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Foreword

The publication you are holding is the culmination of, and a tribute to, a life's work dedicated to farmers and the animals they care for. This book is about how traditional outcomes of Animal Science (efficiency and productivity) have been enhanced by one of the newest disciplines – the study of animal behavior. For this reason I approached Dr. Harold Gonyou, in the period leading up to his retirement, to capture the evolution of this new science, and using this knowledge of applied science to address the key question of our day – the housing of pigs - in particular the care and housing of gestating sows.

I first met Dr. Gonyou in August 1992, both of us new employees at the newly-created Prairie Swine Centre. Although we did not know each other previously, there was a certain familiarity having both come from a mixed farming background in southern Ontario, and having our undergrad degrees from the University of Guelph. During his career he has spent over 20 years working as a Research Scientist in ethology at the Prairie Swine Centre. His research has added greatly to our understanding of pig behaviour, and the behaviour and management of group housed sows in particular. We are pleased and indebted to Harold for spending his career with us helping to make a difference in science and industry.

Over the past 50 years, the science of ethology has helped producers to improve management practices, reduce animal stress, and to achieve unprecedented production levels. This publication presents a combination of scientific and practical information on the subject of sow management in groups. Our hope is that producers will use this information to help manage their sows productively and profitably, and that the concepts presented will stimulate further thought and innovation, taking sow management to 'the next level'.

This publication of 'science of ethology' articles were written by Harold and collaborators, Fiona Rioja-Lang, Jennifer Brown and Yolande Seddon, following his retirement in 2011. Their role was pivotal in ensuring the final document reflected not only the most recent scientific literature but also the broad range of applications this science has contributed to industry.

For us the reader, the publication was intended to provide a concise source of knowledge on a subject we see every day in the barn – animal behavior, to inform and inspire better ways of managing pigs. Our ethologist authors help us interpret filter and use that knowledge to improve the daily experience for both the stockperson and the livestock.

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Introduction

In the slightly over 100 years of its existence, the field of Animal Science has experienced a shifting of both goals and scientific disciplines. Traditionally its goals have been productivity and efficiency, and the major disciplines included nutrition, genetics, and physiology. This approach brought the field to the highly technical production of animal-based food in the post-war period of the mid-twentieth century. These techniques included, depending on the animal commodity, year round confinement, diets balanced for nutrients rather than feedstuffs, selection based on breeding values, artificial insemination, and the development of additives to enhance growth.

The field of Animal Science experienced an expansion of its goals during and subsequent to the 1960s. Much of this shift could be explained by concern over the intensive production practices that had developed. In addition to the goals of productivity and efficiency, issues such as food safety, environmental protection, and animal welfare became issues for the public, and therefore the producer. Animal agriculture not only had to be efficient, but it had to be carried out in a socially conscious manner. Just as productivity and efficiency involved several disciplines, the new goals (impact on behavior and welfare) were also best addressed in a multi-disciplinary manner, including several new ones. not sure about this, can we be more specific?

Ethology, or the study of animal behaviour, has had a role during both eras of Animal Science. As the discipline developed within biology in the mid-twentieth century, its applied component studied means to improve productivity in farm animals. Although a relatively minor discipline of the day, its contribution to animal productivity included reproductive, maternal, social and feeding behaviours as well as environmental control. There were few scientists in applied ethology. In the 1970s only three Canadian universities had agricultural faculty for whom behaviour could be called their primary discipline.

With greater emphasis on social concerns, ethology took on an expanded role, particularly in the area of animal care and welfare. This goal is still multi-disciplinary (see chapter on Animal Welfare Science), but ethology has been the most widely recognized of those disciplines. Much of the work has been to determine how well an animal can adapt to its production environment. In meeting this need for welfare assessment the discipline of 'applied ethology' has to some degree become the discipline of 'welfare science'. Many of its scientists have become proficient, through personal training or collaboration, in disciplines such as stress physiology, immunology and environmental management.

However, the discipline also retains a strong production component. As consumers demand a change in production practices, ethology joins with other disciplines in finding ways to produce efficiently under the new standards. As an example, prod-free handling has become the standard for most situations in the pig industry for reasons of both welfare and meat quality. Ethology has contributed to this transition in management through facility design, handling methods, and training of personnel.

The bulk of this publication is on sow housing and management. Once the industry within a country decides to move to group housing, the role of ethology has been to develop facilities and management methods to ensure efficient production within those systems. Thus we now talk of grouping strategies, mixing vs feeding based aggression, and competitive vs non-competitive systems. All of these are based on behavioural principles.

With the expanding goals of Animal Science, the role of ethology has grown as well. At least 10 major research groups in applied ethology exist within Canadian universities and research centres at this time. These include programs in each of the five major animal commodities. We now have more than 15 faculty/scientist positions within the country and numerous post-docs and graduate students working within the discipline.

While efficient production will always remain the goal of all animal industries, it must also be our goal to produce animal products in a socially responsible manner. Whether that is with a greater concern for food safety, the environment, or animal welfare, the field of Animal Science has shifted to place greater emphasis on disciplines such as ethology.

Harold W. Gonyou, Ph.D.

A Comprehensive Approach to Animal Welfare Science

Harold Gonyou, Ph.D. and Jennifer Brown, Ph.D.

Concern for animal welfare is evident at all levels of swine production, from producers and industry to society and consumers, and takes different forms at each level. For the individual producer, it involves daily decisions on the basic care of animals- from feeding and general management, to the quality of health checks and maintaining vaccination protocols. Within the pork industry, concern for animal welfare takes the form of codes of practice and quality assurance programs designed to define acceptable industry standards for the care and management of animals. From a societal perspective, concern for animal welfare is shown in laws governing major issues such as humane slaughter and housing practices, as well as in the purchasing choices of individual consumers.

Few consumers know, or are able to select, the farm from which they obtain their food. Their satisfaction with their food relies on their confidence in the industry which produces it. As such, the importance of animal welfare has increased, and with it the need for producers and the livestock industry to demonstrate good care. The field of animal welfare science arose along-side these changes as a tool to help address questions related to management practices that affect the physical and psychological well-being of animals. This article describes general perspectives in animal welfare science, it explores the measures used in welfare science, and how these measures are used to evaluate management practices.

As David Fraser of the University of British Columbia describes in his recent book, *Understanding Animal Welfare* (2008), animal welfare is generally viewed from three philosophical perspectives, with each perspective emphasizing different components of welfare.

One approach to animal welfare examines how well animals function in their environment. The 'functional approach' assumes that if animals are healthy and productive their welfare must also be good, and uses measures related to growth, reproduction, and health (or absence of poor health) to demonstrate good welfare. Physiological measures indicative of stress are also used to demonstrate how well animals are functioning in their production system.

The functional approach can be applied to plants just as well as it can to animals, yet we are more concerned about the welfare of animals than that of plants. The reason for this is that animals are sentient, that is, they have feelings. We recognize that animals



can feel pain, experience fear, and have a sense of comfort and discomfort. A second component of animal welfare relates to these 'affective states', or how animals feel. This approach emphasizes the importance of emotional states and the feelings of animals, using measures such as pain, fear and discomfort (or alternatively, positive emotions) as indicators of well-being.

The third component of animal welfare is known as the 'natural approach'. Through thousands of years living in the wild, our animals have relied on their natural responses to cope with environmental challenges. When they encounter similar challenges in our production systems, they will attempt to use these same natural responses to attempt to cope. Among other things, our animals will use exploratory behaviour to become familiar with their environment, to adapt their social behaviour to alleviate competition, and use thermoregulatory behaviour to avoid cold or extreme heat. If the animal is unable to express these behaviours, it will become frustrated and stressed. It may be able to express the behaviours, but be ineffective in coping because a critical part of the environment is missing, for example, a wallow (cooling device)

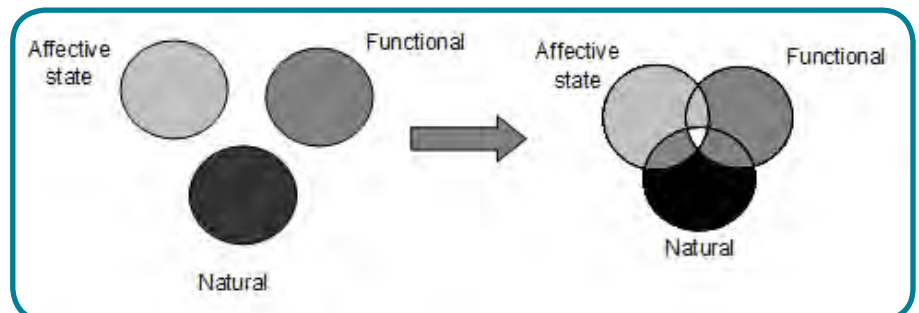


Figure 1. Components of animal welfare and the comprehensive approach



Rather than placing our emphasis on any one component of animal welfare, we should look for systems that meet a comprehensive definition

Freedom from Thirst and hunger	By ready access to fresh water and a diet to maintain full health and vigour
Freedom from discomfort	By providing an appropriate environment including shelter and a comfortable resting area
Freedom from pain, injury, and disease	By prevention or rapid diagnosis and treatment
Freedom to express animal behaviour	By providing sufficient space, proper facilities and company of the animal's own kind
Freedom from fear and distress	By ensuring conditions and treatment which avoid mental suffering

Table 1. The Five Freedoms defined by the Farm Animal Welfare Council (FAWC, 1979)

in hot conditions. In some cases, the behaviour may be harmful, such as when attempts to root for food result in injury. The natural approach considers how well the system accommodates the responses of the animal. Its motto can be expressed as 'fit the farm to the animal, not the animal to the farm'. Freedom of movement is a critical component of the natural approach to animal welfare.

While these three approaches- 'functional', 'affective states' and 'natural'- can be used separately, when used alone they run the risk of jeopardizing other components of animal welfare. Rather than placing our emphasis on any one component of animal welfare, we should look for systems that overlap (see Figure 1), and meet a comprehensive definition: a system in which an animal functions well, in which positive feelings outweigh negative, and in which it can express its natural behaviour in an effective manner.

This comprehensive definition of animal welfare meets the approval of most members of society. It is also evident in the Five Freedoms (Table 1), which are accepted guidelines for animal well-being used by many animal production organizations. In the current revision process for Canadian Codes of Practice, for pigs and other species, the mandate includes this comprehensive approach. The challenge to modern producers will be to achieve these goals in a production system that is also efficient and profitable. From a research perspective, the challenge to scientists at the Prairie Swine Centre is to identify management practices that can optimize animal welfare while at the same time maintaining or improving productivity, efficiency and profitability. This is the first in a series of articles using animal welfare science to address production issues in modern pork production.

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Fraser, D. 2008, *Understanding Animal Welfare: the science in its cultural context*. Wiley-Blackwell, Hoboken, NJ. Farm Animal Welfare Council, 1979. See <http://www.fawc.org.uk/freedoms.htm> a 'drop-off' in the middle of the day. Comparing these results with other studies suggests that the younger pigs were limited in the number of feeder spaces, and had to shift eating from the normal peak periods to the less intensive mid-day period.

Competitive Feeding Systems

Harold Gonyou, Ph.D. and Fiona Rioja-Lang, Ph.D.

