Introduction

During recent decades, there has been a debate about whether farrowing sows need access to nest-building material and space to be able to perform nest building. Studies on the natural behaviour of sows, as well as on physiology, have shown that sows do have a strong motivation for nest building before farrowing and that this to a large extent is internally regulated (for a review, see Algers and Uvnäs-Moberg, 2007). A recent report from EFSA (2007a) concluded that:

- Housing of sows in farrowing crates severely restricts their freedom of movement which increases the risk of frustration. It does not allow them, for instance, to select a nest site, to show normal nest-building behaviour, to leave the nest site for eliminative behaviour or to select pen areas with a cool floor for thermoregulation.
- Sows’ nest-building behaviour is triggered by internal hormonal factors. Thus, the motivation for nest building is high in spite of if housing conditions allow for nest building or not. As a consequence, lack of nesting material is very likely to cause stress and impaired welfare.
- The level of piglet welfare and mortality on farms remains a major problem. Great variation in piglet mortality in different systems makes it difficult to draw a general conclusion about the influence of the farrowing systems on piglet mortality.
- Piglet mortality is a multi-factorial issue. The causes of piglet mortality may differ significantly between the different farrowing systems. The primary cause of piglet mortality is often unknown; however mortality due to crushing has been reported to be higher in loose housing systems.
- In a recent large-scale study on indoor loose farrowing and crate systems, no difference in total piglet mortality was observed.
- Risk Assessment of poor welfare ranked frustration and stress due to insufficient space and due to lack of foraging and nest-building material (sows in farrowing crates and pens which are too small) as major risk factors for farrowing sows.

The purpose of this section is to describe some housing systems that are in line with the conclusions stated above and also how recent national regulations highlight some of these aspects, using Sweden as an example, but also to describe some housing systems for fatteners in relation to their need for straw and social stability.
Changes in Regulations
Since 2007, new regulations on the keeping of farrowing sows apply in Sweden. These new regulations emphasise the importance of the sow being able to perform nest-building behaviour and have access to straw (Swedish regulations DFS 2007:5 (L100), Chapter 3):

§3 ‘A nursing sow’s freedom of movement may be confined during the first days after farrowing by the use of a gate or similar construction if she shows aggressive or abnormal behaviour which forms a threat to injure her piglets. A gate or corresponding equipment may also be used during management procedures if the behaviour of the sow poses a threat of injury to staff or during handling of the sow for care and treatment. Group-housed sows and gilts may be confined in stanchions at feeding or when handled for care and treatment’ (author’s translation).

§8 ‘During the week before farrowing sows and gilts must have access to litter which allows them to carry out nest building behaviour’ (author’s translation).

§10 ‘At least ¾ of the lying area in a pen with litter for a nursing sow must be flooring which is not drained. This part of the lying area must be a homogeneous rectangular area covering the whole width of the pen. The other part of the lying area may be a drained floor with a slot width of maximum 11 mm and a slat width of minimum 11 mm. If the drained floor is made of concrete, the slat width should be minimum 80 mm’ (author’s translation).

§19 ‘Minimum area for farrowing pen: Lying area 4 m², total area 6 m²’.

Recent Trends in Piglet Production in Sweden
Today, farmers commonly choose to use drained flooring on 25% of the lying area, often made from cast iron, which is considered to have the advantages of a more stable surface, which the sow is more willing to tread on, and which is easier to clean. The disadvantage is that it is more abrasive to the piglets’ feet and front knees. Recent and ongoing studies suggest that by the use of large quantities of straw, these disadvantages can be limited. Common problems facing the pig producer today are piglet mortality, feet and leg injuries in piglets and their consequences, as well as shoulder lesions in sows.

In piglet production, piglet mortality decreased between 1993-2000 but has since increased (PigWin, 2008) (Figure 45.1). The introduction of sow crating on some farms has not positively affected piglet mortality.

