



MIXING SOWS - HOW TO MAXIMISE WELFARE

GROUP HOUSING STRATEGIES FOR MIXING SOWS
POST-WEANING OR POST-INSEMINATION

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EXECUTIVE SUMMARY

- Recommended minimum floor space allowance for group housed dry sows in the Australian Model Code is 1.4m² per sow.
- Current Australian research indicates that the minimum space allowance for group housed sows is likely to be somewhere between 1.8 and 2.4 m² per sow.
- Sows adapt and may get used to reduced space during later stages of pregnancy.
- Final recommendations for the space allowance for optimum welfare and productivity of group housed sows at various stages of gestation should be available later in 2014.
- Physical and visual barriers within pens of large groups of sows allow sows to avoid each other and escape aggressive sows.
- Space allowance has a much greater impact on the welfare or reproductive performance of sows than the number of sows in a group.
- Sows should receive average daily intakes that maintain targeted body condition.
- Commercial feeding levels of a dry sow diet are often about 2.3 kg/day in summer and slightly higher, at an average of 2.5 kg/day, in winter.
- Higher feeding levels immediately after mixing and through to day 28 of gestation will minimise the risk of less dominant sows receiving less nutrition, as well as reduce aggression.
- Although some fibre ingredients may be expensive, costs can be reduced by only including them in dry sow diets at critical times such as when mixing sows into groups.
- Further R&D should define any welfare advantages (fullness and enrichment) of providing foraging materials that can be effectively used with existing Australian effluent systems.
- Feed should be spread widely to allow greater access by timid sows.
- Multiple feed drops, every 30 to 60 minutes, may reduce aggression at feeding time.
- Full body length feeding stalls are preferred to shoulder stalls or half stalls.
- Ensure sufficient ESFs for the number of sows in the pen to minimise aggression during entry to the ESF.
- Dynamic groups should not experience more welfare issues than static groups, provided only a small proportion of sows enter and are removed from the group at each change.
- Try to keep the majority of sows in the same group from one pregnancy to the next.
- Match sows into groups, based upon parity and size.
- Skills, experience and knowledge required by stockpeople is different and likely to be much greater when managing sows in groups than in individual sow stall systems.

INTRODUCTION

INDIVIDUAL HOUSING OF SOWS IN GESTATION STALLS HAS BEEN USED FOR MANY YEARS IN COMMERCIAL PORK PRODUCTION TO ENSURE THE SOW CAN BE FED AND TREATED INDIVIDUALLY DURING PREGNANCY.

Commercial production actually moved away from group housing to sow stalls to improve sow welfare and ensure that sows could be given individual treatment. For the past 30 years the Australian pig industry has investigated sow housing, with increasing emphasis on the welfare of sows in stalls. In 2010 the Australian pork industry, in a landmark decision for an agricultural industry, agreed to voluntarily phase out gestation stalls for sows by 2017. Gestation-stall free pork production was defined by an expert group of producers and researchers as sows being loose-housed i.e. sows are able to get up and down and turn around from five days after insemination/mating until being moved into the farrowing housing.

Since this stance for voluntary removal of sow stalls post-insemination by the Australian pork industry, there has been added pressure from retailers to further reduce the time spent in sow stalls. Many of the pork producers supplying these retailers have transitioned to loose-housing for all sows from weaning, through insemination and on entry to the farrowing facility for the subsequent farrowing and lactation period.

Implementing loose or group housing for sows at any stage post-weaning is challenging, as adequate sow nutrition, optimum welfare, minimal stress and aggression between sows and maintenance of productivity must be ensured.

This publication discusses the major factors of sow group housing, both post-weaning and post-insemination, that may impact on the sow and her welfare. From this discussion, the key characteristics of housing sows in groups are presented, along with guidelines on how sows may be weaned into groups after weaning and post-insemination, with special attention to mixing strategies during these periods, to ensure optimum sow welfare.