We define competitive feeding systems as those in which an animal can obtain more feed by winning a fight. However, this does not necessarily mean that you will observe a lot of fighting in such a system. Often, the majority of fighting will occur within a couple of hours after mixing. Once a sow's dominance status has been established by aggression (fighting), it is often maintained by very subtle agonistic behaviour. These behaviours include threats through head movements and body posture by the dominant animals, and, for subordinate sows, moving in such a way as to avoid dominant animals. One study even referred to the social order among sows in a group to be one of 'avoidance' rather than 'dominance' (Jensen, 1982). However, if a sow is able to obtain more feed by any of these means, it is a competitive feeding system. Some feeding systems, such as gated stalls and ESF stations, protect a sow while she is eating and eliminate the possibility of obtaining more feed by fighting. We will discuss these in later articles. In this article we will discuss the ultimate competitive feeding system, floor feeding, and non-gated feed stalls that reduce but don't eliminate competition.

Competition is a characteristic of the social system within a group of animals. In its simplest form we have dominant/subordinate relationships among the animals. The definition of dominance is that it results in priority of access to limited and defensible resources. Pig producers are generally comfortable with group housing if the resource (feed) is not limited: e.g. finishing pigs fed ad-lib. But sows are almost always limit fed to control their body condition, and so we have the possibility of competition. Our management of competitive systems is such that we attempt to reduce the dominant sows' ability to control the resource. We do this in two ways: social and physical management. We will look at different competitive systems and how they can be managed most effectively.

FLOOR FEEDING

Dominant sows have a distinct advantage in terms of feed intake and weight gain in floor feeding systems (Brouns and Edwards, 1994). Subordinate sows, who are also usually younger and lighter, will fall behind in body condition and may have to be removed. A 'relief' rate of 15% is common when floor feeding. Social management is the primary means of evening out feed intake in floor feeding systems. In non-competitive systems, such as finisher pigs, there is some advantage to having a significant variation in the size of the pigs. This is because the social system actually operates better with some variation, i.e. if there are many individuals of the same competitive status, there will be increased aggression until a hierarchy is established. The opposite is the case when dealing with competitive situations, especially situations



of competition over feed. To ensure the most even feed intake among a group of sows, the sows should be as similar as possible, making them equally competitive. This will take the form of sorting sows by parity, weight and body condition. The result is a group of sows having the same feed requirement, and the same potential to compete for it. This sorting within a breeding cohort obviously results in smaller group sizes.

In order to have sows enter the system with similar body condition, it is advantageous to house them in stalls until confirmed pregnant (normally 35 days post-breeding) and feed them to achieve similar backfat levels by that time. Use of such 'breeding and implantation' stalls is particularly important for floor feeding systems as excessive competition and poor feed intake during this critical phase can affect reproduction (Spolder et al., 2009).

In terms of physical management, it is possible to use some dividers within the pen to create several feeding sites. This is only possible with larger groups. In general, the feed should be spread about as much as possible (multiple drop sites), to prevent a sow from defending a large drop of feed.

Using bulky, high fibre feed will extend the feeding time and reduce the incidence of stereotypic behaviours, but may contribute to more aggression. Similarly, feeding on a strawed floor will extend feeding periods and increase aggression (Whittaker et al. 1999). Feeding a bulky diet ad-lib allows the subordinate sows to avoid peak feeding times and consume normal levels of feed (Brouns and Edwards, 1994), but it must be bulky enough to limit total energy intake.



To ensure the most even feed intake among a group of sows, the sows should be as similar as possible, making them equally competitive

Large group floor feeding?

Several farms in Ontario have adopted a novel floor feeding system that differs from most feeding systems in three ways: the groups are large, and may include sows of different parities; the pen has a number of partial divisions that provide some separation of the multiple feeding sites; and, the feed is dropped in several (typically 6) drops per day, spaced 30 to 60 minutes apart. Large, non-uniform groups reduce social tension in finisher pigs, but are not generally advocated for in competitive systems, such as gestating sows. The barriers provide sows with some physical protection, as seen in short-stall systems, but several sows still eat from the same feed drop. Frequent feed drops that allow subordinate animals to eat from the later drops as the dominant sows feel satiated from eating from the first may be the key to the system.

Although several farms have adopted this system, it has not been studied in comparative tests. As with any floor feeding system, some sows have to be removed. At least one producer does not include gilts with the sows. The system as a whole, and multiple feed drops in particular, should be studied before being widely adopted. However, it illustrates that floor feeding can be managed in many different ways.

Keys to successful floor feeding

- Sort sows by parity, size and body condition.
- Use the time in breeding/implantation stalls to even out body condition.
- Spread feed as evenly as possible.
- Use dividers within the pen.
- Remove sows that fall behind.

PROVIDING PROTECTION: NON-GATED STALLS

As an alternative to floor feeding, producers should consider the use of feeding stalls in order to provide protection during eating. In this article we will only discuss non-gated (no back gate) systems, as gated stalls will be discussed as a type of non-competitive feeding system in a future article. Recalling the earlier statement on dominance, we note that dominant animals will exert themselves when resources are both limited and defensible. Defensible refers to the ability of the dominant animal to control more than their share of the resource. Non-gated stalls prevent

the dominant animal from monopolizing the feed by allowing the subordinate animals to defend a small portion of the total feed available, that is, their share of the feed. However, with enough effort dominant sows will be able to force a subordinate out of a non-gated stall and thereby obtain more feed.

Non-gated systems should make use of the social management techniques outlined for floor feeding (e.g. sorting by size and body condition). However, these systems also use physical methods to interfere with dominant sows attempting to displace subordinates from their feed. Non-gated stall systems use feed troughs so that the feed can be delivered and limited to a defined area. These troughs are divided so that individual allotments of feed are dropped into each division. Stalls are added to these divisions to provide protection to each sow as she eats. The longer the stalls, which typically vary from shoulder length to full body length, the less aggression and more even intake of feed (Barnett et al., 1992, Andersson et al., 1999). Floor feeding gives a distinct advantage to the dominant sow. Partial stalls reduce this advantage and allow the subordinate animals to spend more time eating and achieve a higher intake.



Sows in a floor feeding system. Note the divisions within the pen to separate feed drop areas. (Courtesy of Franklin Kains)

Two Types of Problems

If the performance of your sows in a competitive feeding system is below your expectations, it is easy to blame the feeding system. However, feeding system design is not always the problem. Two types of stressors can affect animals in groups: competitive and general. To determine which stressor is most likely within your system it is important to determine the demographics of the problem. If the problem affects younger, smaller animals more than larger, older animals, it is likely a competitive issue. A common problem in competitive feeding systems is the fat sow/ thin sow syndrome, in which smaller sows get thinner and larger sows get fatter. In this case you should attempt to reduce competition during feeding. However, if your problem is as common among larger sows as it is among smaller ones, then it is likely a general stressor that affects all of the pigs similarly. Examples of general stressors would include high temperatures, poor flooring, poor air quality or space restriction. The solution to these problems is quite different to that of a competition problem. In some instances, the problem may involve both general and competitive stress. For example, if poor flooring results in 10% of the sows becoming lame, evenly distributed across all sizes, the smaller lame sows may be at a greater disadvantage when trying to compete for feed. If you can identify that lameness was the initial problem, and improve the flooring, you will be more successful in correcting the subsequent problem caused by competition.

Shorter stalls, such as those that only extend back to the animal's shoulders, will not fully protect a subordinate animal. In systems with these stalls, it is common to see cuts and scratches on the sides of the lower ranking individuals where the dominant sows have attempted to displace them from the feed trough. Longer stalls will provide more protection, but some displacement may still occur. If longer stalls are better, then why would a producer use short stalls? It is a balance between protection during feeding and the amount of space the system requires. Group housed sows should have a sufficient amount of free space (outside of the stall) to move about freely. If a producer uses long stalls, additional space is necessary behind the stalls to provide this loafing area. Longer stalls also represent a greater capital expense, in addition to the increased floor space.

Are there other means to reduce aggression and displacements among sows in non-gated stall systems? There appear to be at least two: increasing the eating speed of the sows will reduce the time required to consume their feed and decrease feeding associated aggression (Andersson et al., 1999). One of the easiest ways to increase the speed of eating is to provide wet feed, either as a slurry, or by adding water in the feed trough. By eating faster, the subordinate sows are nearly finished their feed by the time the dominant sow is able to displace them from the stall. Although reducing aggression and displacements, the rapid eating may increase other problems associated with short meals, such as increased stereotypic behaviour.

Keys to successful non-gated stall systems

- Longer stalls will reduce aggression
- Wet diets take less time to consume and reduce aggression
- Trickle feeding prevents the accumulation of feed in front of slow-eating sows

The second method used to reduce displacements from short stalls is trickle feeding. Typically all of the feed for a sow is dropped into the trough at the same time. Faster eating sows consume their feed and then attempt to displace slower eating animals and steal their remaining feed. Trickle feeding meters the feed into the trough over an extended time, typically 30 minutes or

so (Hulbert and McGlone, 2006). Ideally, the rate of feed supply should be as slow as or slower than the eating speed of the slowest eating animal. If a faster eating animal decides to leave its stall to displace a slower eating one, no feed would have accumulated in the slower one's trough. The advantage to displacing another sow is lost. However, if the drop rate is the same as the eating speed of the faster eating sow, the slower eating animals will accumulate feed in their trough space and be vulnerable to attack from other sows. Trickle feeding has received mixed reviews. If it is well managed it may well reduce feeding associated aggression among sows. However, this is not always the case (Hulbert and McGlone, 2006).



Floor Space for Floor-fed Sows

The floor space allowance for floor fed sows should be fairly easy to define in terms of productivity, incidence of injuries and level of aggression. The system is essentially an open pen with the condition that sufficient solid floor area is provided for feeding. However, few studies have examined the question of floor space allowance. One such study, by Sequin et al (2007), reported no advantage in any of these measures among space allowances starting at 2.3 m²/sow (24 ft²) and going up to 3.2 m²/sow (34 ft²). Salak-Johnson and coworkers (2007) reported problems at 1.4 m²/sow (15 ft²) compared to 2.3 m²/sow (24 ft²), but did not examine any intermediate levels. From these studies we know that 1.4 m²/sow is not enough and 2.3 m²/sow is sufficient; but there is a large range in between that has been poorly researched.

If we look to grower/finisher pigs, who are also housed in open pens, there are detrimental effects on productivity below a space coefficient of $k=0.034$ (Gonyou et al., 2006) and changes in lying posture (indicative of decreased comfort) when k drops below 0.038 (Averos et al., 2010). Using weights from our facility for females near the end of gestation, gilts are observed at 220 kg and mature sows (3+ parity) at 310 kg. Applying the k values given above, gilts require between 1.24 and 1.39 m²/gilt (13 to 15 ft²) and sows between 1.56 and 1.74 m²/sow (17 to 19 ft²). The European Union specifies increased amounts of floor space for gilts (1.6 m²/gilt; 18 ft²) and sows (2.3 m²/sow; 24ft²) (Mul et al., 2010).

Additional research is required on floor space allowances in the range of 1.4 to 2.3 m²/sow (15 to 24 ft²). Until further research has been conducted, 1.4 – 1.6m²/gilt (15 – 18 ft²) and 1.7 – 2.3 m²/sow (19-24 ft²) is the suggested amount of floor space. It is necessary there is sufficient solid floor area to feed sows without excessive aggression.

THE BOTTOM LINE

Choosing Between Floor Feeding and Non-Gated Stalls

Both systems are less expensive than the non-competitive gated stall and ESF feeding systems. Producers who use these systems are looking for a less expensive system and are prepared to accept more aggression and to give up some control over feed intake. If the producer is prepared to place a great deal of emphasis on social management, then they are more likely to choose floor feeding. It is the least expensive of all of the systems. However, if they find social management difficult, they may want to spend more and provide their animals with the partial protection of short, non-gated stalls. In larger operations, the decision may be based on the confidence the operator has in the ability of their staff to socially manage the animals. As in every system, better management will result in better production.