There is considerable variation between farms in production records (PigWin, 2008), showing a potential for improvements through the introduction of better housing and management (Table 45.1).

Housing Systems
Below, some housing systems that comply with the biology of sows in the sense that they allow for group living, nest building and manipulation of nest material are described.
Group Housing of Dry Sows

In group housing conditions, sows form a strong hierarchy within the group. This is especially seen during feeding, when less dominant sows will give way to dominant individuals. Dry sows are typically fed a relatively small amount of a concentrate diet in one or two daily meals. This has influenced the design of group housing facilities where use of individual feeding stalls is recommended to reduce aggression. Several different group housing systems exist.

a) Group Housing with Individual Feeding Stalls

Individual feeding stalls confine the sows temporarily during feeding, preventing dominant individuals chasing off less dominant sows in order to get access to extra feed rations. Feeding stalls are slightly smaller than ordinary stalls, 0.4-0.5 x 1.9-2.0 m. The gate closing behind the sow can either be operated by the sow herself or by working staff. The feeding stalls are often combined with communal lying (solid floor with limited use of bedding material) and dunging areas (slatted flooring). Design varies with group size, which is highly variable (5-40). One example is seen in Figure 45.2. Feeding stalls can also be used in combination with deep straw bedding (Figure 45.3, left). Total free space available (excluding feeding stalls) is commonly 2.25-2.8 m² per sow depending on group size. If stall width is a minimum of 60 cm and sows have free access, the stalls may be used for both feeding and resting, reducing the total space needed.

b) Group Housing with Electronic Sow Feeder (ESF)

In ESF systems each sow carries a transponder (ear tag or collar), allowing passage to a feeder station. A precisely measured individual ration of food is then dispensed to that animal and she is protected while eating by a specialised feeding stall with gates operated by the sow herself or by the feeding computer. A single feeding station can be shared by up to 70 sows. In this system sows are often kept in large dynamic flocks (50-300 sows) with communal dunging and lying areas (Figure 45.3, right).

Farrowing and Lactation

Sows are typically moved from dry sow to farrowing accommodation 3-7 days before the expected farrowing date (115 days after service).

In outdoor systems, farrowing and lactating sows are housed in either individual or group paddocks, with access to individual farrowing huts (Figure 45.4).

The use of individual pens for the farrowing/lactating sow and litter is common only in countries where farrowing crates are no longer allowed. These may be simple pens of approximately 2.0 x 3.0 m with anti-crush rails around the walls and a heated creep area for the piglets (Figure 45.5, left). Traditionally the pens had access to a dunging alley with scrapers, but in newer systems the floor is mostly partly slatted. Beneath the slatted flooring, scrapers or liquid manure systems are used. The type of manure handling system influences the possibility to use straw during farrowing. Slats are either made of concrete, iron or a plastic material. These pens sometimes contain a

Table 45.1. Piglet production in Sweden – average values.

<table>
<thead>
<tr>
<th>In total 68,008 sows</th>
<th>2007</th>
<th>Best 25%</th>
<th>Worst 25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average no. of sows and gilts</td>
<td>234</td>
<td>251</td>
<td>178</td>
</tr>
<tr>
<td>Produced piglets/sow and year</td>
<td>22.4</td>
<td>24.8</td>
<td>19.0</td>
</tr>
<tr>
<td>No. of litters/sow and year</td>
<td>2.19</td>
<td>2.25</td>
<td>2.06</td>
</tr>
<tr>
<td>Proportion of gilt litters, %</td>
<td>25.9</td>
<td>22.4</td>
<td>29.2</td>
</tr>
<tr>
<td>Liveborn/litter</td>
<td>12.3</td>
<td>12.8</td>
<td>12.0</td>
</tr>
<tr>
<td>Stillborn/litter</td>
<td>0.90</td>
<td>0.91</td>
<td>1.0</td>
</tr>
<tr>
<td>No. of weaned/litter</td>
<td>10.3</td>
<td>10.9</td>
<td>9.6</td>
</tr>
<tr>
<td>Weaning age, days</td>
<td>34.0</td>
<td>33.4</td>
<td>36.2</td>
</tr>
<tr>
<td>Piglet mortality, birth-weaning, %</td>
<td>16.2</td>
<td>14.4</td>
<td>19.5</td>
</tr>
<tr>
<td>Returns, %</td>
<td>9.0</td>
<td>6.2</td>
<td>12.2</td>
</tr>
<tr>
<td>Daily growth from weaning-delivery, g</td>
<td>426</td>
<td>463</td>
<td>407</td>
</tr>
</tbody>
</table>
temporary crate structure made by moving a partition into place at the time of farrowing (Figure 45.5, right.) This reduces the total space available when the sow is loose.

