.

Table 2: Human health responses to various gases that can be found in swine buildings (CHEMINFO, 2000)

Gas	Appearance and odour	Concentrations (ppm)	Health responses
Ammonia	Colourless, sharp odour, pungent and irritating detected at 0.6 to 53 ppm	24 to 50	Nose and throat irritation after more than 10 min. exposure.
		72 to 134	Irritation of nose and throat after 5 min. exposure.
		Above 500	Immediate and severe irritation of nose and throat.
		Above 1500	Pulmonary edema, potentially fatal accumulation of fluid in lungs.
Carbon Dioxide	Colourless and odourless	Above 20,000 (Can displace oxygen in the air)	Can affect respiratory function and cause excitation by depression of the central nervous system.
Carbon Monoxide *	Colourless and odourless	50 and above	Mild headache.
		Above 200	Severe headache.
		Above 400	Weakness, dizziness, nausea, fainting.
		Above 1200	Increased heartbeat, irregular heartbeat.
		Above 2000	Loss of consciousness and death.
Hydrogen Sulphide	Colourless, rotten eggs from 0.13 to 100 ppm	Above 5000	Death may occur in minutes.
		Above 100	Paralyses sense of smell.
		50 and above	Marked dryness and irritation of the nose and throat. Long exposure can result in runny nose, cough, hoarseness, shortness of breath and pneumonia.
		200 to 250	Severe irritation, headache, nausea, vomiting and dizziness. Prolonged exposure can cause lung damage.
		300 to 500	The above severe symptoms. Death may occur in 1 to 4 hours.
		500	Excitement, headache, dizziness, staggering, unconsciousness and respiratory failure occur in 5 min. to 1 hour. Death can occur in 30 min. to 1 hour.
		Above 500	Rapid unconsciousness and death.

* Responses may occur at lower concentrations or more rapidly for smokers that already have carbon monoxide in their bodies and for exposed persons that have heavy physical workloads or have heart disease.

As mentioned previously, methane presents a threat to safety because of the possibility of explosion. Chances are very high that an explosion will occur before methane causes asphyxia to workers by oxygen depletion.

Gas exposure can have long-term effects on workers particularly when severe exposure occurs. Exposure to high levels of hydrogen sulphide can result in nerve tissue damage, memory loss or paralysis of facial muscles. Poisoning with carbon monoxide can result in permanent brain damage and recovery after intoxication at lower levels can cause symptoms such as headache, dizziness, vision problems, memory loss, confusion and mental problems. Long-term exposure to ammonia can result in the development of a tolerance to the irritating effect and a high exposure during an extended period of time may result in eye damage.

Dust exposure limits have been defined by Donham and Cumro (1999) after having analyzed the results of different experimental studies completed in swine and poultry facilities. Exposure limits in livestock buildings are different and lower than the limits given for other activities as dust in livestock facilities is organic and results in higher responses from humans than inorganic dust. Table 3 gives concentrations that represent exposure limits for different type of particles present in swine buildings - these limits should be considered as levels to maintain for a working week-period exposure. Short-term levels, such as STEL and IDHL, have not yet been developed.

Table 3: Exposure limits for dust found in swine buildings (Donham and Cumro, 1999)

Type of particles	Concentrations
Total dust	2.4 mg/m ³
Respirable dust (0.5 < particles < 5.0 µm)	0.16 mg/m ³
Total endotoxins	614 EU/m ³
Respirable endotoxins	0.35 EU/m ³

Health responses to dust exposure will vary with individuals. Periodic and acute episodes of symptoms such as fever, headache, muscle aches and pains, chest tightness and cough can be experienced and have been reported by livestock workers and those can be labelled under the “organic dust toxic syndrome” (Donham, 1999). Also Donham (1999) mentioned many studies where livestock workers reported acute or subacute respiratory symptoms such as dry cough, chest tightness, wheezing, irritation of nose, eye and throat and stuff nose and head. Chronic symptoms, such as chronic bronchitis, occupational (non-allergic) asthma and non-infectious chronic sinusitis, can also develop after a long-term exposure to livestock dusty environment (more than 6 years).

WORKER PROTECTION PHILOSOPHIES

In any kind of contaminated working environment, the worker safety can be ensured using different approaches or philosophies that we will define as: 1) engineering control; 2) administrative control; and 3) personal worker protection. An engineering control philosophy is applicable when the use of equipment, air cleaning devices or technologies can be implemented to dilute the contaminant or clean contaminated air to bring air specifications back to acceptable levels for human exposure.