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Non Competitive Feeding Systems

Gated Stalls

Harold Gonyou, Ph.D. and Fiona Rioja-Lang, Ph.D.

In our previous article, we have defined a non-competitive feeding system as one in which a sow is not able to obtain more feed by winning a fight. Fights may occur in such a system, but the winning sow does not steal food from the loser. This is accomplished by protecting the sow in a fully enclosed stall while she eats. There are two basic types of non-competitive feeding system, the gated stall and the electronic sow feeder (ESF). In an ESF system, there will only be one feeding station for a group of sows. However, in the gated stall system, all of the sows in a group eat at the same time, and there must be a stall for each sow. Gated stalls, or free-access stalls, are the most common system used in several European countries, including Belgium where 31% of farms and 37% of sows use the system. Within that country it is the most popular choice when making conversions (Tuytens et al., 2011).

GATED STALL SYSTEMS

The original gated stall system, in use before the industry adopted gestation stalls, has manually operated gates used to lock the sows into the stall only during feeding. At other times the gates are open and sows are free to come and go. This system is sometimes called a lock-in system.

In order to eliminate the need to have someone present during feeding, gating systems have been developed that can be controlled by the sow herself. If no sow is in the stall, the gate is open and any animal in the group can enter. Upon entering the stall, the gate is engaged and closes behind the animal by a cantilever mechanism. The gate locks and cannot be opened by any sow outside the stall, thus preventing the chance of food stealing or displacements. The sow inside the stall can open the gate, usually by backing against it, and is free to leave. These stalls are sometimes also called free-access or walk-in/lock-in stalls.

Unless otherwise specified, our comments in this article refer to these walk-in/lock-in stalls.

A third arrangement of gated stalls has arisen in order to reduce the space and cost of the system. In a cafeteria arrangement all of the sows in a group eat at the same time from a bank of lock-in stalls. When one group has finished feeding, they are moved out and a second group of sows is fed from the same bank of stalls. Rather than providing a feeding stall for each sow in a herd of 100, a single bank of 20 could be used to feed 5 groups of 20 during the day. This arrangement involves reduced installation costs, and provides protection whilst feeding, however, obviously there is an increased labour cost. A large scale cafeteria system has been studied in Australia (Karlen et al., 2007).



Figure 1. Photo of sow exiting free access stall. Pressure against the back gate releases the lock and allows it to be pushed back and upwards to an open position.

Control Over Feed Intake

Because we limit feed sows, we are also very concerned about how well we can manage their feed intake. Competitive systems allow us to control the amount of feed that a pen of animals consumes, but not the amount that each individual sow will eat. With gated stalls, we know how much feed each animal will consume. But because we do not know which sow will be in which stall at feeding, the best we can do is to divide the feed evenly among the sows. All animals will eat the same amount. This brings about two important management methods for adjusting feed according to the requirements of different sows. The first is to form groups based on desired feeding level: thin sows together and fat sows together. The second is to regularly provide additional feed, by hand feeding, to those sows needing more. For example, thin sows can be identified using stock marker, allowing the stockperson to top up those stalls very quickly.

Communal Loafing Space

Typically, free access stalls are arranged in one of several possible configurations. The two primary ones are the 'I-pen' or 'I', and the 'T-pen' or 'T' configurations. The 'I-pen' consists of an alley with slatted flooring running between two lanes of stalls from which open to the alley. The alley is typically 3 m (10 ft) wide. The length of the alley depends on the number of width of the feeding stalls. The 'T-pen' configuration consists of an identical alley with an additional solid floor area at one end of the pen. The 'T' typically adds at least 3 m (10 ft) to the overall length of the pen. The 'T' area may be bedded with straw, and is sometimes lower than the 'I' portion of the loafing area to retain straw on its solid floor.



In order to eliminate the need to have someone present during feeding, gating systems have been developed that can be controlled by the sow herself

Automated Cafeteria System

Most cafeteria systems involve manually opening gates and moving groups of sows to and from the bank of feeding stalls. Although this labour requirement provides an excellent opportunity to health check each sow every day, it is too labour intensive for many commercial operations. With this in mind, an automated cafeteria system was developed in the early 1990's (Morris and Hurnik, 1990) at the University of Guelph. Pens using a common set of feeding stalls were timed to open and close as each group of animals took their turn eating. Although the system used small groups of sows, it could be adapted to larger groups on today's commercial farms.

The study ran for several years and provided data on the productivity and longevity of sows in the system compared to sows in gestation stalls. Litter performance was similar for both treatments, but there was a higher attrition rate, particularly in the first gestation, for animals in gestation stalls. In addition, more sows remained in the herd beyond six parities in the cafeteria system. The end result was that sows in the Hurnik-Morris system had higher lifetime productivity than the conventional stalls (Morris et al., 1998).

Cafeteria systems could run with equal amounts of feed provided to each sow within a pen, and for each pen of animals. However, the researchers realized they could upgrade the feeding stalls to identify each sow as it entered a feeding stall and adjust its feed according to specific needs. It was deemed viable to increase investment in each feeding stall because each stall is used by several sows in the herd, spreading the total cost. The same principle applies to electronic feeding stalls (ESF) which we will consider in our next article.

Some producers may be tempted to reduce with width of the free space area between the two rows of stalls, however this is counter intuitive. It is not only important that we provide free space outside of the stalls, but the space must be of sufficient quality i.e. adequate flooring, adequate space to avoid aggressive encounters etc, and to increase usage, it would also be advised to provide some sort of enrichment, and water drinkers etc. It is very important that two sows from either row of stalls can exit their stalls without having to maneuver around one another and possibly having to avoid an aggressive encounter.

Use of the Communal Loafing Space

Part of the rationale for group housing systems is that the animals benefit from increased exercise and social interactions. Studies demonstrated that sows in an ESF system were found to have increased bone strength and decreased muscular atrophy than those housed an equal period of time in gestation stalls (Marchant and Broom, 1996). Yet one of the greatest criticisms of the walk-in/lock-in stall system is that sows spend most of their time within the stall. Our own observations, in a typical non-bedded free access system, is that using the loafing area is highly variable among the sows (Lang et al., 2010). Although the average amount of time

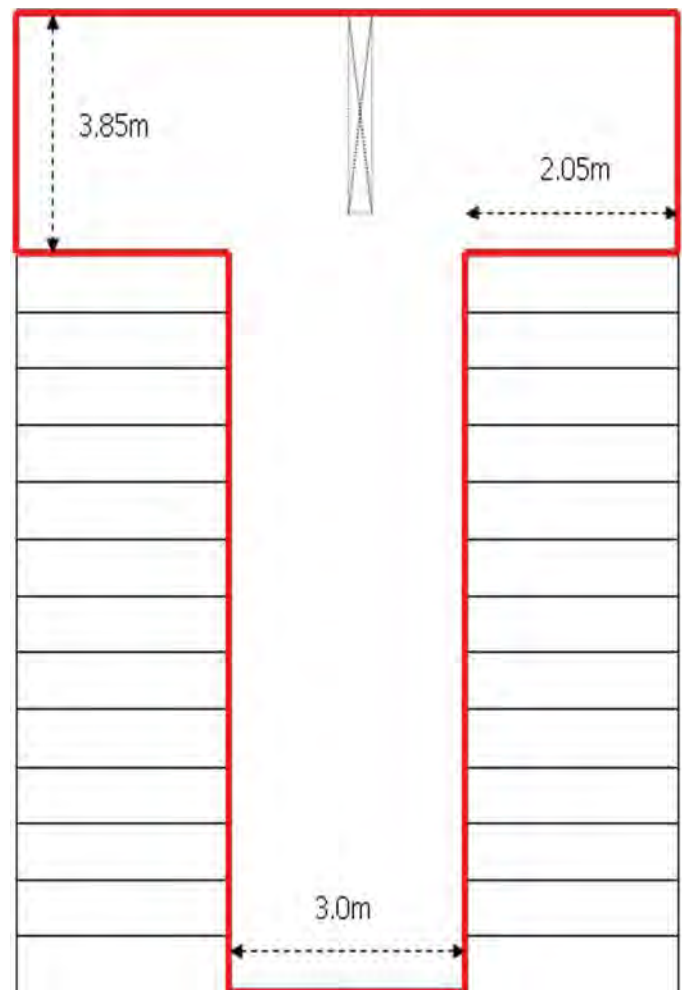


Figure 2. Diagram of a 'T-pen' showing feeding stalls with an alley between two rows of stalls and a solid floor loafing area at the end of the pen. An 'I-pen' is identical except it does not have a pen-wide loafing area at the end.

How much Space?

There is limited research data on the amount of space required per sow for free access stall systems. Leaving how much space is needed up to estimation, but in this regard the system is more complex than most other group housing. Free access stalls can be considered as having two parts: the feeding stall and the loafing area. Feeding stalls are generally designed to accommodate the animal for both feeding and resting. In order to allow large sows to rest comfortably in the stall, they are provided with a minimum of 0.60m (24 in) width, and 2.10 m (7 ft) length for a total of 1.3 m² (14 ft²) per sow (Nielsen, 2008). Comparatively, cafeteria systems, in which the sow only uses the stall only for feeding, a narrower and shorter stall that is wide enough for her to stand in but not wide enough to lie down can be used. The 'I' configuration, with only a slatted floor between two rows of stalls, is seen as the minimum loafing area. It is generally 3 m (10 ft) across to facilitate sow movement, which provides an additional 0.9 m² (10 ft²) per sow when using 60 cm (24 in) stalls. This provides sufficient area for approximately 50% of the sows to use at one time (assuming a need for 1.7 m² or 19 ft² per mature sow), but it is unlikely that 50% of sows would be in the loafing area at once, in particular as slatted floors are relatively uncomfortable and discourage sows from using the loafing area. For producers who simply want to provide sows the opportunity to leave the stalls, the 'I' configuration with about 2.2 m² (24 ft²) per sow would be sufficient.

However, if the intent is to provide a more comfortable loafing area, in order to encourage sows to use it for an extended period, both quantity and quality of space should be increased. In order to allow all sows to use the loafing area simultaneously, approximately 3.0 m² (33 ft²) of space is needed for both the stall and loafing. To achieve this level of use, the loafing area would have to be more comfortable than the stall, requiring solid floor and bedding (or rubber mats).

The cafeteria system, in which several groups of sows share a bank of feeding stalls, has the potential to reduce space needs. If six groups of sows share a set of 'feed only' stalls, the stall requirement is less than 0.2 m² (2 ft²) per sow. Providing a loafing area of 1.7 m² (19 ft²) per sow would result in 1.9 m² (21 ft²) per animal for the stall and loafing area combined. However, a cafeteria system also includes extensive alleys to move sows to and from the feeding stalls. Some of the space savings would be lost to these alleys.

Even at its minimum, a gated stall system requires more space than most other group housing. Achieving high usage of the loafing area would require even more space. The high space requirement is the greatest drawback of gated stalls, and producers should consider using low-cost buildings for this system.

spent outside the stall is approximately 4 hours, some sows may not leave the stall at all during the day and others will be out more than 20 hours. The sows least likely to be outside the stall are the smaller, younger sows, while larger, older (dominant) sows, spend the most time in the loafing area. We hypothesize three possible reasons for this. The smaller sows may be intimidated by the larger, dominant sows; the larger sows may be more uncomfortable in the gestation stalls; and, the smaller sows may have difficulty opening the back gate of the stall due to their size or lack of training.

