Housing systems in pig husbandry aimed at welfare; consequences for fertility[1]

Nicoline M Soede and Bas Kemp

Adaptation Physiology Group, Department of Animal Sciences, Wageningen University, PO Box 338, 6700 AH Wageningen, The Netherlands

Corresponding author: nicoline.soede@wur.nl

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Contents

In Europe, housing conditions of sows are currently changing, related with a larger emphasis on pig welfare. As a result, sows are and will be less kept in crates, but more so in loose housing systems (farrowing, lactation) and group housing systems (pregnancy, lactation, weaning-to-oestrus interval). These changes in housing conditions may affect reproductive functioning of the sows. Group housing of sows may decrease farrowing rate and litter size when stress levels rise or when feed intake in early pregnancy is not fully secured. Loose housing during farrowing results in an improved farrowing process, but may increase piglet mortality by crushing during early lactation. Further, group housing during lactation may induce lactational oestrus. Thus, new –welfare friendly- housing systems require increased attention to management to ensure optimal reproductive performance.

Introduction

In most commercial pig production systems in the world, sows are individually housed in stalls or crates for most of their reproductive life; during pregnancy (~115 d), during lactation (most commonly 20-30d) and also between weaning and oestrus (4-7d). The housing systems are mostly slurry based, with (partly-) slatted floors and provide limited or no bedding. The short lactation periods optimize the number of litters per sow per year from an economic point of view since sows generally remain anoestrous during lactation.
Besides economic advantages, these systems allow easy control of individual animals for aspects like feed intake, health and oestrus.
However, from a welfare point of view these systems are far from optimal. Gestation stalls and farrowing crates restrict freedom of movement, and may increase skin lesions due to prolonged contact with hard surfaces (Bonde et al., 2004; KilBride et al., 2009). Farrowing crates have been developed to protect piglets from being crushed by the sow. However, crated sows show increased heart rate and cortisol concentrations around farrowing as compared with loose housed sows, indicating that this restrain is stressful for the sow (Oliviero et al. 2008, Cronin et al. 1991, Jarvis et al. 2001). Crated sows normally are also

unable to perform nest-building behaviour, which is a behavioural need for the pre-partum sows that affects the farrowing process and, as a consequence, piglet vitality (Wischner et al. 2009). During lactation, sows in farrowing crates and pens are continuously exposed to their piglets, whereas in more natural systems (e.g. get away systems (Pajor et al. 2000)) sows can leave the pen. Welfare issues in commercial pig production systems have triggered societal call for alternative pig production systems. Various countries have developed legislation that resulted in changes in pig production systems, such as, for instance, group housing for pregnant sows in Europe. This review will shortly introduce various management systems that are (being) developed and discuss the reproductive issues associated with these systems.

The pregnant sow

Systems

For pregnant sows, housing conditions vary largely. Sows can be full-time housed in individual crates, or they can be housed in groups, whereby group sizes may vary from small (4 to 5 sows) to very large (up to 250 sows). Also feeding systems for pregnant sows vary greatly, sows are mostly restricted fed during pregnancy, but also ad libitum feeding is used, sows can be fed using e.g. feeding troughs, trickle feeders or electronic sow feeders (ESF), they may receive wet or dry feed, and they may eat together or one by one. In Table 1, an impression is given on the use of the different systems in a few selected countries. A note should be made that in the EU, from January 1, 2013, onwards, pregnant sows may only be individually housed during the first month of pregnancy. Depending on national legislation, sows in some countries (e.g. Finland, The Netherlands) need to be group housed during complete gestation. In Sweden and the UK, sows not only need to be group housed during pregnancy, but also during the weaning-to-oestrus interval.

The choice for a housing system is usually not based on fertility criteria, but may be based on e.g. welfare legislation, trade mark production, building costs, labour requirements or level of control of the animals (Tuyttens et al. 2008, Tuyttens et al. 2011). Van der Peet-Schwering and Hoofs (2010) evaluated the different group housing systems for these and other aspects and summarised their findings in Table 2. In the Table, score 1 means ‘best’ and score 5 means ‘worst’, which means that according to Van der Peet-Schwering and Hoofs (2010), large dynamic group systems require the highest labour input, particularly those that use straw bedding. On the other hand, these systems require relatively low investments. Concerning reproductive performance, the authors concluded that the systems are quite similar; variation in reproductive performance between farms is more related with the management of the system. This will be discussed below.