1.0 FACTORS AFFECTING THE WELFARE OF SOWS IN GROUPS

OF THE MANY FACTORS WHICH CAN AFFECT THE AGGRESSION, INJURIES AND STRESS OF GROUP-HOUSED SOWS, MOST CAN BE CONTROLLED OR INFLUENCED BY THE PRODUCER OR STOCKPERSON.

Several of these factors are more critical at mixing and for a short period after the sows are mixed, regardless of when they are mixed. These aspects are explored more fully in later sections of this publication.

1.1 Pen space allowance

Research by several research groups indicates that floor space allowance has important implications for sow welfare and productivity. But these recommendations often differ, which can be confusing. The current recommended minimum floor space allowance for gestating sows in the Australian Model Code of Welfare for pigs is 1.4m² per sow for dry sows housed in groups. European researchers however, suggest that sows require at least 2.25 m² per sow. Many Australian pork producers have adopted a space allowance greater than 2.0 m² per sow for their dry sows. Research has shown that 1.4m² per sow is not enough from an animal welfare perspective, as well as negatively affecting the reproductive performance of the sows.

Recent research funded by Australian Pork Limited is the most substantial research in this area. In a study by Paul Hemsworth and the Animal Welfare Science Centre (AWSC) involving 3,120 mated sows, increasing floor space from 1.4 m² per sow to 1.8 m² per sow reduced stress and aggression.

However, increases from 1.8 m² per sow to 3.0 m² per sow showed a less clear relationship, suggesting that the optimal space allowance may be somewhere between 1.8 and 2.4 m² per sow. Currently, with Pork CRC support, this research group is examining these space allowances more intensively and by late 2014 will have more information to identify the required space allowance to optimise the welfare and productivity of group housed dry sows.

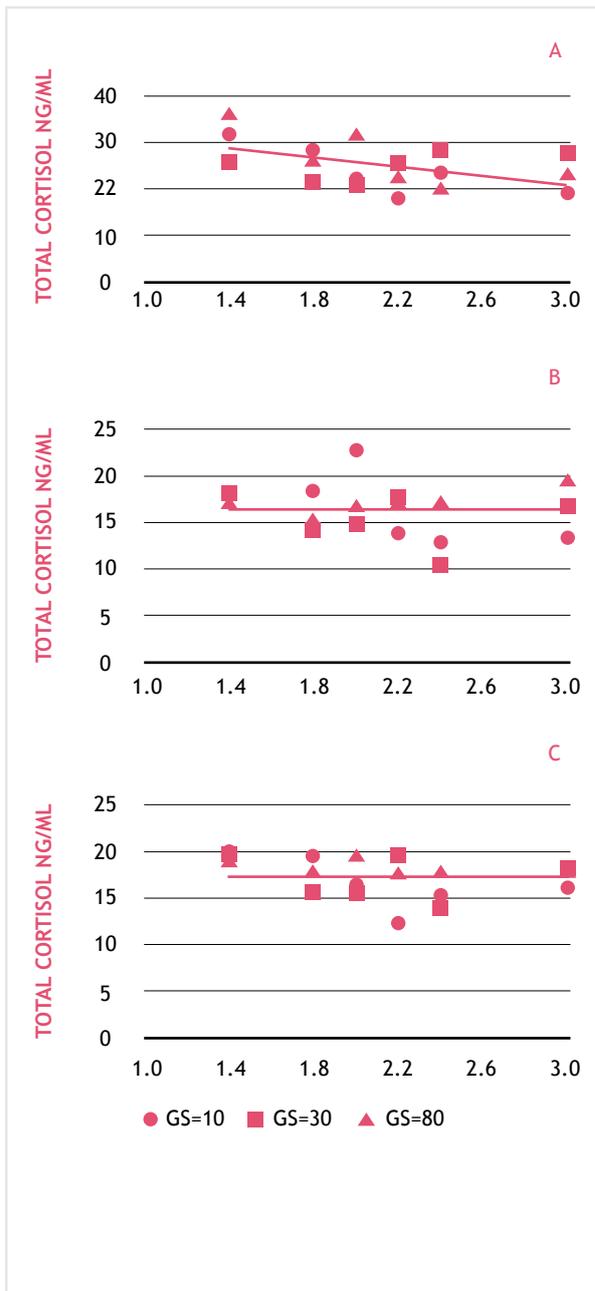
One important finding from much of this recent research is that sows adapt over time to group housing and may have a reduced requirement for space during later periods of gestation. Although sow aggression and stress (indicated by cortisol levels) at day two after mixing dropped with increasing space allowance in the earlier APL funded project, there was no evidence that space allowance affected aggression at day eight or stress levels at days nine and 51 of the experiment (Figure 1).