Use or non-use of the loafing area will be dependent upon the relative costs and benefits of leaving the stall. The costs will include the social tension of interacting with other animals, while the benefits may include issues of comfort and access to resources. Many existing free access systems provide little incentive to use the loafing area. All resources (food and water) are provided in the stall, and the loafing area consists of spindle walls, slatted floors and no bedding or enrichment devices. Why would a sow spend a great deal of time in what would be a relatively uncomfortable environment?

Two general methods may be used to encourage sows to increase the use of the loafing area, and thus increase the exercise that they experience. The first is to provide resources outside the stall such that animals will exit at least once a day to access them. An obvious choice would be to provide water in the loafing area but not in the stall. This would require that we have a great deal of confidence in the gate locking system that sows could easily leave

the stall at any time. As mentioned above, there is some concern that not all systems are easy to open by small sows. Another resource that sows would likely access would be sources of fibre, such as chopped straw or a hay rack.

A second means to increase use of the loafing area would be to improve comfort in the area. For example, sows prefer to rest against solid walls rather than spindle penning and solid floors are preferred to slatted. In many 'T' systems, the 'T' section is bedded



Figure 3. A gated stall system with rubber mats installed over the slatted floor of the loafing area.

Rubber Mats

One way to increase the comfort of the loafing area is with the addition of rubber flooring. Rubber flooring has been extensively used in agriculture, particularly in dairy barns to increase cow comfort. It has been suggested that comfortable flooring may impact many aspects of an animal's state of well-being, including lying behaviour and ability to change position, as well as the incidence of lameness and skin and foot lesions (Boyle et al., 2000; Rushen et al., 2007; Tuytens et al., 2008). The problem, until now, has been to find a product durable enough to withstand manipulation by sows. Such a product is now available and studies have begun to assess the potential benefits.

A study recently completed at the Prairie Swine Centre investigated whether it is possible to increase the amount of time sows spend in the communal area by adding rubber mats to increase comfort, and by grouping sows by age to reduce fear in younger (subordinate) sows. The results indicate that in both 'young' and 'old' sow groups, pigs spent significantly more time in the free space areas with rubber flooring than concrete flooring, in both pen configurations (I-pens and T-pens). There was also increased lateral lying on the rubber flooring, suggesting increased comfort. Sows housed in pens with rubber flooring were also significantly cleaner than sows housed on concrete flooring. Grouping older and younger sows separately was found to increase the usage of the loafing area by younger sows, compared to previous studies with mixed age/parity groupings. The ability to identify optimum flooring and social management options will improve producers' decision making capabilities when making the transition to group housing. These results suggest that using rubber flooring will encourage gestating sows to use the free space areas more frequently, and is likely to promote the associated benefits of increased activity, including increased muscle and bone strength. Housing groups of young and old sows separately should also increase the utilization of the free space..

with straw. Nielsen (2008) indicates that 50-75% of sows use the 'T' section, but is it unclear if this refers to the average proportion of sows using it at any time, or those that use it at least once per day.

What Role Does Competition Play?

Gated stalls are the least competitive of all the group housing systems. A sow need only enter the feeding stall and she is protected from the remaining sows in the group. This is true both during feeding, and during social interactions in the loafing area. The stalls provide an escape from aggression. But competition remains for other resources within the pen. If water, a straw rack or some form of enrichment is available in the loafing area, the dominant sows will have preferred access to it. Dominant sows will make use of preferred lying areas, whether they are against the wall

of the loafing area or areas with straw or rubber mats. Subordinate sows will be relegated to slatted areas and thus may have a higher incidence of 'discomfort' injuries such as lameness or calluses. In some groups, the dominant animal may be a despot and attack all other sows with little regard to the cost of such behaviour. It may be advantageous to remove a despot so that a new dominant sow can be established that does not upset the entire social group. But the bottom line is that gated stalls virtually eliminate competition related production losses.

KEYS TO SUCCESS

Gated systems are an opportunity to buy success through design rather than management. Nonetheless, a few management practices will contribute to the smooth operation of the system:

1. Maintain the gates so that they are easily opened by all sows when exiting the stall. Training of new sows may be helpful.
2. Make the loafing area as conducive to sow use as possible, by providing adequate space, water, fibre, and comfortable floors.
3. In large herds, sort the sows by age so that younger animals use the loafing area as well.
4. Remove despot sows that constantly attack other animals in the loafing area.

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Non Competitive Feeding Systems

Electronic Sow Feeders

Harold Gonyou, Ph.D. and Fiona Rioja-Lang, Ph.D.

The electronic sow feeding system represents the ultimate in the use of technical control to manage sows. The use of electronics to control all aspects of the system is a major shift in the management of sows, somewhat akin to the use of robotic milkers for dairy cows. It requires a significant shift in our approach to managing animals and the daily routine of the barn.

HOW THE SYSTEM WORKS

An ESF system generally provides a single (or very few) feeding station(s) for a large group of sows (typically 40-60 sows/station). The sows must eat sequentially, one after the other, from the same station. Once a sow enters the station the entrance gate locks behind her and she is identified by means of a transponder in her ear tag. The computer controlled feeder allots her a specific amount of feed, dropped into the feed bowl over a limited period of time. During the feed drop, and for several minutes afterward, the entrance gate remains locked so that other sows may not enter. The sow may leave at any time, ending the dispensing of feed and unlocking the entrance for the next sow. The computer records the amount of feed that has been dispensed to each sow (not the amount actually eaten), and allocates any undispensed allotment to a subsequent entrance by the same sow that same day, or to her next day's feed. The system typically cycles on a daily basis, with a new allotment of feed being made available to each sow every 24 hours. As the stockperson will not be present while each sow eats, the system must provide feedback on any sows that fail to eat their allotment each day. This feedback is in the form of an 'attention' list available to the stockperson at the end of each 24-hr cycle, and is used to identify animals that may need additional care.

Controlling Feed Intake

ESF is the only group housing system that currently allows for true control over individual feed intake. When a sow initially enters the system (pen) the manager enters a personalized feed program for her into the system. This will set the amount of feed the sow will receive each day, and allows for increases as gestation progresses. The manager can base these levels on the sows' age, weight, body condition score or back fat measurement. Other group housing systems try to achieve equal feed intake for every sow in the group, but in ESF systems sows can be programmed to receive more or less than the pen average. It is also possible, with many ESF systems, to program different diet compositions for sows within a pen, allowing the delivery of two different diets to each station, sows being programmed to receive one or the other of the two diets. The two diets can also be blended to achieve the appropriate protein and energy combination for individual sows.

Problems with feed intake may occur if sows do not eat on a regular basis. Most sows will have days when they do not eat their entire ration. ESF systems records how much feed has been dispensed to a sow before she leaves the feeder, and adds the undispensed portion to the following day's allowance. However, the sow may leave a portion of her ration in the feed bowl and this is not carried over to the next day. Some sows may not eat every day. Although such sows may eventually consume their allocation on subsequent days, some may not if they habitually miss feedings. This will be addressed under overstocking and training in later sections.

How Sows Behave

A common observation of people when first observing a group of sows in an ESF system is that the animals are quiet and restful. Because the sows eat sequentially, rarely is the entire group active at the same time. Typically only a few sows are standing, even when stockpeople enter the pen and move about the animals. The greatest activity occurs immediately after the station initiates a new day of feeding (Hodgkiss et al., 1998). Several sows will approach the entrance and compete to be among the first to feed. Towards the end of the feeding cycle only timid, subordinate animals will be left to eat (Strawford et al., 2008).

If the feeding station permits, sows will pass through the feeder approximately 3 times per day (Cornou et al., 2008), and if there is more than one station in the pen they will have a strong preference for one of the stations (Eddison, 1992). Under moderate stocking rates most sows will eat all of their food allowance on their first trip through the feeder (Eddison, 1992; Cornou et al., 2008). When in the feeding station, sows eat quickly, and will show impatience with the dispenser by banging it with their head if feed is not falling as quickly as they are eating. Once finished eating, sows





Electronic Sow Feeding systems are the only group housing system that currently allows for true control over individual feed intake

will usually leave quickly rather than waiting for the entrance gate to open and to be pushed out by another sow. Upon exiting the station, a sow typically has an additional drink and may urinate or defecate before moving to the loafing area. Recycling through the station many times during the day is characteristic of a few sows, particularly if the feed bowl is designed such that a small amount of feed falls on the floor or remains in the bowl.

Competition is evident among sows. More dominant sows (typically older, larger and more senior in the group) will enter the station earlier in the feeding cycle. This may involve some aggression in station entrance area, and in late gestation this may result in injuries to swollen vulvas (Rizvi et al., 1998). Dominant sows will also claim the best lying areas of the pen; on solid floor, near a wall (Strawford et al., 2008). Subordinate animals are typically found near the exit of the station or in the dunging area (Moore et al., 1993).

PROBLEMS WITH ESF SYSTEMS

Other sow housing systems will continue to function well if staff are negligent in inputting data into the system. This is not the case with ESF systems. Management of sows, in terms of feed distribution, monitoring intake etc., is heavily reliant on the electronic identification system and computer programming. It is critical that animal information be updated in the computer whenever animals are added to or removed from a pen. Information on the animal, in terms of the appropriate feeding curve and due date, allows the system to provide the correct amount of feed and schedule the animal for sorting when necessary. Failure to keep up to date and accurately input information can be a major problem with ESF management. The output from the system, in the form of the daily attention list, is also a key component of electronic management. In addition, lost or failed electronic ear tags must be replaced promptly if the sow is to continue to be fed. Although not common, failure of the equipment must be addressed quickly and a backup feeding system must be in place (typically floor feeding).

Failure to train animals to the system will result in many missed meals and eventually require the removal of these sows (Bressers et al., 1993). Training is not particularly difficult with a well designed training pen and protocol. Gilts should be trained within a week by housing them in small groups and ensuring that each animal passes through the station each day. Once trained in a small group, the animals should be incorporated into a moderately sized group before eventually entering a large group. The longer the training period the fewer days of missed feed will occur. Because feed intake can be variable during training, it should be avoided as much as possible during the first month of gestation.

One of the greatest problems with ESF management is the tendency to overstock feeding stations. The more sows being fed from a station, the less time is left at the end of the feeding cycle for young, timid sows to enter and feed. Overstocking results in competition to access the feeder, evidenced by increased aggression at the station entrance and frequent missed feedings by subordinate sows. The key to achieving a high stocking rate on a station is to decrease the amount of time spent in the station by each sow. Early studies often used stocking rates of 40 sows per station, but many farms are now successfully feeding 60. However, this level could be problematic if managed incorrectly. Overstocking will result in uneven body condition and poor performance by the thin animals.

Keys to Managing Electronic Sow Feeders

- Ensure that all sow IDs, breeding dates and feeding levels are entered into the system whenever a sow joins a group.
- Train animals well so that they are confident in using the feeding system before entering a large group.
- Base your daily management on the attention list generated by the system at each daily reset.
- Create a good flow of animals with your pen design, that promotes movement from entrance, to exit, to loafing areas.
- Avoid overstocking the station. Every animal should be able to eat easily each day.

