

# Internal report



## Housing of farrowing and lactating sows in non-crate systems

Lene Juul Pedersen and Vivi Aarestrup Moustsen (eds.)



Danish Pig Production

**Faculty of Agricultural Sciences**

# Housing of farrowing and lactating sows in non-crate systems

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Housing of farrowing and lactating sows in non-crate systems  
Copenhagen, 12 June 2008

## 1. Breeding for improved piglet survival in non crate systems – the UK perspective

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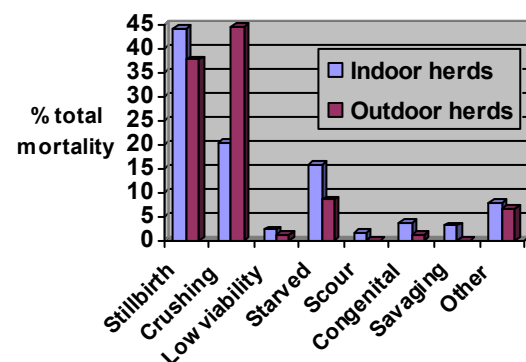
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### Background to UK herd performance

Within the UK herd, total pre-weaning mortality of piglets has shown little reduction over the last 25 years. Any reduction in postnatal mortality has been offset by corresponding increases in stillbirths (MLC Pigplan Recording Scheme data, 1975-2008). Whilst the number weaned has shown a progressive increase as a result of greater total litter size, this also has stabilised over the last 10 years. Earlier reductions in total mortality in the 1970s and 80s were attributable to better management of the farrowing environment, including the widespread adoption of farrowing crates. Whilst these offer many benefits for piglet management and survival, they also raise significant sow welfare concerns. The UK is unique in farrowing a large proportion of the national sow herd in outdoor systems (currently ~40% of sows). National herd records indicate that piglet survival in these relatively unsophisticated systems can match or exceed that in the more controlled indoor environment (Table 1), but attempts to replicate this performance in large scale non-crate indoor systems have to date proved unsuccessful. Examination of the causes of mortality in indoor and outdoor systems from both farm records, which have been shown to sometimes be unreliable in classification of causes, but also from specific experimental studies, show a different pattern of causes (Fig 1). The crushing of piglets by sows in non-crate systems is therefore the major constraint to the phasing out of the farrowing crate. In non-crate systems, where environmental control and human intervention are more restricted, greater reliance is placed on the inherent vitality of the piglet and maternal behaviour of the dam. Selection of animals genetically less predisposed to mortality in different production systems may thus further improve both production performance and welfare aspects, and has been the subject of a recent UK project.

**Table 1. Results from MLC Pigplan herds (2000-07)**

	Indoor	Outdoor
Total born	12.07	11.49
Liveborn mortality %	12.0	10.5
Total mortality %	19.5	16.2
Weaned	9.71	9.64



**Figure 1. Causes of mortality (Riart et al., 2000)**

### The GENOMUM Project

This project was funded by the British and Scottish governments and an animal welfare NGO, and involved major collaboration from two international breeding companies and a large outdoor pig production company. The objectives were to: (1) Estimate the genetic parameters (direct and maternal) for different forms of piglet mortality, by analysis of existing database information, and identification of families with genetic variation in piglet survival. (2)

Determine the concordance of genetic parameters for piglet survival derived from two different populations of pigs, and the genetic and phenotypic correlates of piglet mortality with other important production traits. (3) Determine whether high genetic merit for piglet survival in crates is also expressed in a commercial outdoor (non-crate) pig system, using a breeding based intervention study to assess the value of selecting dams and sires varying in genetic merit for survival, and confirm the applicability of a breeding index for piglet survival traits in non-crate systems.

The project comprised both analyses of historic breeding company databases, to characterise the direct and maternal genetic influences on piglet survival traits, and collection of novel data in a large scale breeding intervention study to verify the predictions from theoretical genetic modelling. A two-generation breeding intervention study was carried out under outdoor farrowing conditions. In phase 1, 414 litters were sired by Landrace damline boars, selected for either high or average estimated breeding values (EBVs) for maternal genetic effects of postnatal survival. Female piglets weaned from the experimental litters provided 515 replacement females for the next generation. In phase 2, these were bred to Large White boars selected for either high or average EBVs for direct genetic effects on postnatal survival. In the first parity of the second generation, matched mating of high or control groups for direct and maternal genetic effects was carried out. In order to disentangle direct and maternal effects, and to identify interactions between different combinations of direct and maternal selection groups, in the second and third parity cross-classified mating of all four selection groups in direct and maternal effects was carried out. Following completion of the three parities from second generation animals, data on 21,835 individual piglet observations were used in a combined genetic analysis. Bayesian analysis based on a multiple trait model was performed to estimate genetic parameters of survival traits at birth (SVB) and during the nursing period (SVNP), and birthweight (IBW). The heritabilities of survival traits and birth weight were moderate in the range from 0.15 to 0.36. The magnitudes of direct heritabilities of all three analysed traits were substantially higher than reported in the literature. Maternal heritabilities of survival traits and IBW were lower than those for the direct genetic effects and more in agreement with previously published estimates. Genetic correlations between survival traits and birth weight were favourable and significantly different from zero. Direct and maternal genetic effects within trait showed moderate negative correlations ( $-0.36$  to  $-0.45$ ), suggesting negative interactions due to resource constraints.