When no technology can be effectively used to clean air but the risk associated with the contaminants can be dealt with by restricting worker exposure, an administrative control can be implemented. For example, depending on the contaminant, the worker may be safe in spending 15 minutes a day in presence of the contaminant. Adjusting schedules and restricting the time exposure to a specific contaminant or contaminated area is what we call an administrative control.

In some cases, no engineering control can be put in place and the contaminant level is such that no risk can be taken in exposing the worker even by reducing the exposure time. In this situation, some protection equipment (ex.: personal respirator) should be used. Instead of cleaning the air of the whole area or room, the worker is provided with the proper equipment to safely deal with working conditions.

The occupational health and safety knowledge has mainly been developed from industrial sectors where very toxic environments are being encountered. Air quality in swine buildings is generally poor but contaminant concentrations and toxicity levels are much lower than for other industrial activities. However, pig buildings present a challenge as the ambient air is contaminated with a “cocktail” of substances (gases, dust).

LIMITING WORKER EXPOSURE TO CONTAMINANTS

DUST

Dust is one of the important contaminants found in pig barns. The following section describes different techniques to protect barn workers against dust.

Disposable mask. Wearing a disposable mask still is the best option available to barn workers to ensure long-term protection of their lungs. Workers are exposed to dust everywhere in the barn and for all the tasks they need to perform. Worn properly, a disposable mask offers good protection against dust at all time during the working day.

The efficiency of disposable respirator has been well documented for industrial applications. More recently, Dosman et al. (2000) evaluated the acute health effects of wearing a N-95 (two straps, metal nose clip) disposable respirator in a swine confinement facility on human subjects not previously exposed to a swine barn environment. The results demonstrated that a two-strap mask was helping to significantly reduce acute negative health effects in subjects in

terms of lung functions and immune response. Although unproven yet, it seems reasonable for the authors to suggest that both the reduction of exposure through dust control and the use of personal protection should result in similar beneficial long-term effects, at least for most exposed workers.

To be effective, disposable masks must be properly fit on the subject (well sealed on subject face) and the worker must be willing to wear it all the time. Specific masks will fit some people better than others and the level of comfort provided by the mask is related to the person physiognomy. A conventional two-strap mask without exhaust valve will be comfortable to perform tasks that are not physically demanding. However, a mask provided with an exhaust valve would be more appropriate to use during high physical activities as less restriction for breathing would be created.

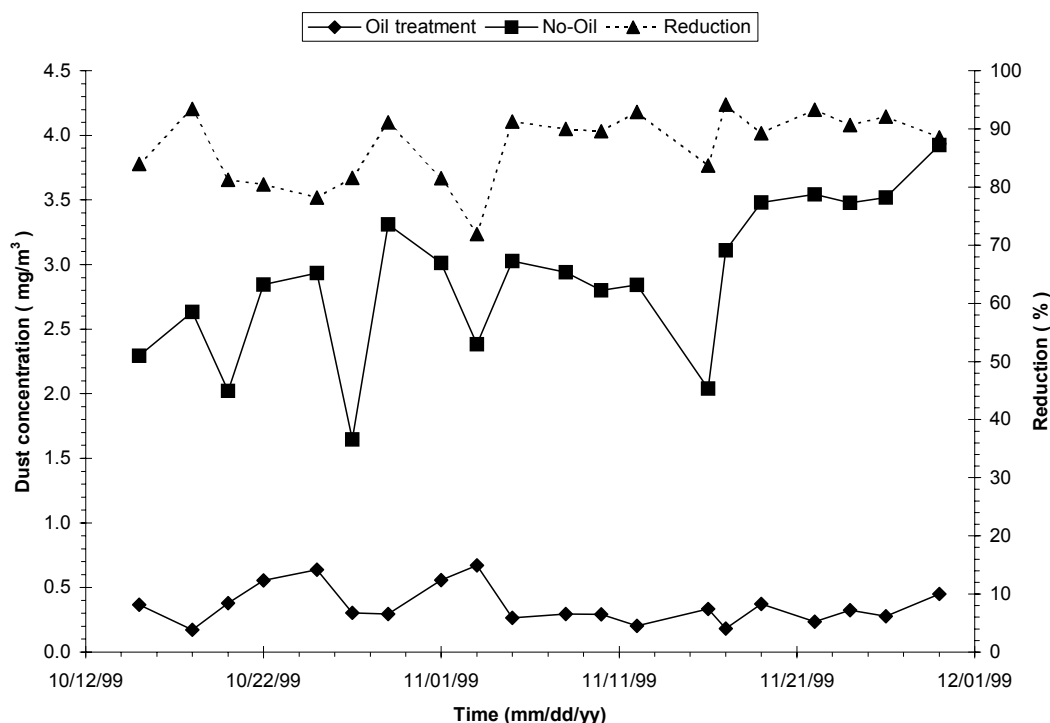
Oil sprinkling. Until now, oil sprinkling/spraying reduces dust concentration more efficiently than other techniques tested in swine buildings. By spraying a mixture of water and rapeseed oil, airborne respirable dust concentrations in pig houses were reduced by 76, 54 and 52% in long-term observations in houses for piglet, growing and finishing pigs, respectively (Takai et al., 1995). Sprinkling a small quantity of canola oil on the floor of growing-finishing rooms reduced respirable and inhalable dust by 71 and 76% (Zhang et al., 1996). In most of those previous experiments, the oil was manually applied once or twice a day.