Reducing Time Spent in the Feeding Station

Overstocking of an ESF occurs when there is not enough time during a feeding cycle for all sows to pass through the station and consume their ration. This problem can be resolved by either reducing the number of sows/station or by reducing the amount of time spent in the station by each sow. One study reported that sows spent an average of 25-30 min/day in the station (Edwards et al., 1988). However, there are a number of ways to reduce this time to make the system more efficient.

Sows eat faster if water is provided in the feeding stations. Including approximately 50% water with the feed (e.g. 50 ml per 100 g) will increase rate of eating by as much as 35%. If water is added, there is little difference in the eating speed for mash vs. pelleted diets. Water should be added with each drop of feed. Most manufacturers make provision for this in their equipment, but managers must ensure that it is working well and maintained.

The feed drop rate can be set to keep up with the fastest eating sows. Sows differ considerably in the time required to consume their daily ration, even if all are fed a wet diet. Older sows may finish their feed in as little as 10 minutes, while gilts will often take longer than 20 minutes. By setting the station to dispense the diet over a 10 minute period, faster eating sows can finish and be out of the station within 12-15 minutes. Once they have exited, the entrance gate will unlock to allow another sow to enter. Slower eating sows and gilts will need to have the entrance gate locked for up to an additional 10 minutes for them to consume their feed and leave. One problem with this approach is that a slow eating animal that leaves after 15 minutes will leave a significant portion of her ration in the feed bowl, and this will be recorded as feed consumed. She will not have access to it the following day.

Total time spent in the station is reduced if sows are discouraged from multiple entries (recycling). It has been reported that sows will enter the station an average of 3 times per day, and some sows will recycle much more often. An important change in feeder design occurred in the mid-90's when the feed bowl was closed after a sow left and only reopened if the next sow had not already consumed her daily ration. The only feed available to a sow that recycled was whatever had fallen on the floor around the bowl. A second means of reducing recycling is to have an identification panel at the entrance to the station that only unlocks the entrance gate if the sow has not previously consumed her entire ration. Sows quickly learn that there is no point in attempting to re-enter the station. A final means of eliminating recycling is to use a 'one-pass' pen design (Stewart et al., 2008). As seen in Figure 1, a set of gates can be used to divide the pen into pre- and post-feeding zones. All sows are herded into the pre-feeding zone prior to the daily reset of the system. Once a number of the sows have passed through, the zones are re-configured to shift space from the pre- to the post-feeding zone. Prior to the subsequent reset of the system, unfed sows can be herded through the station. A single pass system may not be appropriate for all pens on a farm, but could be used for training and problem animals.

PEN LAYOUT

Because it does not involve a row of feeding stalls, or even a long feeding trough, an ESF system can be very flexible in terms of pen design. However, many report that the system is more efficient if the pen is seen as three distinct areas: entrance, exit and loafing. We will take that approach in describing pen design.

The entrance is the area in which sows await their opportunity to enter the station. The animals are hungry and this is the area of greatest aggression. There should be room for animals to flee from more aggressive sows, and corners should not be so tight that animals can be trapped in them. Some form of roughage (e.g. Straw rack) can be provided in this area to help alleviate hunger among the animals (Stewart et al., 2008).

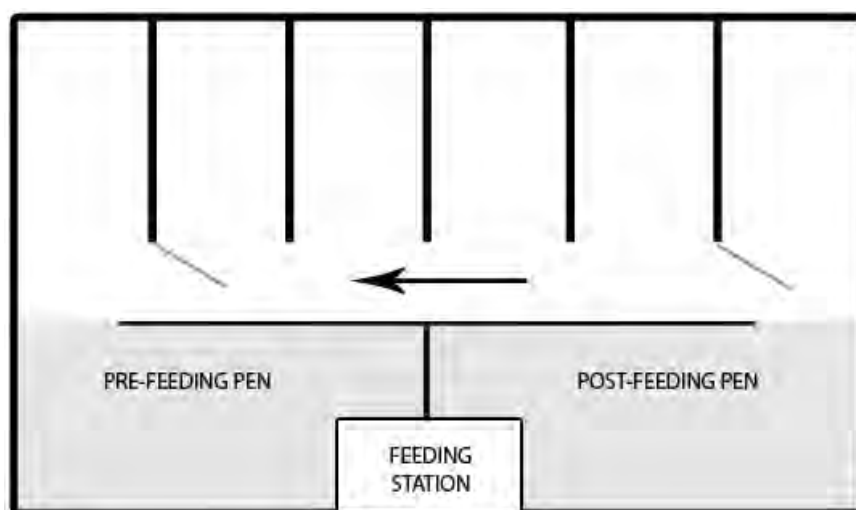


Figure 1. Diagram of a single pass system

Animals should pass through the exit area fairly quickly, but they may want to drink additional water as they have just finished eating. Although many pen layouts allow sows to move directly from the exit back to the entrance area, this only contributes to recycling. A better animal flow is created if sows must pass through the loafing area before returning to the entrance.

The loafing area is often a large open area for the sows to rest. If any area in the pen is to be solid floor or bedded, it should be the loafing area. Although an undivided area is common, it may be helpful to provide barriers that divide the loafing area into several bays. This is particularly important if a dynamic grouping system is in place, as sows that enter the pen at the same time will generally move into the bay or bays vacated by the group that recently left.

Although there are many variations of this three-zone system, Figure 1 illustrates the principle well. Sows enter the station from one zone, exit into another, and then move to the loafing areas before returning to the entrance. The figure also illustrates the use of gates that can be used to separate the group into pre- and post-feeding. This can be helpful in training or for caring for problem animals that have failed to cope with the competition around the entrance. By closing gates between the pre and post feeding animals, competition is greatly reduced. However, this would only be used in a few pens within an operation.

If pen layouts are well designed, ESF systems can operate well at space allowances of 18-20 sqft per sow. However, aggression and skin injury scores can be reduced by providing more space (Remience et al., 2008)



Figure 2. Electronic sow feeder (photograph Fiona Rioja-Lang)

POTENTIAL FOR ELECTRONIC BASED MANAGEMENT

An ESF system identifies animals as they pass through critical points in the pen each day. This information can be used to help manage the animals. For example, in dynamic systems it is common to have to vaccinate or sort for farrowing a number of animals on a given day. Most systems have a sorting system incorporated in the station exit that uses the electronic ID to move these sows into a holding area. If a few sows should be marked for attention within the group, their ID can be flagged within the system and they will be sprayed with paint as they feed.

An early innovation using the electronic ID of sows was to detect animals in estrous. In estrous sows are attracted to boars, and so will spend a great deal of time near a boar pen located in the exit area. Sensors mounted to the boar pen can identify sows and record the time spent in close proximity, which can be used to identify those in estrous. The system could also be set to monitor the time at which sows enter the station, the amount of time spent eating, and the occurrence of low-feed intake days. Each sow will have a repeatable pattern for these measures, and a deviation may be indicative of a change in physiological state such as estrous, illness, or injury (Cornou et al., 2008).

An interesting approach to reducing recycling of sows through the ESF and the associated aggression is to program the system to call individual sows to the station (Mantenffet et al., 2011). The computer is programmed to allow each sow to eat during a specific time, and initiates a voice call just prior to the station accepting them. Sows will learn that there is no point in trying to enter the station until they are called. Although not in commercial application, this approach illustrates the type of potential that exists with electronic based management.

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Re-Grouping and Timing of Re-Grouping

Harold Gonyou, Ph.D. and Fiona Rioja-Lang, Ph.D.

One of the greatest objections to group housing of sows is the fear of aggression among the animals. The vast majority of aggression in groups of sows occurs either at the time of re-grouping, or during the daily feeding. Re-grouping aggression may be intense, but is generally short-lived and contributes to acute stress. Feeding aggression is repeated daily and can be considered a chronic source of tension and stress within the group. The issue of feeding aggression has previously been addressed in our discussion of feeding systems. In this article we will examine re-grouping aggression and its impact on management and productivity.

Why do sows fight when re-grouped?

Our reluctance to keep sows in groups seems somewhat misplaced as in the wild pigs live quite harmoniously in groups of numerous sows and their litters (Gonyou, 2001). The difference between commercial production and living in the wild is that sows in the wild rarely, if ever, incorporate new sows into their group. If any sow attempts to join a group, she will be attacked by the resident sows and forced to leave. That is really what happens when we mix sows in commercial conditions: the resident sows attempt to drive away the intruders (Fig. 1). Difficulties arise because the new animals cannot leave (Mendl and Held, 2001). Although we often attribute the aggression of newly mixed pigs to the need to establish their dominance order, that is likely a secondary aspect of the aggression. Subordinate animals cannot just submit and accept a low position in the dominance hierarchy; they must also find a way to be tolerated within the group.

The key to remaining in the group is to stay on the periphery. Moore et al., (1993) and Kraus and Hoy (2011) studied the lying position of sows after new animals were added to an established group. The new animals slept together, apart from the resident animals for several weeks after being introduced. Gradually they were able to integrate into the main group. Once established, the stability of a group of sows is maintained more by avoidance than by aggression (Jensen, 1982). Maintaining separate sleeping areas contributes to this avoidance.

Within a well managed group housing operation, many animals within a group will be familiar with each other from their previous gestation period. Sows are able to remember previous pen-mates even after several weeks of separation during farrowing and nursing (Arey, 1999). Consequently, when sows are grouped for a subsequent gestation period, the group consists of previously acquainted sows (an established group) and a number of new animals. The new animals will generally be gilts or 1st parity animals recently added to the breeding herd. Thus, the challenge often associated with younger animals, being the least able

to dominate, is confounded by the fact that they are also new. Younger animals (Strawford et al., 2008) and newly introduced animals (Moore et al., 1993) end up sleeping in the least preferred areas of the pen.

How much do sows fight, and how severe are the injuries?

Re-grouping aggression is described as intense but short-lived. Fighting is greatest during the first three to four hours after mixing, and decreases to very low levels by 3-4 days after re-grouping. Reports differ in how aggression has been defined, but the average number of fights during the initial three hours is generally less than three per animal (Moore et al., 1993, Strawford et al., 2008, Kraus and Hoy, 2011). Extrapolating the data of Kraus and Hoy (2011) we estimate that new sows added to a pre-existing group of familiar animals will fight less than 30 times during the first four days. The length of fights have been found to range from eight to 420 seconds but average at around 70 seconds (Arey, 1999). In the first three hours after mixing, the average time spent fighting by sows was reported to be 68 seconds by Strawford et al., (2008). A very similar value was reported by Moore et al., (1993) for new sows in a group, but new gilts were much lower, and fought for a shorter duration. In general, new sows are involved in more aggression (Kraus and Hoy, 2011), and older animals fight more than younger ones (Moore et al., 1993).

Fighting is sometimes assessed by the degree of injuries received over a period of time. Hodgkiss et al., (1998) reported that only 0.16% of injuries received (when studying sows in an ESF system) were considered severe, and of the severe injuries, half were to the vulva. The vast majority of injuries due to aggression are in



Figure 1. Sows fighting at mixing (Photograph courtesy of Dr Emma Baxter)



Re-grouping aggression is described as intense but short-lived. Fighting is greatest during the 3-4 hours after mixing, and decreases to very low levels by 3-4 days after re-grouping

the form of surface scratches to the skin, generally on the neck and shoulder. However, the incidence of scratches is greater for younger, smaller animals (Hodgkiss et al., 1998) even though they are involved in less fighting than older sows (Strawford et al., 2008).