One interpretation of this space allowance effect early after grouping is that sows may adapt over time to reduced space. Without a doubt, there is a need to examine the effects of increasing space at grouping and reducing space during later stages of gestation because this may offer the opportunity for 'staged-gestation penning'.

TAKE HOME MESSAGES:

- Recommended minimum floor space allowance for group housed dry sows in the Australian Model Code is 1.4m² per sow.
- Current Australian research indicates that the minimum space allowance for group housed sows is likely to be somewhere between 1.8 and 2.4 m² per sow.
- Sows adapt and may get used to reduced space during later stages of pregnancy.
- Final recommendations for the space allowance for optimum welfare and productivity of group housed sows at various stages of gestation should be available later in 2014.

FIGURE 1. Predicted values of total cortisol concentrations as affected by floor space allowance, at three group sizes, on: A) day two; B) day nine; and C) day 51. (Hemsworth et al., 2013).



1.2 Pen barriers

Not only is the amount of floor space important in loose-housed sows, but the quality (set-up, including physical and visual barriers) of that space may also affect aggression by allowing sows to avoid and escape other sows. These factors seem to be particularly critical soon after mixing, and it may be that pen barriers that provide escape areas and easier access to feed and water may allow lower space allowances to be used immediately after mixing. Even in later gestation, correct set-up of barriers in pens with large group sizes will minimise aggressive encounters between sows and promote better dunging habits, keeping dry sow pens cleaner and drier. Denmark researchers are presently examining several configurations of barriers in group pens of 50-60 sows.

TAKE HOME MESSAGE:

- Physical and visual barriers within pens of large groups of sows allow sows to avoid each other and escape aggressive sows.



1.3 Group size

Most recent research shows that group size has much less effect on welfare and productivity than space allowance. Aggression will increase as a function of group size because the natural grouping of sows in the wild is relatively small and thus dominance groupings are easily formed. In large groups, where individual recognition is less likely, animals may use different strategies to create social groupings. It is possible that larger numbers of animals provide more shelter for targeted sows, allowing them to hide behind others or escape into the group. Additionally, sows may also form sub-groups in which social groupings may develop. Certainly sub-groups have been observed in groups of 40 sows, at least in terms of lying behaviour.

Hemsworth et al. (2013) reported no significant effects of group size on sow aggression, stress and fertility, within the group size range of 10-80 sows. These observations support an earlier Australian study that found behavioural, lesion and reproductive data showed little effect of group size from five to 40 sows (Table 1). Other factors, such as flooring and competition for feed, or access to feeding areas, may have a greater impact on aggression, injuries, stress and reproduction than group size.

TABLE 1: Effect of group size during gestation on performance and welfare of sows (Taylor et al., 1997).

Number of sows in the group	5	10	20	40
Aggressive interactions (no./sow/hr)				
Day 1	1.2	1.5	1.2	1.5
Day 2, first hour after feeding	1.4	1.6	1.4	0.9
Total injuries	32	41	35	40
Farrowing rate (%)	90	94	90	94
Litter size (total born)	11.0	11.0	10.9	10.9

TAKE HOME MESSAGE:

- Space allowance has a much greater impact on the welfare or reproductive performance of sows than the number of sows in a group.