Lemay et al. (1999) developed a low pressure sprinkling system using undiluted canola oil in grower-finisher rooms designed to control dust levels. Using recommended oil application rates for dust control (Zhang et al., 1996), the sprinkling system provided a dust mass concentration reduction of 79% compared with the control room over a two-week period. Respirable (0.5 to 5.0 μm) and inhalable ($\geq 0.5 \mu\text{m}$) dust particle counts were reduced by 73 and 80%, respectively.

The same system was tested again over a seven-week period to simulate a complete growth cycle (Lemay et al., 2000). The application rate was optimized by reducing the oil application rate compared to previous experiments and by not sprinkling operator walkways. The dust mass concentration was reduced by 87% comparing the oil treated room to the untreated room (Figure 2) and inhalable ($>0.5 \mu\text{m}$) and respirable (0.5 to 5.0 μm) dust particle counts were lowered by 90 and 86%, respectively. Compared with oil application rates recommended by Zhang et al. (1996), similar dust reduction results were obtained with a 36% reduction of the total oil usage applied over the seven-week period.

While using the automatic sprinkling system, oil needs to be applied in the pens at the following application rates: 40 ml of oil/ m^2 -day on the first two days, 20 ml of oil/ m^2 -day on the next two days, and 5 ml of oil/ m^2 -day on every day for the rest of the growth cycle to achieve the 75 to 80% reduction of dust concentration. Including the cost of the sprinkling system, this control technique costs less than a \$1.00/pig sold.

Figure 2: Dust mass concentration in both untreated and oil treated rooms from October 15th to November 29th, 1999 (Adapted from Lemay et al. 2000)



General recommendations. The most practical option to protect barn workers against pig dust in all building sections is to use personal disposable masks. In the case where a pig producer is willing to invest some dollars to improve air quality in the barn, the oil sprinkling technique is certainly the most promising solution and is worth to be considered.

HYDROGEN SULPHIDE

As mentioned before, hydrogen sulphide is the most harmful gas that can be encountered in swine operations. When there is no manure agitation, the hydrogen sulphide concentration is generally very low in the barn. However, when manure is agitated (pulling plugs, manure flow at lift stations, manure transfer from lift station to lagoon, manure agitation in manure storage facilities), a very high quantity of hydrogen sulphide can be released.

To control the hydrogen sulfide exposure, three control philosophies can be adopted: an engineering control through sufficient ventilation, an administrative and personal protection control through the combination of standard operating procedures and proper safety equipment. Wherever the manure handling happens through out the barn (pulling plugs in rooms, manure transfer at the lift station), it is generally beneficial to have a high amount of air exchange (high ventilation rate) in the particular room or area where the procedure is performed. The person performing these tasks should be equipped with an H₂S monitor that

will warn him/her if the concentration increases above the recommended levels (Table 1). Thus the ventilation rate can be manually increased until the manure handling procedure is finished. For lift stations, inlets providing fresh air to the area should preferably draw the air directly from the attic or outside as air from alleyways may have been also contaminated with hydrogen sulphide. If the hydrogen sulphide production increases because of manure agitation, the ventilation system will at least dilute the hydrogen sulphide and reduce the room concentration and worker exposure.

Standard operating procedures must be developed for manure handling in the barn to prevent worker exposure to hydrogen sulfide. As an example, each barn should clearly define an appropriate procedure for pulling plugs that may be site specific, but will ensure that people are not exposed to high levels of hydrogen sulfide while performing the task. All staff should adhere to those procedures at all times. It is also recommended to always have two persons that are properly equipped working together in this case as protective equipment can fail. Devices should be available to help workers that have to rescue his/her partner in case of distress or loss of consciousness, particularly when working in enclosed areas.