In the mid 1980s, there was a trend to introduce a change from confinement systems to group housing of lactating sows. Indoor group-farrowing systems are still in use in commercial practice but only to a small extent. This is because these systems operate very differently compared with conventional ones, in matters such as identifying the maternal characteristics of sows to cull for poor maternal abilities or finding new practical means of identifying and catching piglets in a large group in large pens, farmers had to find their own ways of coping with these challenges as advisors were not trained to help. Thus, many who did not find practical ways of managing the herd re-converted to conventional systems, but those who found out how to manage stayed on. The knowledge required to manage the system is different from that for conventional systems, as is the need for large quantities of straw (1,000-1,500 kg per sow and year; Algers, pers. comm.) so there is no ‘natural’ spread of the use of these systems. There has been a knowledge transfer on the operation of such systems to the USA (Halverson, pers. comm.) and many such systems now are used in the US. In these systems, 5-10 sows are kept in groups where each sow has access to an individual farrowing nest and a communal resting area, often on deep straw bedding (Figures 45.6-7). In this system the sows are moved to the big pen some days before farrowing and a cubicle for each sow is erected along the walls. The cubicle is about 1.75 by 2.40 m and has an entrance for the sow with a 40 cm high threshold with a 15 cm wide roller on top to protect the udder of the sow but also to prevent the piglets from leaving the cubicle during the first week. There are no rails, creep area or heat lamp in the cubicle as it can distort the interaction between the sow and piglets during the nest phase. Piglets remain in the deep bedded system until they reach approximately 25-30 kg.

These systems are described in detail by Algers (1991), Braun and Algers (1993) and Halverson (1997). The nest boxes are taken out when the piglets have left
the nest, usually 10-14 days after farrowing. Data collected from 469 sows on four Swedish deep-bedded system farms (Marchant, 1996) showed an average production of 21.8 pigs/sow/year based on a 92% farrowing rate, 11.2 pigs born alive per litter, preweaning mortality of 11.5% and weaning 21.8 pigs per/sow/year at 6-week weaning. Hultén (1997) found that when mixing sows without their litters, lactational ovulations occurred more frequently in group-housed sows than in single-housed, and piglet mortality was higher in group-housed sows. Nowadays, this practice of mixing sows without their litters has been abandoned by farmers as a result of this. Algers (1991) found a lower incidence of MMA in sows kept together during farrowing in a group housing system in comparison to traditional single, loose housing of sows.

Ebner (1993) noted that grouping sows before farrowing caused considerably less aggression that grouping after farrowing. Wülbers-Mindermann (1992) found that cross-suckling occurs in group-housed sows with litters and that this does not cause any detrimental effects as regards mortality or piglet growth, but it could be stressful to some sows when forced to give milk to many demanding piglets. It has been shown that piglets develop different strategies for their cross-suckling and that such strategies are of adaptive value (Braun, 1995).