It needs to be recognized that most reports on aggression and injuries report average values for either the entire group of animals, or particular sub-groups (such as gilts or newly introduced animals). The extremes in terms of number of fights, time spent fighting and severity of injuries may not be reported. Nevertheless, it can be said that the majority of sows in a group are involved in few fights and for a short period of time after regrouping.

Reducing aggression at re-grouping

We want to approach this challenge from a behavioural perspective, and will categorize methods to reduce re-grouping aggression according to the behaviour of the animals. The first approach is to reduce aggression by increasing familiarity among the sows. Whenever sows are grouped following breeding, you will have some sows that were housed together during their previous gestation, and those that were not. Gilts will almost always be unfamiliar with the older sows in a breeding cohort. In a study at the Prairie Swine Centre we formed groups entirely of familiar animals or groups that included a number of unfamiliar sows (not housed together previously). The familiar sows did fight, but the fights were very short and produced few injuries. Fighting decreased rapidly over the first few days together. We observed the same pattern among sows that were grouped at weaning and then stalled for breeding. When placed into gestation groups they appeared to re-familiarize themselves with each other quickly and then aggression stopped (Rioja-Lang et al. 2011). Pre-mixing unfamiliar sows in a specially dedicated mixing pen can see levels of aggression reduced after 1-2 days together. These mixing pens tend to be larger in size, and more complex (contain dividers) thereby allowing individuals to retreat. Durrell et al., (2002) pre-mixed unfamiliar animals that were added to an already familiar group, and found that there was less aggression in the post-breeding mixing. However, because most of the aggression is directed towards the unfamiliar animals, it appears that adding just a few new animals to a group is detrimental (O'Connell., 2004). The conclusion is that if unfamiliar animals are part of a group, they should make up more than 10% of that group.

The second approach to reducing aggression at re-grouping is to control the amount and layout of the space and allow animals a means to escape from an attacking sow. We found that providing escape stalls within the pen greatly reduced the injuries due to fighting. Free access feeding stalls will provide such an escape. An



Figure 2. Mild, average, and severe injuries from post-grouping aggression intermediate means of providing separate space for new sows is to divide the pen into sub-sections so that unfamiliar sows will claim one of them as their own (Sequin et al., 2006). Unfamiliar sows in a large group tend to form a new group of their own for lying. However, these sub-sections must be large enough to allow several sows to lie together. Small sub-sections may become a form of trap as animals flee from a fight. Finally, providing more space is a means of allowing animals to avoid an unfamiliar animal, flee from a fight, or rest on the periphery of the group. The shape of the pen may help in allowing sows to avoid one another, and flee from a fight. Rectangular pen shapes appear to be more use than square



Figure 3. Level of injuries sustained throughout gestation

pens and in allowing sows to avoid one another, pen shape could play a more important role than space allowance (Barnett et al., 1993).

A third approach to reducing aggression is to attempt to create a stable social structure. Small groups (less than 8-10 sows) will form stable, linear hierarchies but mid-sized groups are less stable. However, pigs in large groups (over 40-60) develop a different social strategy in which they tolerate other animals rather than having to try to dominate them (Turner et al., 2001; Samarakone

et al., 2009). Replacement gilts previously housed in large groups may be better prepared for group housing as sows. An alternative means of preparing gilts for life in groups is to frequently re-group them during development. Such animals are less likely to be aggressive once they join a sow group (Bolhuis et al., 2004; van Putten and Buré, 1997). Generally groups made up of a range of body weights will form a more stable social hierarchy, but the subordinate animals may be at too great a disadvantage in a competitive feeding system. However, several studies have examined using one or more clearly dominant animals in a group to try to suppress aggression. Our attempt to do so with large, higher parity sows in a group of younger animals did not reduce aggression. Reports on the use of a boar to suppress aggression in a group of sows have produced mixed results (Luescher et al., Sequin et al., 2006).

Several miscellaneous methods have been used to reduce aggression when re-grouping. Barnett et al (1994) reported that it was best to group animals late in the day just before the lights are turned off. Feeding the animals a double portion of their diet just before mixing can also be effective. Finally, Hemsworth et al (2006) and Strawford et al (2008) reported that sows that are several weeks pregnant fight less when regrouped than those that have recently been bred.

When to Re-group

Considerable variation exists in the time at which sows are regrouped both in legislation and commercial practice. The range includes forming groups immediately after weaning until after pregnancy is confirmed by ultrasound (typically 35 days post-breeding). Physiological studies, in which stress is applied at different times during this period have generally failed to generate a significant difference in loss of embryos, although the period from 10-15 days post-breeding seems the most sensitive period (Einarsson et al., 1996). This period coincides with the time when embryos are migrating within the uterine horns prior to implantation.

In a survey of commercial farms it was reported that excellent productivity could be obtained regardless of the time of re-grouping on well managed operations (Spoolder et al., 2009). However, of the farms with poorer productivity, the largest proportion re-grouped their animals between 7 and 21 days post-breeding. Again, this coincides with the period of embryo migration. Some producers have found that if you re-group prior to implantation, it is critical to do so within 2-3 days of breeding (ten Beek, 2011). Our experience with an ESF system at the Elstow research facility was that regrouping at 7-9 days post-breeding resulted in a 5% reduction in farrowing rate compared to waiting until 35 days (Gonyou et al., 2006). Lastly, another alternative is to wean sows directly into group housing. Despite the concerns of mixing sows at weaning, this area has not been investigated extensively and there may be benefits which are generally overlooked.

Einarsson et al. (1996) examined three sources of stress that could be key to the question of how to manage re-grouping during the critical time period. Heat stress will affect farrowing

The Time Course of Implantation

After breeding, pregnancy is confirmed by the absence of a return to estrus at 21 days, or a positive ultrasound test at about 28 days after breeding. Any loss of pregnancy during this time is generally attributed to stress, such as regrouping of the animals. Einarsson and coworkers (1996) suggested that several types of stress could affect pregnancy during this time such as food deprivation, poor thermal conditions, as well as social stress of regrouping. To understand what is happening during this period of time, he reviewed the process of implantation.

Embryos enter the uterus 2-3 days after breeding and then must migrate throughout the uterine horns to evenly distribute themselves. Migration of the embryos continues up to approximately day 12 post-breeding, and then follows the process of attachment or implantation which occurs from about day 13 to day 18 after breeding.

In an effort to determine at what stage pregnancy loss was most susceptible to stress, Einarsson and coworkers (1996) injected a number of sows with ACTH (a stress hormone) once daily for 5 days from periods of 1-5, 6-10, 11-15 and 16-20 days of gestation. Although there was not a significant effect on embryo survival, the lowest level was observed for animals injected between days 11-15 after breeding. Several other papers have suggested that day 11-15 after breeding, during the initial stages of implantation, may be the period of pregnancy most susceptible to failure.

Pigs in the Wild

When one considers that sows in the wild live almost entirely in social groups, it seems a bit odd that there is so much concern over keeping sows in groups in commercial production. There are three types of social groups among wild pigs: a boar with sows, a peri-parturient sow with her offspring, and a group of several sows with their offspring. Boars are solitary and only join a group of sows during the breeding season. A second group consists of an isolated peri-parturient sow and her litter. Separation from the primary social group lasts from a few days before farrowing until about ten days after the birth of the piglets. This group remains in close proximity to the farrowing nest and rejoins the main group as the piglets become mobile. The primary social group is called a sounder, and consists of several sows and their adolescent offspring. Sows in a sounder are likely to be closely related, probably sisters, and have lived together their entire lives with the exception of the period when they separate to give birth. Herein lies the difference between wild and commercial conditions. Wild sows never come together to form a new social group, they remain with their litter mates or other females from their mother's sounder, for their entire lives. The only time that they 'join' a new group is when their mother rejoins her sounder when they are 10 days of age, and aggression is rare. Interestingly, mixing pigs at 10 days of age results in very little aggression in commercial production as well.

The key point is not that sows in the wild live in groups, but rather that they never form new groups. In commercial production, new groups of sows are artificially formed nearly every reproductive cycle. Many species live in social groups of closely related individuals, and try to exclude any unrelated newcomers to the group. Stookey and Gonyou (1998) demonstrated that it is not lack of relatedness that results in aggression among newly mixed pigs, but lack of previous familiarity. One method to reduce the aggression that occurs when forming groups of sows is to recombine animals that were together during their last gestation. Unfortunately, complete familiarity within a group is impractical to achieve as we must bring in new gilts and incorporate sows that have changed breeding groups due to failed breedings. Complete integration of a group of unfamiliar animals into a familiar group often takes several weeks, although aggression usually subsides within a couple of days (Moore et al, 1993).

rate regardless of the system, but re-grouping in hot weather probably adds to the problem. Re-grouping in the coolest part of the day, or the use of cooling devices, should help to alleviate the problem. Aggression is often considered the reason for the loss in productivity, but again, research has failed to demonstrate this clearly. Nonetheless, managing to reduce regrouping aggression, as outlined above, should be practiced for animal welfare as well as potential production effects. The final stressor considered for reduction in embryo survival and farrowing rate is reduced feed intake. Several days of very limited intake can affect embryo survival. In competitive systems, such as floor feeding and short stalls, subordinate animals may be subject to reduce intake during the critical period of implantation. Similarly, in a heavily stocked ESF system, subordinate animals and those less familiar with the system may go several days with below optimum intake. Only the free access stall is likely to guarantee adequate nutrition for all. Therefore, re-grouping sows prior to implantation may be more detrimental in competitive and ESF systems than in free access stalls.

In summary, the critical period for loss of pregnancy appears to be 7-21 days after breeding. Re-grouping at that time may affect productivity if management is poor or average. Systems that manage heat stress, re-grouping aggression and feed intake well will probably still achieve acceptable productivity.

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Dynamic Mixing to Increase Group Size

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One of the roles we play in raising livestock is that of social managers of the animals. We decide which animals live together in a group, and when and how the group is formed. In the case of gestating sows, we decide which sows live with each other during their period of gestation. Our default social group, the one that happens if we disregard our role as managers, would be the breeding cohort. This would include all of the animals that were bred during a set period, which on most farms would be a week.

In previous articles, we have discussed the most common social management decisions, which involve sorting the cohort according to one or more of the following criteria: nutritional needs, competitiveness, or experience with the housing system (particularly ESF). The outcome of this sorting would be multiple groups, each of which is more uniform than the original breeding cohort. Another outcome is that the groups are smaller than the cohort as a whole. These groups are often managed as static groups, that is, no animals are added to a group once it has been formed.

The two main options for managing sow groups are to either keep them as a large (breeding cohort) group that includes a great deal of variation, or to form a series of small groups that are very uniform. But there is another option. Dynamic grouping involves adding animals, usually from a subsequent breeding cohort, to a previously formed group. If you simply combine two entire cohorts, you have a very large group with a great deal of variation. But if you combine animals already sorted by one of the above factors, you have a larger group of uniform sows. An example would be a group comprised of only gilts, but from two or more breeding cohorts. Dynamic social management exists in order to create larger groups of animals. However, it involves a second re-grouping event which will result in another bout of aggression. Is there an advantage to dynamic mixing?

WHY LARGER GROUPS?

There are a variety of reasons to house sows in larger groups. One of the most evident to operation managers is that sows in large groups (over 40 animals) require less space per animal than those in smaller groups. The EU recommendations are that the standard recommended space allowance should be increased 10% for groups of 6 or fewer animals, but can be decreased by 10% when group size is of 40 or above, animals. (Council Directive, 2001).