Handling the manure out of a deep pit building can produce substantial amount of hydrogen sulphide and a lot of care must be taken to ensure barn worker and animal safety. When such a large amount of manure needs to be agitated, the ventilation system should run at maximum capacity over the whole agitation process and for a sufficient period of time after the agitation is complete before anybody can be allowed to enter the building unless provided with full respiratory equipment. The same comment can be made for maintenance on manure pumps in lift stations. No one should enter an enclosed area where hydrogen sulphide may have accumulated without a full respirator.

Manure handling outside the barn represents risks as well. People have died after entering a manure tanker that had to be unplugged.

In a case of an accident, the person who is victim of hydrogen sulphide poisoning should be rescued only if the proper safety equipment is readily available. No one should try to rescue the person without respiratory protection. Too many incidents have happened where more than one person was killed trying to rescue each other. A person who has been exposed to high levels of H₂S should be taken in for proper medical care.

Different kinds of hydrogen sulphide monitors are available on the market and can be worn while working in the barn. Those instruments have alarm features and will vibrate, make noise or flash when alarm levels are exceeded. Monitoring of hydrogen sulphide should be done at all times during manure handling procedures so the worker can leave the room or enclosure if the levels are getting high. Not every barn worker needs to have one of those units but as a minimum, the person involved in manure handling should wear such a monitor at all times when performing those tasks.

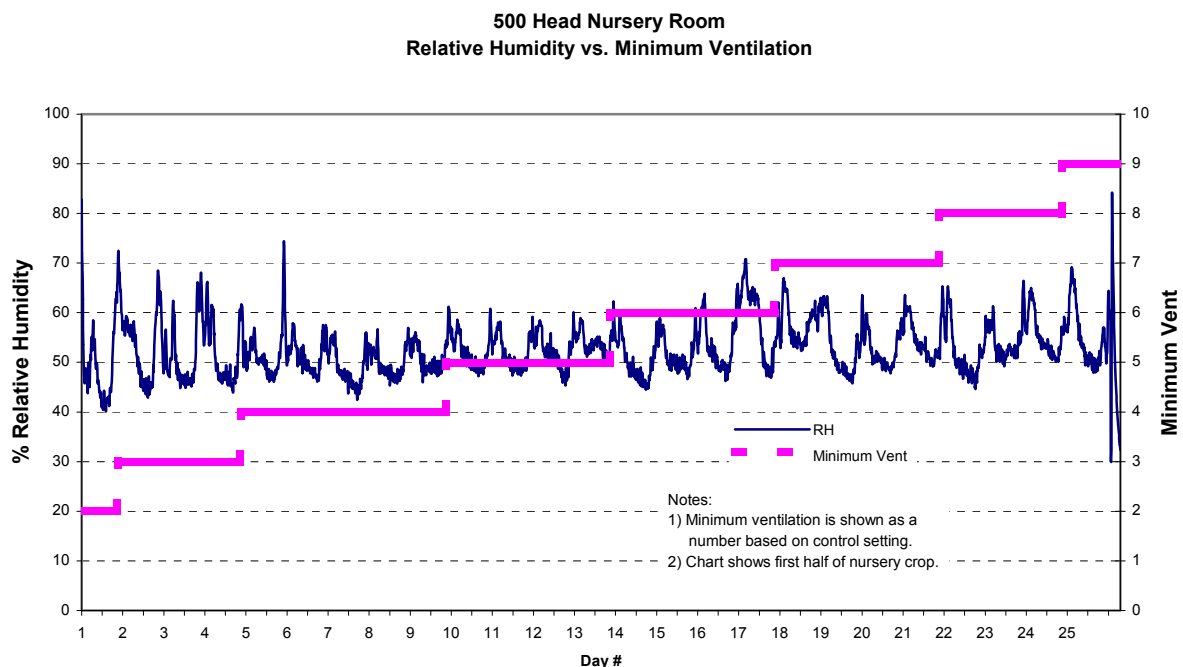
It is important to mention that manure management tasks performed in one area of the barn may result in H₂S production in other areas. Under specific conditions, pulling plugs in a room can cause other plugs to pop in other rooms and some H₂S can then be released.