A large-scale study of group housing systems for lactating sows commercially used in Sweden was performed by Mattsson (1996). The study comprised 49 herds with group housing and 296 control herds where sows were kept loose but singly, in individual pens. The study concluded that group-housed sows had slightly higher piglet production per sow and year on average, that piglet mortality was similar in both groups, that returns were less in the group-housed sows and that the piglets in the group-housed group reached 25 kg on average 5.3 days earlier (see Table 45.2). This is probably due to the significantly lower incidence of weaning diarrhoea in group-housed sows (Table 45.3).

A number of the farms with group housing successfully produced 22-25 piglets per sow and year, which shows the potential of the system. It should also be borne in mind that these production results are maintained using the normal practices in Sweden of weaning at 5-6 weeks, without the regular use of antibiotics in weaner feed and without the use of any hormones for synchronisation of the breeding.

Although the data in the two tables above (Mattsson, 1996; Holmgren and Lundehelm, 1994) were obtained from many farms, there might be confounding factors that at least partly contribute to the effects shown. The data should therefore be interpreted mainly to show the production levels that are possible in group housing systems.

Fattening Pigs

Behaviour of the Growing Pig

Being generalists, i.e. having an innate capability to adapt to various habitats, pigs have a natural tendency to ex-
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plore (Wood-Gush and Vestergaard, 1991). Exploration is shown by all pigs, allowing the individual to be prepared for effective food acquisition, response to danger from predators, attack by conspecifics and response to other adverse conditions or needs. Exploration is therefore not only linked to nutritional needs or foraging motivation. In barren environments, pigs redirect exploratory behaviour at the body of pen mates (Algers, 1984; Fraser et al., 1991). Exploration will be difficult if there is insufficient space available and if the environment is barren. All pigs are motivated to explore by digging and manipulating with their nose and mouth.

Apart from adult boars and sows around parturition, pigs are social animals associating and interacting in a friendly way much more than in an aggressive way (e.g. Stolba and Wood-Gush, 1989). Sleeping in pigs is often a social activity, in that pigs prefer to rest near or alongside other pigs. Pigs naturally live in stable groups and lack of social contact causes poor welfare in pigs. However, mixing of unfamiliar pigs always results in aggressive interactions to establish dominance relationships (Turner et al., 2001). In order to avoid further aggression, subdominant animals avoid dominant animals. Moreover, a restriction in access to important resources, such as the number of feeding places, results in increased levels of aggression (Spoolder et al., 1999).

| Table 45.2. Herd average comparisons: The Swedish deep-bedded group housing system for lactating sows versus loose housing of single sows. (Mattsson, 1996). |
|---|---|
| Group housing | Single housing |
| Number of herds | 49 | 296 |
| Av. no. of sows per herd | 95.2 | 77.9 |
| Conception rate, % | 91.1 | 87.6 |
| Liveborn per litter | 11.0 | 11.0 |
| Stillborn per litter | 0.7 | 0.9 |
| Piglet mortality until weaning | 14.7 | 14.9 |
| Weaned pig/sow and year | 19.9 | 19.1 |
| Weaning, days | 38.9 | 40.2 |
| Age at 25 kg, days | 80.7 | 86.0 |
| Working hours per sow | 18.1(a) | 28.9(b) |

(a= data from 7 herds, b= data from 42 herds)

Table 45.3. Incidence of weaning diarrhoea and consumption of antibiotics and chemotherapeutics in different pig weaning systems (Holmgren and Lundehaem, 1994).

<table>
<thead>
<tr>
<th>Group housing</th>
<th>One unit pen</th>
<th>Weaning pen</th>
</tr>
</thead>
<tbody>
<tr>
<td>% treated piglets</td>
<td>21a</td>
<td>59b</td>
</tr>
<tr>
<td>Kg medicated feed/sow and year</td>
<td>78a</td>
<td>278b</td>
</tr>
</tbody>
</table>

Differences a-b, p<0.05.