1.4 Feeding level

Individual feed intake of gilts and sows to meet their nutrient requirements during pregnancy should be not less than about 2.2 kg/day for gilts and 2.5 kg/day for sows. While these levels are enough to satisfy the sow's nutrient requirements, they probably don't completely satisfy her, which, in turn, increases competition in group-housed sows for feed or access to feeding areas.

Significantly increasing feeding above these levels during extended periods of gestation may improve a sow's satiety or 'fullness' and decrease stress, particularly at feeding times, but it will also cause excessive fatness in sows and other possible welfare issues. So, there is little justification to markedly increase the feeding levels of sows during pregnancy. However, there may be critical times when mixing groups that short term increased feed intake will positively impact sow welfare and productivity.

Recent Pork CRC research suggests higher feeding levels from mixing to day 28 of gestation do not adversely affect reproduction and there is increasing commercial and experimental evidence that higher feeding levels (2.7 kg/day) during this period improves reproductive performance, particularly in younger sows. In a retrospective study at Rivalea, Sawyer et al. (2013) observed in their ESF system, that sows which ate more in early gestation had a higher farrowing rate. Later in a more controlled study, Athorn et al. (2013) reported that an increase in weight gain between insemination and day 28, led to a significant improvement in farrowing rate and also tended to improve subsequent litter size in early parity sows (Table 2).

TABLE 2. Effect of weight gain from day 2 to 28 of gestation on reproductive performance in parity 1 and 2 sows (Athorn et al., 2013).

Average daily gain between day 2 to 28	Low	Intermediate	High
Farrowing rate (%)	92 ^b	97 ^a	98 ^a
Litter size (TBA)	11.1	11.3	11.6

a,b within rows, means that have different superscripts are significantly different (P<0.05)

There is also commercial evidence suggesting higher feeding levels immediately after mixing reduces aggression in group housed sows. In one situation, increasing feeding level to 4.0 kg feed/day for the first four days after mixing for sows housed in groups with 1.8 m² floor space, was suggested to reduce aggression and to have minimal impact on overall feed costs. Higher fibre diets and materials offered liberally in the first four to five days after mixing has also been shown to reduce aggression in sows grouped at weaning in commercial situations. Pork CRC will do further R&D in 2014 on the effects of feed level and feed type after mixing on the welfare and reproductive performance of sows.

TAKE HOME MESSAGE:

- Sows should receive average daily intakes that maintain targeted body condition.
- Commercial feeding levels of a dry sow diet are often about 2.3 kg/day in summer and slightly higher, at an average of 2.5 kg/day, in winter.
- Higher feeding levels immediately after mixing and through to day 28 of gestation will minimise the risk of less dominant sows receiving less nutrition, as well as reduce aggression.

1.5 Fibre ingredients in dry sow diets

Including diet ingredients that induce fullness and reduce aggression, particularly during feeding, has been investigated as a possible strategy in the nutritional management of sows during pregnancy. Increasing fibre content in a sow diet prolongs feeding time and gut fill, which, in turn, may increase fullness and consequently reduce feeding motivation.