AMMONIA

Minimum ventilation rate. A proper setting of the minimum ventilation rate is one of the first things to look at to maintain acceptable ammonia and carbon dioxide concentrations in a pig barn. Considering that the barn ventilation system is not controlled by the room ammonia concentration, it cannot react to an increase in ammonia release. In winter conditions and when ammonia production is controlled to a minimum (clean barn conditions, water layer into manure gutters to reduce ammonia emissions), the rotation speed of the first stage fan should be set to provide enough ventilation rate to maintain ammonia concentration below 25 ppm while controlling the relative humidity. Figure 3 shows the range in relative humidity to be expected as pig activity, time of day and outside temperature change. The solid line in this case indicates the changes in settings on the minimum ventilation rate, adjusted to keep the relative humidity within the 55% target.

If the minimum ventilation rate is set too high, the room air quality will be good but the energy consumption of the heating system will be drastically increased. A proper setting of the first stage fan should maintain gas concentrations without wasting energy.

Figure 3: Typical relative humidity graph of a nursery unit



Diet formulation. The first method to reduce ammonia emission caused by excess nitrogen is reducing the nitrogen content in diets. In the past, dietary requirements of grower-finisher pigs for each of essential amino acids were met by including enough crude protein in diets to meet requirements for lysine, the first limiting amino acid. Reduction of dietary protein

combined with supplementation of synthetic amino acids in pig diets might reduce total nitrogen excretion by 25 to 40% (Jongbloed and Lenis 1993; Hartung and Phillips 1994; Kay and Lee 1997). Reduction of dietary protein by 29% resulted directly in a reduction of ammonia emission by 52% (Kay and Lee, 1997). Moreover, concentrations of other major odour components responsible for pig odour were significantly lower in slurry from pigs fed low crude protein diets compared to a control diet (Hobbs et al., 1996).

An additional method to reduce emissions caused by excess nitrogen, in particular ammonia, is by alteration of the ratio of nitrogen excretion in urine versus feces (Mroz et al., 1993). Reduction of nitrogen excretion in urine as urea, the primary precursor for ammonia volatilisation, combined with shifting nitrogen excretion into the feces, primarily as bacterial protein, will reduce ammonia volatilisation and thereby ammonia emission of swine barns. Inclusion of fermentable carbohydrates or non-starch polysaccharides (NSP) into diets stimulates bacterial fermentation in the hindgut and reduced urinary versus fecal nitrogen ratio by 68% (Canh et al., 1997a). In a subsequent study, ammonia emission was reduced up to 40% by dietary inclusion of fermentable carbohydrates (Canh et al., 1997b).

Godbout et al. (2000) have measured ammonia emissions with low protein diets and low protein diets including fermentable carbohydrates. The results indicated that diet formulation significantly reduced ammonia emission rates. In average, low protein and low protein diets including fermentable carbohydrates provided a 21 and 38% reduction in ammonia emissions from experimental chambers.

Nutrient management can have a very important impact on ammonia emissions from swine barns and on the level of exposure to ammonia workers are subjected to. More research needs to be conducted to evaluate the effect of various ingredients on emissions and to optimize diet formulations. Until now, the main limitation of implementing those diet formulations is an increase in feed cost.

CARBON MONOXIDE AND METHANE

The production of carbon monoxide in swine buildings is mainly related to poor gas combustion of the gas heaters. Gas space heaters should be well maintained to ensure that they operate with a good burning efficiency. A good burning efficiency reduces energy consumption for the same heat output and minimises carbon monoxide emissions.

Methane production will occur when pig manure is maintained under anaerobic (without oxygen) conditions for a long period of time. With a shallow pit barn, methane production is very low and it is not an issue. Deep pit barns are more likely to promote methane accumulation in the pits and those pit areas should be properly ventilated to reduce risks of explosion.

CHANGES IN THE INDUSTRY

The knowledge we have on the impact of barn air quality on human health was primarily gained on family farms where people were spending few hours a day in the barn. We do not have much information on career barn workers that spend 40 hours a week in a swine facility. We do not know yet what might be the long-term effect, if there is any, of the air quality on health status of established swine workers.

Having said that, to be responsible as an industry, we should promote the usage of disposable masks and personal monitors. As well, respiratory equipment should be available whenever it is needed. It might also be good to have a follow-up of the health status of our swine workers to ensure that there is no detrimental effect for specific individuals of working in a pig barn and that all the steps are taken to insure their good health.

Overall, more research is needed to investigate the impact of the contaminants present in pig barns. Exposure limits have been defined for single contaminants and very little information is available on the synergy of those contaminants together.