Factors that may affect fertility in group housing systems

Several studies have compared group housed sows to individual kept sows and concluded that reproductive performance, measured as farrowing rate and litter size, may be at risk in

group housed sows (e.g. McGlone et al., 2004, Kongsted, 2004a). Only few studies have compared reproductive functioning in different group housing systems. Broom et al. (1995) found similar performance in a dynamic 38-sow Electronic Sow Feeder (ESF) group compared to a 5-sow group with feeding stalls, (Courboulay and Gaudré 2002) compared 6-sow trough fed groups with 12-sow ESF groups and found a tendency for lower litter size in ESF sows. In a study of Van Der Peet-Schwering et al. (2003), sows in a static ESF system (25 sows in the group) had a higher return rate than sows in a groups of 12 with free access stalls. Van der Peet-Schwering et al. (2003) suggested that either the lower feed intake or the high level of aggression around the feeder caused the higher return rate in ESF sows. More recently, Van der Peet-Schwering et al. (2009) investigated success factors of group housing systems for sow welfare and performance by evaluating both performance, welfare, management and housing of sows on 70 farms with group housing during the complete pregnancy (<4 d from insemination). It was concluded that in "each system of group housing, adequate reproductive results and animal welfare can be achieved". The system in itself was not a major success factor. This is illustrated in Figure 1, which shows the variation in farrowing rate between the group housing systems in the study. Similar results were found for other production measures (number of piglets weaned per sow per year; culling rate) and animal measures (backfat, claw lesions, skin lesions). Similarly, in more than 250 farms, Boulot et al. (2011) found that farms with group housing during pregnancy had similar reproductive performance as farms with individual housing during pregnancy, seeing a large variation in performance within the systems. They concluded that gilt management, time of grouping and ESF-management are critical success factors for group housing. Van der Peet-Schwering et al. (2009) concluded that successful group housing needs famers that have an animal-directed approach, as shown, for instance, by their attention to individual sows in feed allowance, and also several aspects of gilt rearing, such as space allowance and feeding strategy. Only few specific housing conditions appeared to be important. For instance, on the 25% farms with the lowest farrowing rate (<83%), sows tended to have a lower space allowance than on the 25% farms with the highest farrowing rate (<83%: 2.1 m^2, 83-89%: 2.2 m^2 and >91% 2.6 m^2).
The question, obviously, remains which specific aspects of group housing systems affect reproductive functioning. Based on extensive literature reviews, both Kongsted (2004b) and Spoolder et al. (2009) concluded that (variation in) feed intake and stress may be major factors affecting reproductive performance in group housing systems during pregnancy. These factors will be shortly reviewed below.

Stress Stress factors such as stocking density, grouping of unfamiliar animals and associated aggression, competition for food, poor environments, thermal extremes and poor human-animal handling may all affect reproductive functioning (e.g. Varley and Stedman (1994). During pregnancy, such factors may lead to embryonic mortality, especially when (the combination of) such stressors results in chronically elevated cortisol levels. In the majority of group housing systems, grouping takes place during pregnancy. Both Van der Mheen et al.

(2003); dynamic 52-sow ESF groups) and Kirkwood and Zanella (2005); static 15-sow groups with floor feeding) concluded that grouping preferably takes place immediately after insemination and should not take place around the period of maternal recognition of pregnancy (wk 2-3 of pregnancy). Van Wettere et al. (2008; 6-gilt groups with floor feeding) however, did not find effects of timing of grouping on embryonic survival. This suggests that other factors may overrule the potentially negative consequences of grouping on embryonic mortality. However, to be safe, grouping should be avoided in wks 2-3 of pregnancy.