Even when pigs are fully supplied with their daily nutrient requirements for good health and performance, they may have other needs relating to the quantity or form of the diet. Foraging behaviour accounts for up to 75% of the daily activity of pigs kept in a semi-natural enclosure and they show a wide range of various behaviours to investigate and manipulate the environment (Stolba and Wood-Gush, 1989). In addition to the need to feed, pigs therefore need permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities. There is a close relationship between foraging and exploration needs. Pigs are highly motivated to work for access to foraging material such as straw or wood shavings (Ladewig and Matthews, 1996). Insufficient provision of foraging material increases the incidence of tail-biting in fattening pigs (Day et al., 2002; Moinard et al., 2003) and stereotypical behaviour in sows (Spoolder et al., 1995; Whittaker et al., 1998).

Fattening Pig Housing

When piglets reach approximately 30 kg live weight they are usually moved to further accommodations for finishing their growth prior to slaughter. This is currently done in various intensive housing systems and only marginally in outdoor facilities in the EU. Housing system designs are affected by a number of factors including climate, legislation, economics, etc.

Individuals are usually selected to fill pens in the fattening sheds based on live weight, so members of different litters may become pen mates in the fattening pens. This mixing will provoke the establishment of new social hierarchies, resulting in antagonistic behaviour. If not castrated, males become sexually mature at this stage and aggressive behaviour may be intensified (Rydhmer et al.,
2006). There are a few incidences where pigs are housed together during the entire rearing period from weaning to slaughter. Ekkel et al. (1996) reported that health, production and welfare were improved when pigs were kept in these housing systems without being mixed or transported. Such systems are most often seen in straw-based housing systems in Scandinavia.

Indoor systems can be divided into three categories based on the manure-handling system adopted: deep-litter systems, scraped systems and slatted systems. Some of these systems provide different climatic zones where the pig can choose its microclimate for various activities (i.e. for resting in kennels or under thermo-boards). The latter systems may provide supplementary heating only in the lying area, which reduces the overall energy input for the building. The various systems are briefly described below. For further details, see the EFSA (2007b) report on animal health and well-being in fattening pigs.

**Weaners**
A variety of housing systems are used for weaned piglets. Piglets are typically housed in highly controlled environments with supplementary heating in partly or fully-slatted pens, or raised on flat decks, in groups of varying sizes (10-40 kg). They may be moved from the first stage weaner accommodation to larger, second stage accommodation after 2-4 weeks, or remain in the same pen until they are 10 weeks of age (30-40 kg) or, in a few instances, until slaughter. The pen area per pig varies from 0.2 (< 20 kg) to 0.3 m² per pig (< 30 kg). Weaner pigs are typically fed ad libitum (dry) or restricted (liquid).

**Grower/Finisher Pigs**
Accommodation for fattening pigs may be fully-slatted, partly-slatted, minimally bedded with scraped dunging area or deep bedded with straw or sawdust. Although there are national differences, housing with fully or partly-slatted flooring (typically on concrete slats with 17-20 mm slot spacing) with a pen floor area of 0.7 m² at the end of the finishing period predominates within the EU (Figure 45.8-9).
Feed can be provided either wet or dry. Feed is increasingly distributed automatically to sensor-controlled liquid feeders or slop feeders (semi-liquid). Dry feed is often given ad libitum from one or more hoppers, although feed may be restricted in the later stages to prevent excessive fatness of unimproved genotypes or with very heavy slaughter weights (>120 kg). Traditionally, fattening pigs are housed in groups of 10-15, but recently the use of units with larger group sizes on perforated floors has increased. Large group sizes are also typical for deep litter systems.

Kennels are typically used in cold non-insulated buildings or outdoors providing a sheltered separate resting area.

**Fully Slatted Floor**

Slatted housing systems are widely used in the industrialised world. In these systems, slats cover the entire pen area, usually to maintain hygiene. Foraging material, if used, is small in quantity. One vital component for the successful use of slatted flooring is the proportion of the floor solid/slot dimensions in relation to the dimensions of the feet of the pig at any given age. Furthermore, sharp edges may cause injuries when the loading force exceeds the strength of the digits (e.g. Webb and Nilsson, 1983).