CONCLUSIONS

- The main contaminants in swine buildings are dust, hydrogen sulphide, ammonia, carbon dioxide, various micro-organisms and other gases.
- For each contaminant, there are some exposure limits to be maintained in the barn to ensure worker health and safety.
- Wearing a two-strap disposable mask is the best way of protecting yourself against pig dust and the long-term effect it might have on your lung functions.
- Hydrogen sulphide is the most harmful contaminant found in pig barns and is mainly released when swine manure is agitated.
- A proper personal respirator should be worn whenever someone needs to enter an enclosed area where hydrogen sulphide or other gases may have accumulated.
- See your physician on a regular basis to verify your personal capabilities of dealing with a barn environment exposure and keep him/her informed of your working situation.

LITERATURE CITED

- ASHRAE. 1993. Fundamentals Handbook. ASHRAE, Atlanta, USA.
- ASHRAE. 1999. HVAC Applications Handbook. ASHRAE, Atlanta, USA.
- Butera, M., J.H. Smith, W.D Morrison, R.R. Hacker, F.A. Kains and J.R. Ogilvie. 1991. Concentration of respirable dust and bioaerosols and identification of certain microbial types in a hog-growing facility. Canadian Journal of Animal Science 71: 271-277.
- Canh, T.T., M.W.A. Verstegen, A.J.A. Aarnink and J.W. Schrama. 1997a. Influence of dietary factors on nitrogen partitioning and compositions of urine and feces of fattening pigs. J. Anim. Sci. 75:700-706.

- Canh, T.T., A.J.A. Aarnink, J.W. Schrama and J. Haaksma. 1997b. Ammonia emission from pig houses affected by pressed sugar beet pulp silage in the diet of growing-finishing pigs. Proceedings of the International Symposium on Ammonia and Odour Control from Animal Production Facilities, 273-281. CIGR and EurAgEng publication, Rosmalen, The Netherlands.
- CHEMINFO, 2000. Canadian Centre for Occupational Health and Safety. Issue: 2000-3 (August 2000).
- Cormier, Y., G. Tremblay, A. Meriaux, G. Brochu and J. Lavoie. 1990. Airborne microbial contents in two types of swine confinement buildings in Québec. American Industrial Hygiene Association Journal. 51(6): 304-309.
- Donham, K. 1999. A historical overview of research on the hazards of dust in livestock buildings. Proceedings of the International Symposium on Dust control in animal production facilities. Aarhus, Denmark, 30 May – 2 June. pp.13-21.
- Donham, K and D. Cumro. 1999. Setting maximum dust exposure levels for people and animals in livestock facilities. Proceedings of the International Symposium on Dust control in animal production facilities. Aarhus, Denmark, 30 May – 2 June. pp.93-110.
- Dosman, J.A., A. Senthilselvan, S.P. Kirychuk, S.P. Lemay, E.M. Barber, P. Wilson, Y. Cormier and T.S. Hurst. 2000. Positive human health effects of wearing a respirator in a swine barn. CHEST 118(3):852-860.
- Godbout, S., S.P. Lemay, R. Joncas, J.P. Larouche, D.Y. Martin, M. Leblanc, A. Marquis, J.F. Bernier, R.T. Zijlstra, E.M. Barber and D. Massé. 2000. Reduction of odour and gas emissions from swine buildings using canola oil sprinkling and alternate diets. Proceedings of the 2nd International Conference on Air Pollution from Agricultural Operations, 211-219. ASAE Publication 701P0003, Des Moines, Iowa, USA.
- Groot Koerkamp, P.W.G., J.H.M. Metz, G.H. Uenk, V.R. Phillips, M.R. Holden, R.W. Sneath, J.L. Short, R.P. White, J. Hartung, J. Seedorf, M. Schöder, K.H. Linkert, S. Pedersen, H. Takai, J.O. Johnsen and C.M. Wathes. 1998. Concentrations and emissions of ammonia in livestock buildings in Northern Europe. Journal of Agricultural Engineering Research. 70: 79-95.
- Hartung, J. 1993. The effect of airborne particulates on livestock health and production. In Pollution in livestock production systems. Edited by Ap Dewi, R.F.E. Axford, and Faye M. Marai and H.M. Omed, 55-76.
- Hartung, J. and V.R. Phillips. 1994. Control of gaseous emissions from livestock buildings and manure storages. Journal of Agricultural Engineering Research 57(3):173-189.
- Hobbs, P.J., B.F. Pain, R.M. Kay, P.A. Lee. 1996. Reduction of odorous compounds in fresh pig slurry by dietary control of crude protein. J. Sci. Food Agric. 71: 508-514.
- Jongbloed, A.W. and N.P. Lenis. 1993. Excretion of nitrogen and some minerals by livestock. In (Verstegen, M.W.A., L.A. den Hartog, G.J.M. van Kempen and J.H.M. Metz, Eds.): Nitrogen Flow in Pig Production and Environmental Consequences. Pudoc Scientific Publishers, Wageningen, The Netherlands. Pp 22-36.
- Kay, R.M. and P.A. Lee. 1997. Ammonia emission from pig buildings and characteristics of slurry produced by pigs offered low crude protein diets. Proceedings of the International Symposium on Ammonia and Odour Control from Animal Production Facilities, 253-260. CIGR and EurAgEng publication, Rosmalen, The Netherlands.
- Lemay, S.P., E.M. Barber, M. Bantle and D. Marcotte. 1999. Development of a Sprinkling System Using Undiluted Canola Oil for Dust Control in Pig Buildings. In Proceedings