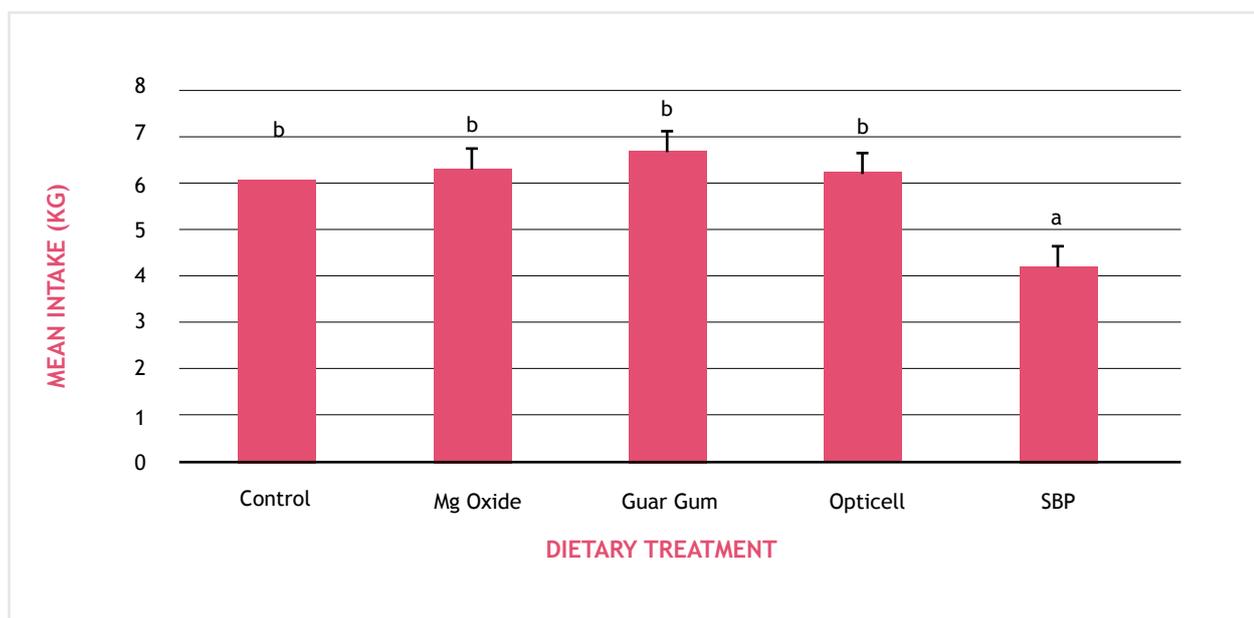
Research outcomes on the impact of a high fibre diet on feeding motivation at first glance seem to differ, but often the response depends on the type of fibre ingredient in the dry sow diet. Highly fermentable fibre ingredients, such as sugar beet pulp and guar gum, which have a high water holding capacity, could have positive effects on fullness and aggression in group housed sows. Results of a recent Pork CRC study by Tracy Muller showed that including sugar beet pulp, but not guar gum, increased meal time and reduced voluntary feed intake (Figure 2).

Many dry sow diets in Europe contain at least 10 per cent sugar beet pulp, where it is a relatively inexpensive feed ingredient. These types of ingredients appear to stabilise glucose and insulin levels and reduce physical activity in restrictively-fed sows several hours after feeding, possibly indicating a prolonged feeling of fullness. These dietary ingredients that promote fullness in pregnant sows are often quite expensive in Australia, but may be beneficial and commercially viable if used short term during the critical time of mixing sows into groups.

TAKE HOME MESSAGE:

- Although some fibre ingredients may be expensive, costs can be reduced by only including them in dry sow diets at critical times such as when mixing sows into groups.

FIGURE 2. Mean voluntary feed intake (kg/d) of sows offered a frequent feeding regime fed a control diet or a diet containing 0.5% Guar gum, 4 % Opticell®, 0.1 % Magnesium oxide (MgO) or 20 % Sugarbeet pulp (SBP).



1.6 Foraging material in gestation pens

There is evidence that providing additional fibre, as part of the diet or as foraging materials such as straw in the pen, reduces feeding motivation. Overseas studies indicate that high levels of chain and bar chewing in restrictively-fed sows can be prevented by providing straw, which acts as a foraging substrate. Giving access to a foraging substrate may have additional welfare benefits by making the environment more interesting and providing an outlet for exploratory behaviour. It has been suggested that a small quantity of straw or other foraging material may help keep sows otherwise occupied at mixing, thereby reducing aggression. One interesting innovation in Denmark is supply of grass silage in feed racks to dry sows. The benefit of silage over straw is that much of the material is consumed by the sows, with less being wasted through the slats and causing issues with the effluent systems.

TAKE HOME MESSAGE:

- Further R&D should define any welfare advantages (fullness and enrichment) of providing foraging materials that can be effectively used with existing Australian effluent systems.