**Partly Slatted Floor**

Partly-slatted flooring may reduce emissions of ammonia and other gases released from urine and faeces and, if correctly designed and well-drained, can lower emissions considerably. Partly-slatted floor systems, preferably with a raised level of the slatted part, make it possible to use sufficient supplies of straw.

**Solid Floor**

Solid concrete floors are often used for both the resting and defecating areas. The manure is scraped, manually or by mechanical scrapers, at frequent intervals and the urine usually drained separately. A dry concrete floor can easily be warmed and it retains heat quite well, but it exacerbates the harmful effects of low temperatures if floors or bedding are cold or damp. Therefore, solid floors are found to need either insulation or a floor heating system (warm water pipes or electric cables), whether used with or without small amounts of bedding materials.

The straw-flow system is used for growing pigs from 10 weeks (20–30 kg) to slaughter (90–150 kg). The straw-flow pen system is characterised by sloping concrete floors, where the lying area has a curved surface, with a slope of 5-7% towards the dunging area. The resting area is sometimes levelled about 5 cm above the manure area, which has a slope for allowing the manure to flow down into a manure channel. The group size in straw-flow systems is about the size of a litter and having more than 30 individuals is not recommended (Jackisch et al., 1996).

Surplus straw is as favourable for health and welfare as in the deep-bedding systems. However, the use of straw
is much lower and the area per pig cannot be increased significantly because of the system itself. For the flow function of the pen, an amount of 50 grams of straw per pig and day is satisfactory; the amount should not exceed 100 grams to avoid clogging or flow malfunction if short straw is used. With longer straw, however, quantities may be substantially increased. Uninsulated floors need a bedding depth of at least 75 mm for the weaned pig to achieve a thermal resistance to the floor above about 0.5 °C/W (Bruce, 1990).

Deep bedding with materials such as straw, sawdust, wood chips, peat, etc. usually has a solid concrete floor underneath (Figure 45.10), although sometimes a slatted floor is used for drainage of the litter bedding. The deep litter system has disadvantages in that it increases the emissions of ammonia, nitrous oxide, nitrogen and methane (Groenestein and Van Faassen, 1996).

In insulated buildings, especially when the bedding is ‘fermenting’ and producing a large amount of heat, the temperature may rise and may cause thermoregulatory problems for the pigs, resulting in heat stress and decreased performance unless the pigs have access to a cooler lying place (van den Weghe et al., 1999) or unless ventilators and other means of climate regulation are used.

Outdoor Rearing Systems
Outdoor rearing systems can be seen in many various forms. In outdoor rearing either the pigs are provided with a large paddock and a simple shelter, or they are confined within an outdoor hut-and-run system.

The stocking rate suggested in paddock systems is 40-50 finishing pigs/ha (Brownlow et al., 1995). Housing for free-range pigs usually comprises corrugated iron arks or wooden sheds, although tents have recently been developed in Denmark. The housing is generally flexible, so that the shelters can be moved and each new batch of pigs can begin in a clean paddock. In systems with huts, the pigs are provided with a hut and small outdoor run area bounded by solid fencing and bedded with straw to maintain hygiene. The hut often has an adjustable ventilator as well as a feed hopper. It is moved to fresh ground for each new batch of pigs.

Conclusions
Mixing of pigs causes aggression and injury. Pigs have a strong innate motivation for exploration and in the case of the sow, for nest building before farrowing. Farrowing systems as well as systems for weaners and fattening pigs should allow for the handling of destructible nest material to enable investigation and manipulation activities. They should also allow the sow’s nest-building behaviour to be expressed and sows and fatteners to be kept in stable groups.
References

Chapter 44


Chapter 45


References


DFS, 2007. DFS 2007:5 Djurskyddssmyndighetens författningssamling


Further reading


Chapter 47


References

Chapter 46

Further reading