- of the International Symposium on Dust Control in Animal Production Facilities. 215-222. Scandinavian Congress Center, Aarhus, 30 May – 2 June.
- Lemay, S.P., L. Chénard, E.M. Barber and R. Fengler. 2000. Optimisation of a sprinkling system using undiluted canola oil for dust control in pig buildings. Proceedings of the 2nd International Conference on Air Pollution from Agricultural Operations, 337-344. ASAE Publication 701P0003, Des Moines, Iowa, USA.
- Maghirang, R.G., L.L. Christianson, G.L. Riskowski and H.B. Manbeck. 1995. Dust control strategies for livestock buildings - a review. ASHRAE Transactions SD-95-15-1:1161-1168.
- Martin, W.T., Y. Zhang, P. Willson, T. P. Archer, C. Kinahan and E.M. Barber. 1996. Bacterial and fungal flora of dust deposits in a pig building. *Occupational and Environmental Medicine* 53(7): 484-487.
- Mroz, Z., A.W. Jongbloed, S. Beers, P.A. Kemme, L. de Jonge, A.K. van Berkum and R.A. van der Lee. 1993. Preliminary studies on excretory patterns of nitrogen and anaerobic deterioration of faecal protein from pigs fed various carbohydrates. In (Verstegen, M.W.A., L.A. den Hartog, G.J.M. van Kempen and J.H.M. Metz, Eds.): *Nitrogen Flow in Pig Production and Environmental Consequences*. Pudoc Scientific Publishers, Wageningen, The Netherlands. Pp 247-252.
- Seedorf, J., J. Hartung, M. Schöder, K.H. Linkert, V.R. Phillips, M.R. Holden, R.W. Sneath, J.L. Short, R.P. White, S. Pedersen, H. Takai, J.O. Johnsen, J.H.M. Metz, P.W.G. Groot Koerkamp, G.H. Uenk and C.M. Wathes. 1998. Concentrations and emissions of airborne endotoxins and microorganisms in livestock buildings in northern Europe. *Journal of Agricultural Engineering Research*. 70: 97-109.
- Takai, H., F. Møller, M. Iversen, S.E. Jorsal and V. Bille-Hansen. 1995. Dust control in pig houses by spraying rapeseed oil. *Transactions of the ASAE* 38(5):1513-1518.
- Takai, H., S. Pedersen, J.O. Johnsen, J.H.M. Metz, P.W.G. Groot Koerkamp, G.H. Uenk, V.R. Phillips, M.R. Holden, R.W. Sneath, J.L. Short, R.P. White, J. Hartung, J. Seedorf, M. Schöder, K.H. Linkert, and C.M. Wathes. 1998. Concentrations and emissions of airborne dust in livestock buildings in Northern Europe. *Journal of Agricultural Engineering Research*. 70: 59-77.
- Zhang, Y., A. Tanaka, E.M. Barber and J.J.R. Feddes. 1996. Effects of frequency and quantity of sprinkling canola oil on dust reduction in swine buildings. *Transactions of the ASAE* 39(3):1077-1081.

IDENTIFICATION, INVESTIGATION AND IMPLEMENTATION OF SOLUTIONS TO HEALTH PROBLEMS

**Reg Reed
Mitchell Veterinary Services
Mitchell, Ontario**

SUMMARY

Most production limiting health problems can be dealt with. However, the ease with which they are recognized, diagnosed and solved can really vary. Choosing to ignore production-limiting issues of any sort can prove to be very expensive.

Even if recognized, it is important to thoroughly investigate a health issue to come up with the right diagnosis and thereby develop strategies that will overcome the problem.

Two case studies are presented to demonstrate management of health problems on specific pig units and to emphasize the importance of the above statements.