Body condition/feed intake In most group housing systems, sows may experience a more variable feed intake than sows housed in stalls. A series of Swedish experiments have shown that short time food deprivation during the first weeks of pregnancy may affect embryo functioning in different ways. For example, food deprivation at Day 2-3 after oestrus delayed ova transport through the oviduct (Mwanza et al. 2000, Razdan et al. 2004), food deprivation at Days 10-11 decreased systemic progesterone and oestradiol levels (Tsuma et al. 1996) and food deprivation at Days 13-14 decreased Day 30 allantoic progesterone levels (Mwanza et al. 2000, Razdan et al. 2004). Although in these experiments embryo survival was not affected, they suggest that reproductive performance in group housing systems may be at risk when sows have to compete for their food. Indeed, Kongsted (2004b) observed eating behaviour in group housed sows in 14 herds and concluded that sows that spent less time eating had a higher risk of returning to oestrus. Also, sows with a lower backfat gain during early gestation had a lower farrowing rate and litter size. In these sows, performance was not related with 'fear' and ' social stress' scores, which suggests that the consequences of a low feed intake may not be stress related. Other studies have also found that relatively high feeding levels during early pregnancy may be beneficial for litter size in sows (e.g. (Sørensen and Thorup 2003, Hoving et al. 2011), although the physiological mechanism has not been elucidated.

Conclusion

The change from individual to group housing for pregnant sows poses new challenges to sow management. Group housing systems vary largely, in many different aspects. To achieve good reproductive performance, specific attention needs to be given to stress levels (related with unfavourable social, management and climatic conditions) and feed intake during early pregnancy.

The lactating sow

Systems

Various systems are used to improve welfare of sows and piglets in lactation, which can be arbitrarily divided into 3 main categories.

Loose housed sow Some systems are characterised by loose housing of the sow during parturition and lactation. Loose housed farrowing systems have recently been critically

evaluated by Baxter et al. (2012); the systems differ in many aspects (size, layout, use of straw), but for the success of the system, not only these aspects, but also maternal characteristics of sows and the quality of stockpersonship is integral. Recently, several loose housing systems have been developed, e.g. the PigSAFE concept (PigSAFE 2010). Loose housed farrowing systems are obligatory in organic sow production and are widely used in some countries (e.g. Switzerland; outdoor housing in the UK).

Get away systems More freedom for the sow is allowed in systems where sows can get away from their piglets (by stepping over a barrier) to go to a communal sow area. Pajor et al. (2000) showed that sows will progressively stay away longer from the piglets when lactation progresses. These systems are currently not used in practice.

Group lactation systems In these systems, not only the sows, but also their piglets are grouped during (part of) the lactation. Group sizes and moment of introduction in the group after onset of lactation vary for the different systems (e.g. Hultén et al. 2006). In general, these systems are normally combined with longer lactation lengths (6-8 weeks). In Sweden, group lactation is obligatory in organic sow production; otherwise, the use is scarce. However, currently, group lactation systems are being evaluated in Germany; one system that combines group lactation with electronically controlled crates (Bohnenkamp 2012) and one with free access farrowing pens (BigDutchman 2012).

Reproductive issues

Farrowing process and piglet survival Loose housed sows that have the opportunity to perform nest building behaviour have a shorten farrowing duration (Oliviero et al. 2008, Oliviero et al. 2010, Thodberg et al. 2002), related to increased oxytocin concentrations (Oliviero et al. 2008). Oliviero et al. (2010) also confirmed earlier findings that a shorter farrowing duration is related with a lower stillborn rate. Further, preliminary analyses in a Dutch study on farrowing behaviour in crated and loose housed sows show that loose housed sows have fewer posture changes during farrowing, accompanied by a lower chance of piglets dying during parturition (Raats, Hoofs and Soede , unpublished results). Thus, loose housed sows may be more relaxed during farrowing, especially when they have the chance to express nest building behaviour pre-partum. This may result in a shorter farrowing process and thus fewer still born and more vital piglets.

It is generally assumed that loose housing increases piglet crushing in the first days of lactation, but large differences are found between studies. For example, Marchant et al. (2000) found a dramatic increase in mortality rates in pens (25%) compared to crates (13%). Weber et al. (2007) also found that more piglets died from crushing in loose housed compared to crated sows, although total piglet mortality was similar. Their data resemble those of KilBride et al. (2012), who, based on data from 112 sow herds in England, also concluded that loose housing increased risk of crushing, but decreased the risk of dying from other causes. Recently, Pedersen et al. (2011) investigated causes of piglet mortality in crates and indoor pens and concluded that the odds for stillborn, crushed or dying of starvation were similar in these conditions. They concluded that the micro-climate at

farrowing and the heat-preserving properties are more important than the housing conditions at farrowing.