1.7 Feeding system

Floor feeding:

Drop feeding, where feed is dropped onto the floor from an automatic feeder or manually, is one of the simplest and cheapest methods of feed delivery. Feed drops are usually spread to cover approximately six to eight sows per feeder, which often leads to timid sows being underfed and exhibiting low weight gain. Increasing the feed drop area can minimise aggression and allow greater feed access for timid sows. Also, multiple daily feed drops reduce injuries and structural problems with feet and legs in group-housed dry sows. Studies of feeding intervals and time of day of feeding indicate that several feed drops, up to an hour apart, most successfully reduce aggression (Table 3).

TABLE 3. Effect of feeding frequency on the welfare of sows in gestation (Schneider et al., 2007).

Frequency of feeding per day	2	6
Skin lesions ¹	1.51 ^b	1.34 ^a
Vulval lesions ¹	1.08 ^b	1.03 ^a
Feet and leg soundness ²	1.21 ^b	1.12 ^a

1 on a scale of 1 to 4

2 on a scale of 1 to 3

a,b within rows, means that have different superscripts are significantly different.

TAKE HOME MESSAGE:

- Feed should be spread widely to allow greater access by timid sows.
- Multiple feed drops, every 30 to 60 minutes, may reduce aggression at feeding time.

Feeding stalls:

While floor feeding is competitive, feeding stalls may also lead to competition between group-housed sows. For instance, in feeding stalls without back gates, aggression often occurs during feeding periods. However, compared to floor feeding, having feeding stalls, particularly full body length stalls, reduces aggression, skin injuries and stress levels in the long term in group-housed pregnant sows.

TAKE HOME MESSAGE:

- Full body length feeding stalls are preferred to shoulder stalls or half stalls.

Electronic sow feeding (ESF) systems:

Sows in most ESF systems are protected from aggression at feeding. However, aggression may still occur in ESF systems, particularly during entry to the feeding station during queuing if there are too many sows to each feeder, or if the ESF is not operating effectively.

TAKE HOME MESSAGE:

- Ensure sufficient ESFs for the number of sows in the pen to minimise aggression during entry to the ESF.

1.8 Static and dynamic groups

Groups of sows can be managed as a static group, in which the group remains the same throughout pregnancy, or a dynamic group, in which sows are regularly removed from or introduced to the group. Static groups are mostly formed after weaning or mating, so that unfamiliar sows are mixed only once. On the other hand, unfamiliar sows in dynamic systems are frequently introduced to the group during pregnancy.

Some researchers suggest that problems with aggression may be greater in dynamic groups of sows. Most recently, Li and Gonyou (2013) reported that while reproductive performance was unaffected, sow welfare in dynamic groups (in which about 30 per cent sows were replaced at a time) appeared to be not as good as sow welfare in static groups (Table 4). There is little definitive proof, hence further R&D should compare sow welfare in the two systems.

TABLE 4: Effect of static or dynamic groups on the welfare of pregnant sows housed in an electronic sow feeding system (Li and Gonyou, 2013).

Group system	Static	Dynamic
Lame sows (%)	1.6 ^a	5.4 ^b
Injury Scores before farrowing	5.7 ^a	6.2 ^b

a,b within rows, means that have different superscripts are significantly different

It is suggested that introducing sows into dynamic groups is limited each time to between 15 and 25 per cent of the group, so that they can be more easily integrated into the larger group. For example, if the group size is 80 sows, then only about 10-20 sows should be introduced to this group at a time to replace the 10-20 sows removed at the end of gestation to enter the farrowing shed.

TAKE HOME MESSAGE:

- Dynamic groups should not experience more welfare issues than static groups, provided only a small proportion of sows enter and are removed from the group at each change.

1.9 Sow familiarity

Familiarity may affect aggression at mixing. Many studies have demonstrated lower levels of aggression in sows familiar with each other, with fights among sows housed together up to six weeks earlier being less frequent. So, mixing sows or a proportion of sows that have been housed together in the previous gestation may reduce aggression at weaning or post-insemination. This may be a viable option to reduce aggression in sows on a farm where most sows tend to remain with their mates.