CASE STUDY #1

A 500 sow herd was established to sell 2 to 3 week old piglets into a three-site system. Farrowing started during the late summer of the first year. During the next 16 months several startup health problems and production problems were dealt with, e.g. greasy pig disease, breeding problems associated with a young herd, etc.

On particular problem, diarrhea affecting the piglets, did not want to go away. The owner, staff and myself had all recognized it as an issue and thought that routine management, i.e. vaccination, and maturity of the herd would result in the problem fading away.

When we really sat down and investigated the problem, a list of recommendations were made to deal with the problem. One of the recommendations was to take three live piglets that had just started to scour but had not been treated to the Veterinary Services Laboratory (VSL) for necropsy and testing. What I really wanted checked out was whether or not coccidiosis, rotavirus or strains of *E. coli* not covered in commercially available pre-farrowing vaccines could be involved in causing the diarrhea. While many of the recommendations were implemented and experimented, submitting piglets to the VSL was postponed for various reasons.

Finally, after struggling with the problem for about one year, submissions were made and a diagnosis of rotavirus was confirmed. Promptly, a proper pre-farrowing vaccination program was put in place and the scour problem was finally brought under control. The pre-weaning mortality dropped from 17% to 11 %. An extra 631 pigs/year were raised. The incidence of

light-weight piglets dropped from 10% to 5% and the average weaning weight improved from 4.8 to 5.4 kg.

All things considered, there was a difference of about \$35,000 the year after resolving the problem over the previous year. This is very significant considering that we thought it was a minor problem. Why did we think that? Because, at the time when we initially identified scours as the primary cause of the high pre-weaning mortality, the herd was producing 21 pigs/sow/year. This was a young herd with a fairly new barn and we were happy with most of the statistics and thought that with herd maturity, etc. everything would fall just in place.

Even though we investigated water, feed, chilling, processing of piglets, disinfection of farrowing crates, etc. and even though the recommendations to submit live piglets to the lab had been made, this one important step was overlooked or put off. This was a big mistake and a costly lesson.

CASE STUDY #2

Often health problems are complex. More than one organism may be involved. Environmental stresses, nutrition and the movement of animals (management of animal populations) may allow organisms that can be controlled to “gang up” in the pigs and cause disease.

In such cases, it is important to identify all of the challenges and to implement sufficient strategies to either eliminate or reduce these challenges or to at least be able to deal with them better.

A client has been purchasing about 100 three-week-old piglets per week from one source. Initially, they are moved to all in/all out weaner rooms for six weeks. While in these rooms they are vaccinated against PRRS and mycoplasma hyopneumonia. Next they are moved into large pens in a converted farrowing/breeding/dry sow barn that is continuous flow. They stay there for 6 to 7 more weeks.

Finally, they are moved to growing-finishing rooms for another 6 or 7 weeks.

Several months ago, Post-Weaning Multi Systemic Wasting Syndrome (PWMS) started to cause severe morbidity and mortality in the weaner rooms. Laboratory submissions identified:

- field strain of PRRS,
- Circovirus Type II,
- Swine Influenza Virus (H3N2),
- Pasteurella multocida, and
- Hemophilis parasuis (Glasser's Disease).

Recommendations to deal with this were:

- Investigate the sow herd to determine the PRRS situation.

- Vaccinate piglets with a full dose of PRRS vaccine at 3 to 5 days of age to overcome maternal antibodies, immunize and stabilize the piglets with respect to PRRS prior to arrival at the weaner barns.
NOTE: previously they had been give 0.5 dose of PRRS vaccine about 2 days prior to weaning and moving.
- Proper washing, disinfecting, warming of the weaner rooms, etc. was discussed.
- Water treatment with penicillin to reduce the challenge of *Pasteurella multocida* and *Hemophilus parasuis*.
- Injecting piglets with ceftiofur on arrival.
- Discussed vaccinating the sow herd against Swine Influenza, but decided not to.

What happened:

- The strategies resolved the PWMS in the weaner rooms, but the piglets crashed in the starter room because of Porcine Respiratory Disease Complex. Lab submissions revealed:
 - Very low Swine Influenza titres (H3N2), possibly maternal antibodies, and
 - PRRS

Follow-up recommendations:

1. Booster vaccinate the piglets with PRRS again, about 4 weeks after arrival in the weaner rooms. We theorize that early vaccination has helped reduce illness in the weaner rooms but wears off too fast. By re-vaccinating at this time, two weeks before the pigs go into the starter rooms, they will have much better protection.
2. Renovate the starter room into all in/all out units.

Time will tell whether we are on the right track or not.