Lactation oestrus In get-away systems and group lactation systems there are several aspects that pose a risk for lactation oestrus, related with a reduced suckling frequency and a lower weight loss (e.g. Pajor et al. (2002)). Also presence of foreign piglets may have a detrimental effect on nursing when piglets are mingled at a young age (within 14 d.; Weary et al. 2002). As mentioned before, in the studies investigating loose house systems, lactation lengths are generally quite long (6-8 weeks). Milk production and suckling frequency decrease after the 3rd week of lactation and piglets become less dependent on milk. As a result, sows may become anabolic during lactation, which poses another risk factor for lactation oestrus. In an attempt to synchronise lactation ovulation and to inseminate sows during lactation, Kongsted and Hermansen (2009) performed a study in organic sows with an 8 week lactation that were individually housed for the first 5 wks, followed by group housing and introduction of a boar. All sows showed lactational oestrus, of which 84% within one week. Lactational inseminations resulted in a pregnancy rate of 84%. Another approach to stimulate and control lactation oestrus and ovulation in sows is by intermitted suckling. In this approach sows and piglets are separated for 10 to 12 h per day starting at wk 2-3 of lactation (reviewed by Kemp and Soede (2012). The timing of oestrus is very much synchronised; sows show oestrus either at 5-6 d after start of intermittent suckling or at 5-6 d after subsequent weaning. Oestrus induction rates may be close to 100%, but are lower in first litter sows. Reproductive results in terms of ovulation rate, embryo survival, farrowing rate and litter sizes were not compromised when the treatment started after day 19 of lactation.

Conclusion

Farrowing pen design influences the farrowing process and (early) piglet survival. Loose housing systems on the one hand ease the farrowing process, resulting in lower piglet mortality at farrowing, but on the other hand, may increase the risk of piglet crushing. Optimised pen design and management are crucial to reduce this risk. Group housing may increase the risk of lactational ovulation. This risk may be bent into an advantage, when stimulating ovulation induction and oestrus expression, since insemination during lactational oestrus can result in good reproductive performance.

The weaned sow

In some European countries, such as, for instance Sweden and the UK, all sows are group housed from weaning onwards. Effects of group housing of sows may effect oestrous characteristics in sows, as has been reviewed by Kemp et al. (2005). Unfortunately, recent literature is lacking. In modern genotypes, timely oestrus onset is less a problem than it used to be. Therefore, older literature investigating oestrus characteristics in group housed sows may not be relevant to our modern genotypes.

Expression of oestrus Effects of group housing on oestrus detection rate and expression of oestrus are generally small. For example, Langendijk et al. (2000) found no effect of group housing (groups of four) vs individual housing after weaning on oestrus detection rate or duration of estrus. Factors that may affect expression of oestrus in groups are social status of the sows, group size and space allowance. Pedersen et al. (1998) showed that sows receiving the highest amount of aggression in group housing with two other sows after weaning showed significant less social behavior and a shorter duration of oestrus. Moreover, Pedersen et al. (2003) showed that subordinate sows in pair housing showed less proceptive and receptive behavior towards a boar as compared to dominant sows. Subordinate sows showed fear-related behavior in response to boar stimulation even when they were in oestrus. Thus, both oestrus detection and mating may be impaired in subordinate sows.
Not much is known about effects of group size and space allowance on expression of oestrus in weaned sows. Generally it is thought that in group housing space allowance and pen design should be sufficient to allow adequate escape opportunities in order to alleviate the social stress experienced by subordinates in a group (Pedersen et al., 2003).

Conclusion
It can be concluded that effects of group housing of sows after weaning on onset of oestrus and expression of oestrus are variable. Positive effects may be found if oestrous sows are in the group and in cases of extended weaning to oestrus intervals. Negative effects can be found if severe aggression takes place in newly formed groups.

Concluding remarks
In general it seems that more welfare friendly housing systems can have at least similar reproductive results as conventional housing systems. However, several phases of the reproductive cycle need specific management attention to avoid low litter size, piglet crushing and lactational ovulation. In general, in outdoor pig production systems the management control may be more of a challenge and is obviously also more affected by variable environmental conditions (e.g. sun burn, cold stress).
Another crucial element is the fact that after a switch to a new housing system, not only the farmers, but also the sows have to get used to the new systems and associated changes in management. This may temporary result in lower performance of the sows after such a switch.