TAKE HOME MESSAGE:

- Try to keep the majority of sows in the same group from one pregnancy to the next.

1.10 Sow size/parity

Surprisingly, there has been little research on the effects of mixing parity or live weight of sows on sow welfare. USA research has clearly demonstrated welfare and reproduction advantages for parity 1 sows grouped with gilts, compared to those grouped with older parity sows during gestation. Parity 1 sows were either housed with older sows or with gilts between weaning and farrowing and the main results are shown in Table 5. It is suggested that sows are mixed within parity groups and/or of similar weight ranges to make management easier as well as maintain reproductive performance.

TABLE 5: Effects of housing parity 1 sows with older sows or gilts during gestation on the farrowing rate of all sows and the weight gain and injury scores of parity 1 sows (Li et al., 2012).

Treatment	Housed with older sows	Housed with gilts	Significance
Farrowing rate (%)			
All sows	83	88	0.40
Older sows	88	-	-
Gilts	-	85	-
Parity 1 sows	67	94	0.03
P1 Weight gain (kg)	36	59	0.01
P1 Injury scores	12.6	8.0	0.03

TAKE HOME MESSAGE:

- Match sows into groups, based upon parity and size.

1.11 Stockmanship

The move towards group housing of sows requires increased skills and knowledge by stockpeople in observing and managing individual animals in group housing systems. The stockperson may be the most influential factor affecting animal handling, welfare and productivity, particularly where sows are housed in groups. While welfare monitoring schemes are likely to improve animal welfare, the impact of such schemes will only be realised by providing specific stockperson training to target key aspects of stockmanship.

TAKE HOME MESSAGE:

- Skills, experience and knowledge required by stockpeople is different and likely to be much greater when managing sows in groups than in individual sow stall systems.

2.0 WHEN CAN WE MIX SOWS AND WHAT ARE THE CHARACTERISTICS OF THE 'MIXING PEN'?

2.1 Time of mixing

Sows are usually mixed into groups at weaning or within about five days after insemination.

Mixed at weaning:

Housing after weaning is an important period for sow welfare and reproductive performance. Some issues are similar to those for sows grouped after insemination, such as aggression associated with grouping unfamiliar sows and pen design, floor space and feeding system. Other issues may be specific to this period, such as the consequences of housing at time of insemination, on stress and potential injuries arising from sows on heat.

Increased floor space and a non-slip floor, and the option of individually housing sows during the period in which they display oestrus, may help reduce stress and minimise injury to sows through courtship and mounting.

Mixed within about five days after insemination:

The low confinement dry housing of sows was defined by Australian Pork Limited as sows being loose-housed from five days after insemination. Mixing sows about five days after insemination avoids two critical periods, firstly, the period immediately after mating and secondly, during the second and third weeks of gestation when pregnancy is established i.e. during embryo implantation.

2.2 Characteristics of the mixing pen

Several authors have supported the use of dedicated mixing pens containing features that minimise sow aggression or the consequences of aggression on injury and stress. Although there has been little research on the topic, there is sufficient information from the literature, together with industry observations, to identify the main attributes of a mixing pen. As mentioned, sows adapt to grouping/mixing relatively quickly and sows may only need to be housed in a mixing pen for a relatively short period.

A major challenge when housing pigs of any age in groups is aggression. Pigs will fight especially when mixed and competing for access for feed and it is the persistent aggression that reduces pig welfare, mainly through increased stress and injury and restricted access to feed and preferred lying areas. The challenge is to minimise the time and impact of these aggressive confrontations. Aggression is often reported to peak about two hours after mixing and decreases significantly thereafter as a dominance grouping is formed. Aggression has been reported to reach lowest levels within one to two days post-mixing. The rate of decline of aggression is likely to be affected by access to resources such as space, feed, water and lying area. The dominance grouping functions to reduce the need for aggression and injury. Formation of the dominance grouping is an important system that controls aggression where there are limited resources, such as space and feed.