A second reason for using larger groups is related to building costs, because as pen size increases the ratio of perimeter:area decreases. What this means is that the amount of penning needed (and related costs) per sow decreases as group size increases. To house 15 sows in a square pen at 1.8 m² (19.4 sq. ft.) per sow requires a 27 m² (291 sq.ft.) pen (5.2 x 5.2 m, 17 x 17 ft) with 20.8 m of perimeter penning. To house 30 sows in a square pen at the same space allowance would require a 54 m² pen (7.4 x 7.4 m, 24 x 24 ft) with 29.6 m (97 ft) of perimeter penning. On a per sow basis, penning requirements are reduced by nearly 30%.



A third reason to house sows in larger groups is to take advantage of expensive technology. This is best illustrated by the ESF system. The major cost of this system is the feeding station which must be able to identify each sow, dispense a specific amount of feed for each sow, and keep track of which sows have fed. The technology can be used to manage individual feed with preprogrammed increases throughout gestation, to identify problem sows that are not eating regularly, to sort sows out of the group for management events (pregnancy checks, vaccinations, moving to farrowing), and even for heat detection. The system is costly, and it is to the producer's advantage to minimize the cost per sow. If your group size is 30 animals, the cost per animal will be double that for groups of 60 using the same single feeding station.

One additional reason for keeping large groups relates to the social behaviour of pigs. Pigs in small groups have a strict social linear hierarchy whereby one animal (the alpha) is dominant to all others, and a second animal is dominant to all but the alpha pig etc. Such a rigid hierarchy requires effort to establish and maintain. The system works when the benefits of being a dominant animal exceed the cost of maintaining the hierarchy. From research with growing pigs we know that an alternative system forms when the benefits of being dominant are less than the costs. In large groups, pigs become more tolerant of other animals and do not need to maintain a strict linear hierarchy reinforced by aggression (Andersen et al., 2004). The result is that pigs from large groups fight less than pigs from small groups (Samarakone and Gonyou, 2009). The benefits of being dominant in competitive sow housing systems such as floor feeding may always be greater than the costs of that status, but in non-competitive systems such as ESF and gated stalls we can expect to see social tolerance develop and reduced aggression in larger groups. ESF can be competitive in overstocked situations and pushed systems, most ESF systems now have been studied at 80 sows/feeder.

Is Dynamic Grouping all that Different?

A key concept of dynamic grouping is that a new group of sows is added to an already established group. These are often referred to as the 'unfamiliar' (or 'new'), and the 'familiar' (or 'resident') sows,

respectively. In general, aggression within the new combined group occurs between 'familiar' and 'unfamiliar' sows. Aggression among familiar animals is very low, and unfamiliar animals appear to avoid aggression as much as possible as they are the 'invaders' attempting to join the established group (Krauss and Hoy, 2011).

If we consider a static system, in which all members of a breeding cohort are grouped together on the same day, we find some similarities with a dynamic group. In a typical operation animal flow is such that over 50% of the sows in a static group are likely to have been grouped together during their previous gestation.

These are the animals which were not culled and that cycled normally after weaning. These animals will recognize each other as group mates (Arey, 1999) and are similar to the familiar sows in a dynamic system. The unfamiliar sows in a static system are the gilts, and the sows that failed to cycle normally after the last gestation (delayed estrus, or found open and rebred). Thus, in a static system we have large proportions of familiar and unfamiliar animals, similar to what we have in a dynamic system.

There are, however, some differences. The unfamiliar animals in a dynamic system include all parities in a proportion similar to that of the familiar animals. In the static system, the majority of the unfamiliar animals will be gilts which lack both size and social experience to compete for dominance. Also, in the dynamic system, re-grouping aggression will occur after each addition of new sows, at least twice during a gestation. In a static system, re-grouping aggression only occurs once during a sow's gestation.

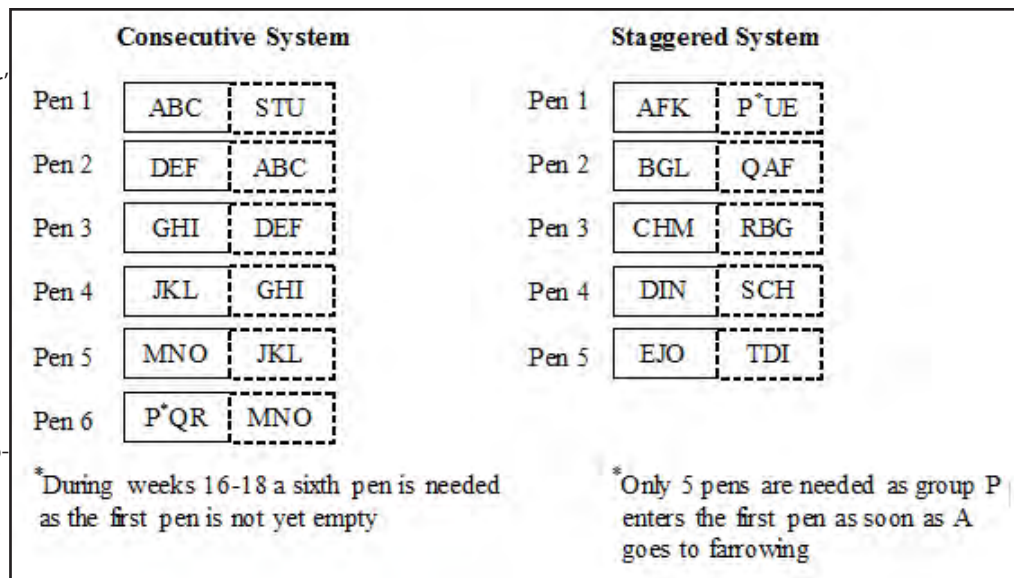


Figure 1. Dynamic mixing of breeding sows in consecutive and staggered systems. N.B. Groups A, B, C etc represent weekly breeding cohorts

We know that newly added sows in a dynamic system will try to avoid confrontation with the established group by lying in a separate area (Moore et al., 1993). In terms of management it may be helpful to section off the loafing area to the existing sows a few days before a new group is added so they can claim that space when they arrive. To ensure that there are enough new animals to act as a cohesive group it appears that the new group should be at least 20% of the resident group (O'Connell et al., 2004)

STATIC VS. DYNAMIC

Most experimental farms operate using either a static or a dynamic system for their group-housed sows, but few have made systematic comparisons between these systems. As a result, most advice is based on professional judgment, experience and common sense, not scientific data. The advantage of static groups is that there

Consecutive vs. Staggered Dynamic Groups

The most common means of dynamic grouping is by forming 'consecutive' groups. A group of sows is placed into an empty pen and more animals are added over consecutive weeks until the pen is full (see Figure 1.). The system is easy to manage and eventually all of the sows will be removed for farrowing before a new dynamic group begins to form.

An alternative to the consecutive system is a 'staggered' group. In this system, the addition of new pigs to a group is staggered, with several weeks between each entry. Between these weeks, newly bred animals are placed in other pens in the system (see Figure 1). The staggered system has two advantages related to the time of grouping and space use. Sows enter a pen after breeding but, unlike the consecutive system, no new pigs are added for several weeks allowing the initial group to be well past implantation before another round of aggression occurs. In addition, when the new sows are added, those already present are well established socially and further along in pregnancy; both of which will reduce aggression (Hemsworth et al., 2006).

In terms of space use, new sows are added to a dynamic pen within a week of the previous group being moved to farrowing. The result is that no pen sits empty, or partially filled, for an extended period of time. Another advantage is that the staggered system can operate with one fewer pens than a consecutive system.

Some studies have used staggered system with grower/finisher pigs in an attempt to reduce floor space allowance (Moore et al., 1994). The new group of pigs added every few weeks fought very little and slept by themselves in a corner of the pen. A similar 'retreat' to an unused area of the pen has been reported for new sows in a dynamic system (Moore et al., 1993). A staggered system was used at Prairie Swine Centre with sows in an ESF, and although we could not compare it directly with a consecutive system, we saw no deleterious effects of dynamic grouping on productivity (Gonyou et al., 2006) nor aggression (Strawford et al., 2008).

Dynamic Management in Non-ESF Systems

Before implementing a management system in an operation, producers should ensure that the benefits obtained will outweigh the costs. Dynamic systems result in some social costs to the animal, but we have seen that this is minimal. In the case of ESF, where large groups allow us to take advantage of electronic management, the benefits of large groups will often outweigh the costs of a dynamic management system needed to achieve those large groups. Are there advantages to large groups in other feeding systems that would justify the use of a dynamic grouping system?

The greatest benefit to large groups in non-ESF systems would be the reduced floor space per sow needed in groups of over 40 sows. The 10% reduction in space requirements would be advantageous, but there are also costs to managing these large groups. When dynamic groups are used, the resulting large group will have to be sorted for management practices such as pregnancy checking, vaccination, and moving to farrowing. Without the convenience of electronic sorting, as can be done in ESF, those procedures would be more labour intensive. The extended social instability of a dynamic system may also contribute to greater competition in an already competitive system. Although it may be possible to use dynamic grouping in floor feeding, short stall or gated stall systems, it is doubtful that the advantages in these competitive feeding systems would outweigh the disadvantages. For the most part, dynamic social grouping should be restricted to ESF systems.

is only one re-grouping event, with aggression minimized to a period of a few days. In a dynamic system there are at least two, and sometimes up to three or more re-groupings, each of which is associated with a period of aggression. However, sows enter the group as 'unfamiliar' animals only when introduced to the pen, and then become 'resident' animals for all subsequent additions. Their level of injuries is likely to be higher following their initial entry than when subsequent groups are added.

In studies in which both static and dynamic systems were compared the results show some variation. Neither Strawford et al. (2008) nor Anil et al. (2006) observed a difference in aggression between the two systems. However, Anil et al (2006) reported a difference in injury scores, with higher levels observed in dynamic groups, while Strawford et al (2008) did not. Interestingly, the difference in injury scores was not evident on the day following introduction, but rather two weeks later. This suggests that dynamic pens took longer to stabilize their social structure than did static groups. Neither research group reported differences in the stress response (cortisol levels) of sows between the two systems.

Gonyou et al., (2006) saw no difference in productivity between static and dynamic systems over a period of five gestations. It should be noted that they used a staggered dynamic system which avoided re-grouping a second time during the pre-implantation period. Nonetheless, it would appear that the relatively minor differences in aggression and/or injuries between static and dynamic systems are not significant enough to affect productivity. It should

also be noted that in all of these comparative studies total group size was confounded with social management system, with dynamic grouping associated with larger groups. Such would be the case on commercial farms as well, and so the results are still applicable to normal production management.

Dynamic grouping has some negative consequences for the sows, but these appear to be minor and can be offset by providing extra space or protective barriers as discussed in previous articles. If dynamic grouping allows producers to obtain some positive benefits for the animals, then it can be used to an advantage. The advantages of an ESF system, such as improved control over feed intake, would seem to warrant the use of dynamic grouping in smaller herds to obtain an efficient group size.

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Groups or Stalls: What Does the Science Say?

Yolande Seddon, Ph.D. and Jennifer Brown, Ph.D.

Several scientific studies and reviews have compared the welfare benefits of stall versus group housing for gestating sows (1, 2, 3). The conclusions of these studies vary because welfare assessment involves a variety of measures, and the conclusions reached will vary depending on the emphasis placed on different measures. The key measures and results of studies comparing sow welfare in stalls and groups are summarised below under the headings: sow health and performance, stress physiology, sow behaviour, and sow aggression. Evaluation of the welfare of sows must consider all and not just some of these factors, and the results show that there are advantages and disadvantages to both stall and group housing systems.