Table 1 An impression of the variability in group housing systems during sow pregnancy (January 2012)

	UK[3]		Finland		Netherlands		Denmark		France		USA	
Feeding system	size	farms (%)	size	F arms (%)	size	farms (%)	size	farms (%)	size	Farms (%)	size	farms (%)
Individual housing throughout pregnancy												
Stalls	xxx	0	xxx	5	xxx	23	xxx	25	xxx	>60	xxx	>80
Group housing - Individual feeding												
Stalls	4-30	27	40	80	10-50	26	30-50	27	10-20	12	20-25	3
Electronic sow feeder	30-100+	15	100	10	40-100+	36	50-150	28	30-150	5	20-25	2
Group housing - Group feeding												
Floor	10-100+	30		0	<15	6	15-20	10	??	2	30-40	5
Trough	5-10	25	10	20	7-15	5	15-20	10	6-9	17	30-40	6
Trickle feeder	4-10	3	20	10	8-20	<1	10-15	<1			na	0
Ad libitum	na	0	40	5	8-20	<1	na	0			na	0
Straw bedding		90	40	60		15				7	xxx	0

[1]Experts from several -mostly European- countries have contributed; UK (A Cliff), FI (O Peltoniemi); Denmark (LU Hansen); France (S Boulot; Courboulay et al., 2010) Br (F Bortolozzo); USA (WF Flowers)

[2]Not included: Brazil (virtually all sows confined in pregnancy).

[3] UK: grouping from weaning onwards, relates to indoor sows only (60% of sows)

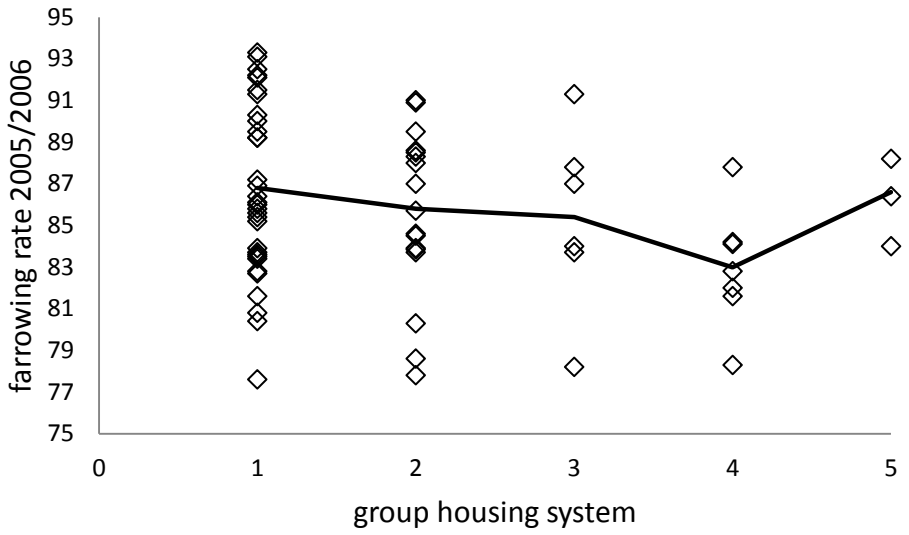
na = not applicable

Table 2 Characteristics of group housing systems for pregnant sows[1] (from: Peet-Schwering et al., 2010)

Group housing System	ESF Stable No bedding	ESF Dynamic No bedding	ESF Dynamic Straw bedding	Crate Stable No bedding	Ad lib Stable No bedding	Floor fed Stable No bedding	Trough Stable No bedding
Labour need	3	4	5	1	2	2	2
Labour circumstances	2	2	3	1	1	1	1
Skills needed	3	3	3	1	2	2	2
Sow Welfare	2	2	1	3	2	3	3
Sow health	2	3	3	1	2	2	2
Technique need	2	2	2	1	1	1	1
Investments	2	1	1	3	2	1	2
Fertility	1	1	1	1	1	1	1
Acceptance society	2	2	1	4	2	3	3
Enforceability	1	1	1	2	1	1	1

[1] 1=best, 4=worst

Figure 1 Variability in average farrowing rate (2005/2006) of Dutch farms with group housing within 4 days from insemination onwards, in relation to the applied group housing system; electronic sow feeders without straw (1), electronic sow feeders with straw bedding (2), free access stalls (3), trough feeding (4) and other (5). Adapted from Van der Peet-Schwering et al., (2009).



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