The overall aim when mixing sows should be to introduce the sows in a setting in which timid sows can avoid aggressive ones when they want to, with minimal risk of injury and stress, while also allowing the social grouping to quickly form. Common suggestions from published research, together with stockpeople's observations, are that the following attributes of mixing pens may reduce aggression among sows:

- Straw or rice hulls may provide a distraction. Straw or rice hulls also allows a good foothold when fighting or fleeing.
 - Easy access to feed.
 - Absence of protruding objects or ridge edges.
 - Absence of tightly confined areas in which a sow could be cornered and unable to escape an aggressive sow.
 - Adequate space for sows to turn around and for two sows to easily pass side by side in all places.
 - Providing feed *ad libitum* on the basis that restrictively-fed pigs may prefer to feed than fight.
 - Use of a solid visual barrier, while not affecting the frequency of fights after mixing, has been shown to reduce frequency of aggressive interactions.
- If a mixing pen is a viable option in commercial piggeries, they may be used for about six to seven days after grouping, particularly if grouping occurs at weaning. Within this period, the social grouping should be established and there will be less aggressive interactions between the sows within each group after this time. Based upon published research results, together with industry experiences, the key features of the mixing pens appear to include:
- Liberal space allowance with at least about 4.0 m² per sow space allowance.
 - Establish the group based upon size and parity.
 - Liberal feeding levels to ensure all sows receive adequate nutrients. Feeding levels of four to five kg/sow/day are acceptable for the first few days after mixing.
 - Ensure sows enter the pen after being fully fed during lactation prior to being mixed at weaning.
 - Visual barriers are also recommended so that sows can avoid the more aggressive sows. Barriers must be at least four to five metres away from the side walls of the pen.
 - Bedding with straw, rice hulls to provide a distraction and better foothold for the sows.
 - Including highly fermentable fibre such as sugar beet pulp in the diet during this period.

CONCLUSIONS

WHILE GROUP HOUSING PROVIDES SOME OBVIOUS WELFARE ADVANTAGES FOR SOWS, SUCH AS MORE FREEDOM OF MOVEMENT, EXPLORATION AND SOCIALISATION, SOME ANIMALS MAY SUFFER FROM EXCESSIVE AGGRESSION, STRESS AND INJURIES.

Unfamiliar sows will generally fight when mixed but this is necessary to establish a dominance grouping.

Many factors impact sow welfare in group-housed sows, with the greatest influence appearing to be space allowance. Pigs require physical space to stretch and exercise. In addition to space requirements for physical size and basic movement, pigs need access to key resources, such as feed, water and lying space. They are also motivated to interact with other sows and to explore. So, they need space not only to access resources but also, if necessary, to distance themselves from other sows at critical times. Optimising factors such as floor space and other design features, including barriers within the pen, plus providing access to important resources such as feed, water and a lying area, appear to be important in reducing aggression and stress at mixing and beyond. Further research is being conducted through Pork CRC to examine the effects of space allowance between 1.8 m²/sow and 2.4 m²/sow to determine recommendations for the optimum space allowance at different stages of gestation. The effect of space on welfare and stress is more obvious early after grouping and sows may have a reduced requirement for space during later periods of gestation.

Since the period immediately post-mixing has the most pronounced effects on aggression and stress, well-designed mixing pens offer the opportunity to reduce aggression, injury and stress, while allowing the social grouping to quickly form before animals are moved to perhaps a less extensive group housing system for the remainder of gestation. The desired features of a mixing pen have been presented, together with ways that sows may be managed during the relatively short period that they are housed within this type of pen. Further research is required to examine the effects of increased space in a mixing pen, the design and duration of housing in the mixing pen, as well as the feeding system that may be implemented during this time.

There are additional challenges when mixing sows at weaning, compared to mixing sows within five days after insemination. So, a better understanding of mixing pen design, including flooring and protection of oestrous sows from mounting by others, as well as strategies such as those mentioned above (dietary and environmental manipulations), are important in minimising injury, stress and reproductive failure in these sows.

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