For example, a 1997 EU report on sow housing (4) indicated that managing sows in stalls has some welfare advantages, "since pigs are not mixed, fighting with associated injuries is prevented, each sow receives the full ration of food available to her, sows can all feed at the same time, care-taking is made easier and signs of morbidity, such as feed refusals or vulval discharge, are easy to detect." However, the report goes on to list several disadvantages to sow stalls, including high levels of stereotypies, unresolved aggression and inactivity, weaker bones and muscles, and reduced cardiovascular fitness. The report goes on to state that, "Some serious welfare problems for sows persist even in the best stall-housing system." On the other hand, the report lists advantages related to group housing, including increased exercise, greater control over the environment, opportunity for normal social interactions and opportunities to root or manipulate materials (4). As a consequence, group-housed sows show less abnormal bone and muscle development, less abnormal behaviour, fewer health problems associated with inactivity, and better cardiovascular fitness. However, it is widely recognized that the main disadvantage of group housing is that injuries can occur due to fighting and/or slipping on the floor. Fighting or injury can lead to embryo loss in extreme cases, and detection of health problems is more difficult in groups. The report concludes that, "an enhanced emphasis on good stockmanship and good group housing system design is necessary to prevent these adverse affects."

WELFARE ASSESSMENT

A comprehensive approach to animal welfare assessment has been described by David Fraser (5) and includes three approaches, examining measures related to: 1) health and productivity (biological function), 2) subjective experiences (affective states), and 3) the ability to express species typical behaviour (natural living). Another accepted approach is known as the 'Five



Sows in group housing

Freedoms'(6). Both of these approaches balance measures of health and productivity with other measures, including the absence of pain, distress and hunger, and the ability to perform a range of normal behaviours.

Historically, welfare assessments placed greater emphasis on health, physiology and production measures, as these are more familiar and easily measured. More recently, measures of affect (emotional state) and normal behaviour have been defined and included as an important component of welfare assessment. This is reflected in the OIE (World Organisation for Animal Health) definition of animal welfare: "Animal welfare means how an animal is coping... An animal is in a good state of welfare if it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and is not suffering from unpleasant states such as pain, fear, and distress..." (7).

These standards are used around the world to evaluate the welfare of all livestock species. In the case of stall housing for sows, the requirements related to 'freedom of movement' and 'the ability to express innate behaviour' are not met due to the restricted movement of sows in stalls, and these criteria are central to welfare arguments against the use of stalls. When studying group housing, another problem arises as there are many different forms of 'group housing.' Group housing can range in feeding and flooring systems, pen designs and grouping strategies, with some systems pointing to better welfare in terms of consistent feed access, lower aggression and increased sow comfort.



There are both advantages and disadvantages to housing sows in stalls and in groups

SOW HEALTH AND PERFORMANCE

The Scientific Committee Report for the Canadian Code of Practice on the care and handling of pigs (8) contains a summary of scientific research comparing the welfare of sows in stalls and group housing systems. Their conclusions are similar to those of the EU report (4) related to sow health and performance, and include the following:

- In general, studies report that the reproductive performance of sows in groups is equal to, or superior to that of sows in stalls, in terms of back fat, sow weight gain, farrowing rate, litter size, piglet birth weight, piglet weaning weight and the wean to oestrus interval (1, 2, 3).
- A survey of Ontario farms found an increase in the number of litters per sow per year in group housed sows compared to sows in stalls (9).
- Compared to sows in groups, sows housed in stalls have been found to have decreased muscle mass, lower bone strength and reduced physical fitness due to lack of exercise (1, 10, 11).
- Stall housed sows were found to have higher resting heart rates compared to group-housed sows. This finding is indicative of reduced fitness and cardiovascular health in stall housed sows (12).
- A field study of 32 herds (18 group housed with ESF and 18 stall housed, all with slatted or partially slatted flooring), found an overall higher prevalence of skin lesions in group-housed sows, likely due to feeding aggression. In stall housed sows, shoulder ulcers were the most common body lesion found (13); and is likely related to reduced movement in stalls. Similar results have been found in farrowing sows, where lying time was related to the incidence of shoulder lesions (14).

- Lameness occurs in both group and stall-housed sows. There has been a higher reported incidence in group housed sows (15, 16), and may be partly due to the ability to detect lameness more easily in group-housed sows. The quality of the flooring, sow genetics and nutrition play key roles in the leg health of sows.

STRESS PHYSIOLOGY

Plasma or salivary cortisol concentrations are commonly used as a measure of stress. However, the results are not always clear as both positive experiences (excitement and arousal) and negative experiences (fear and distress) can both result in increased adrenal activity and elevated cortisol levels (4).

- Zanella et al. (17) found no difference in plasma cortisol levels between group housed sows (fed with ESF) and stall housed sows.
- Pol et al. (18) found no difference in urinary cortisol levels between sows housed in stalls and sows housed in groups of six and fed with individual feeders in partial stalls.
- Group housed sows have been found to have higher levels of cortisol at mixing and throughout gestation (13, 19, 20).
- Group-housed sows have also been found to have a higher level of salivary cortisol during their first week in groups compared to stall housed sows. This difference was no longer present in late gestation, suggesting that group formation was stressful for the sows (10).

Where differences in physiological stress measures have been found, these are often due to differences in other factors such as genetics, feeding or management of the systems rather than directly attributed to the system.



Sows in an Electronic Sow Feeder (ESF) group housing system



Sows in stalls

SOW BEHAVIOUR

As noted, a central concern related to gestation stalls is the restriction it places on the movement of sows. If freedom of movement and the ability to perform normal behaviour is considered in welfare assessments, then sows in stalls will be consistently rated below group housing for these criteria, with tether housing being rated below stalls. Whether freedom of movement is important to the sow is an area debated. Another opinion is that it is more important that the sow has an outlet for behaviours she is strongly motivated to perform, such as rooting, rather than pure freedom of movement. Because of this, another important measure in assessing sow welfare is the incidence of abnormal behaviours, such as stereotypies. Stereotypies are repetitive behaviours that have no apparent function, and are used as an indicator of poor the welfare. Bar-biting, sham-chewing (or vacuum-chewing), drinker-pressing, head-weaving, repeated patterns of trough nosing and tongue-rolling are recognized stereotypies that sows perform. Stereotypies seem an inappropriate behaviour as they have no apparent function (21). Feeding motivation (hunger) is recognized as an important factor contributing to stereotypic behaviour due to the common practice of restrict feeding sows to control sow weight. Sows penned outdoors have also been observed performing repetitive stone chewing, leading some to question if these behaviours are motivated before and after feeding behaviours in sows fed a limited ration (22). Therefore, when evaluating studies on stereotypies a number of factors should be considered, including the housing system, dietary energy content, quantity of food fed and availability of manipulable material (4).

Aside from stereotypies, welfare is also assessed by the sows' response to different stimuli. In this case, reduced welfare is identified in individuals that are abnormally inactive, or unreactive to stimuli which would normally elicit a reaction. Behavioural research related to stalls and groups is summarised below.

- Observing the daily activity budgets of sows, stereotypic behaviour was lower in group housed sows with straw bedding, than in unbedded stall housed sows: Sows in small groups performed stereotypies 8% of the day, sows in larger ESF groups 4% of the time, and sows in stalls 50% of the time (23). All sows in this study were fed the same diet.
- Comparing stall and group housed sows on commercial farms, the proportion of sows showing stereotypies was found to be significantly lower in group housed sows than stall housed sows (21).
- Comparing behaviour of gestating sows kept in stalls, trickle fed groups or larger ESF groups, all unbedded and fed the same diet, stereotypic behaviour was observed in all groups, particularly after feeding. However, the frequency of sham chewing was significantly lower in grouped sows than in stalled sows (16).
- Comparing stall and group housed sows fed the same ration, sham-chewing behaviour was found to increase as the length of time confined to stalls increased, but this was not seen for group housed sows bedded on straw (23).
- Broom (24) measured the responsiveness of group and stall housed sows to food and novel stimuli. Sows that were housed in groups were found to be more responsive to novel stimuli than those housed in stalls.
- Harris et al. (25) found no difference in behavioural time budgets (time spent lying, eating, drinking sitting) between gilts housed in stalls and small un-bedded groups.
- Sows housed in stalls long-term took significantly longer to lie down than group-housed sows (11). The authors concluded that sows housed long-term in gestation stalls had difficulty of movement when lying down.

SOW AGGRESSION

Introduction of unfamiliar sows into groups typically results in aggressive interactions while sows establish a dominance hierarchy. In group housing, sows can cause considerable injuries to one another when they fight, and the welfare of sows will be reduced if they experience fear, injury or pain (4). However,



Sows in groups with drop or floor feeding

the amount of aggression experienced by sows in groups at mixing varies greatly depending on the management of groups. Aggression can be controlled by previous experience (eg by previous mixing of gilts, or housing sows in large groups) and through the provision of sufficient pen space and hide areas, or manipulable materials. Significant aggressive behaviour is also observed between stall-housed sows, and although it rarely results in injury it can result in frustration due to unresolved aggression. When comparing aggressive behaviour between group and stall-housed sows:

- Several studies have shown increased lesions in group housed sows following mixing (10, 18, 20, 25). The study by Harris et al. (25) showed more skin lesions in group-housed gilts than stall-housed gilts from 3 to 13 weeks after breeding.
- Jansen et al. (20) reported no difference in the number of agonistic interactions (fights and non-reciprocated attacks) between stall-housed sows in the two days after relocation beside new neighbours and group-housed sows mixed with unfamiliar sows.
- Broom et al. (23) found the proportion of agonistic interactions which resulted in aggression were greater in stall-housed sows than in sows housed in groups.
- The aggression observed between stall housed sows is believed to be due to the fact that, unlike a group situation, the stall prevents the aggressive interaction being resolved, and also prevents sows from performing submissive or avoidance behaviour. While little injury occurs to stall housed sows as a result, sows are likely to feel fear and frustration (4).

SUMMARY

Clearly, there are both advantages and disadvantages to housing sows in stalls and in groups. The main advantages of stalls relate to their ability to provide individual nutrition and care to sows, and the elimination of injuries associated with aggression at mixing. However, due to the restriction of sow activity in stalls, freedom of movement and the ability to perform a variety of behaviours are extremely limited. The advantages of group housing are that sows have the opportunity to perform a broader range of behaviours and thus receive more exercise, with a range of associated health benefits. The main drawbacks of group systems are the increased incidence of sow injuries related to mixing aggression and competition at feeding which can result in uneven feed distribution. Many of the concerns related to group housing (such as aggression and injury) can be resolved with good system design and stockmanship.

If freedom of movement and the ability to perform a range of behaviours are considered important aspects of sow welfare, as outlined in the OIE definition (7), the overall conclusion is that better welfare can be achieved when sows are not confined to stalls. However, it must be noted that in order to realize the benefits of group housing, only systems resulting in minimal aggression or injury should be used. This can be achieved when sows are fed using systems that ensure each individual can obtain sufficient food without being displaced. Providing opportunities to escape or avoid aggression, such as generous space allowances or well designed partitions, are also important, especially when sows are newly introduced to a group.



Sows approaching herdsman in free access housing

The main advantages of stalls relate to their ability to provide individual nutrition and care to sows, and the elimination of injuries associated with aggression at mixing.



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The advantages of group housing are that sows have the opportunity to perform a broader range of behaviours and thus receive more exercise, with a range of associated health benefits.

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