Over all parities, genetic response to selection of SVNP, calculated as deviation from the control, was positive at 2.6% points, with positive correlated responses of 1.4% points in SVB and 25g higher birth weight. In the first parity, the highest response of SVNP at 3.3% points was obtained, which was associated with genetic improvement of SVB at 1.7% points and an increase in birth weight of 51g. The cross-classified breeding design among selection groups implemented in the second and third parity allowed the estimation of interaction among those groups. Unexpectedly, there was overall a negative response in direct genetic effects of SVNP even when selection was performed only for these effects. In contrast, when considering only dams selected for maternal genetic effects, the direct genetic response in SVNP was positive. This interaction indicates that maternal genetic effects are the first limiting factor for SVNP, suggesting that direct response can only be obtained if sufficient resources for maternal traits are available through simultaneous improvement of maternal genetic effects.

## Conclusions

The genetic parameters suggest that there is substantial potential for genetic improvement of survival traits and birth weight, in both direct and maternal genetic effects, and that this might be especially effective for piglet survival in non-crate, outdoor conditions. The selection for SNVP was successful in practice. Because selection was performed on breeding value estimates based on performance of animals kept under indoor conditions, the obtained selection response suggests that genotype by environmental interactions between indoor and outdoor conditions were of negligible impact. The research showed the importance of selection for maternal genetic effects of piglet survival, which always resulted, independent of the parity and the combination of direct and maternal selection groups, in a favourable maternal response. In contrast, selection for direct genetic effects did not always result in the expected response, in particular when maternal effects were not improved sufficiently to fulfil the requirements of piglets. Therefore, selection pressure on maternal genetic effects should be at least equal or higher than on direct genetic effects on piglet survival.

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## **2. Neonatal Piglet Mortality: outdoor production vs. indoor pen-housing in relation to breeding for improved survival**

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### **Introduction**

Pre-weaning mortality of piglets continues to be a major welfare and economic concern. Environmental modification using the farrowing crate, which involves physical restriction of the sow, raise serious welfare issues and offers no further improvement of survival. A more holistic approach to augment piglet survival, without further compromising the welfare of the sow, would consider the interaction between the sow-piglet unit and their environment and the influence genetic selection strategies might have on improving levels of survival in non-restrictive farrowing systems. National herd recording results for pre-weaning mortality of live-born piglets in the UK suggest that the outdoor environment offers a competitive level of survival (Indoor: 11.8% vs. Outdoor: 10.5%, Meat and Livestock Commission, 2006), and outdoor production systems have grown in popularity (approximately 30% in the UK-Sheppard, 2004). However in indoor loose-housed systems often favourable survival figures are only returned at the experimental level, but not replicated in commercial evaluation (Damm et al. 2005). Alternative farrowing systems have to emulate or surpass survival levels in conventional systems and perform consistently for widespread commercial implementation to be considered. Identifying piglet survival indicators that are influential in these alternative environments is essential to this objective. Further improvement in piglet survival could be attained by incorporating genetic selection strategies targeting piglet survival in non-confined systems.

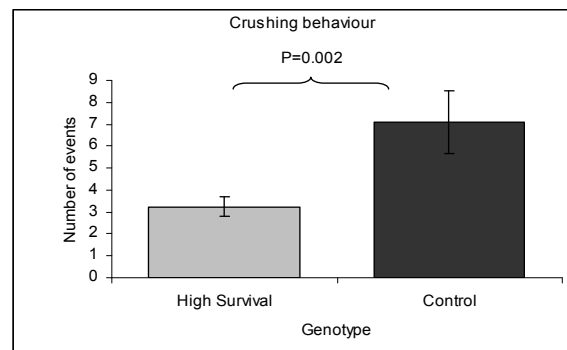
### **Methodology**

Behavioural and physiological indicators of pre-weaning piglet survival were measured on both gilts (N=65) and their piglets (N=757) in a group selected for High (postnatal) Survival (HS) and a Control group (C) farrowing in Indoor loose-housed (I) and Outdoor (O) farrowing systems in a 2x2 design. The gilts were offspring from a previous generation selected for survival traits (Roehe et al. 2008) and bred under outdoor conditions. The O experiment took place on a commercial outdoor pig farm in Aberdeenshire in the UK. Farrowing occurred in double insulated huts, with sloped walls and a floor area of 3.09m<sup>2</sup> (2.22m × 1.39m), roof dimension of 2.22m × 1.22m and a height of 1.09m. At the entrance of each hut was a fender that measured 1.00m × 1.07m and a height of 0.46 m to keep the neonatal piglets within the hut vicinity. Huts were initially bedded with straw to a depth of approximately 10–12cm. This was replenished when needed. The average hut temperature was 18.2°C (±0.21). The I experiment took place on an indoor experimental unit. The farrowing pens were designed to permit loose-housed nesting and farrowing behaviour and therefore gilts were not restrained. The pens (2.3m wide x 3.0m long and 1.2m high) had solid, insulated concrete flooring which was bedded with fresh straw approximately 10-12cm deep, which was replenished once daily after cleaning. There was no designated dunging area, although gilts were encouraged to dung at the front of the pen away from the piglet area. Average ambient temperature was 17.9°C (±0.08) during farrowing. GLMM analysis was used to determine which factors influenced prenatal survival (comparing stillborn piglets with

piglets surviving to weaning) and postnatal survival (comparing piglets that were born alive but subsequently died with surviving piglets). GLM analysis was used to compare indicators at a litter level and to compare gilts. Potential survival indicators measured were based on initial work (Baxter et al. 2008) and included piglet weight and body shape, as measured by ponderal index (PI: birth weight/crown-rump length<sup>3</sup>), body mass index (BMI: birth weight/crown-rump length<sup>2</sup>) and abdominal circumference (AC), piglet temperature and behavioural development (e.g. latency to reach the udder, a teat and to suckle), placental traits and gilt behaviours such as posture changes, crushing and aggression. To determine the influence of genotype and environment on survival indicators and survival per se these factors were fitted into the models.

## Results

Regardless of environment or genotype, important indicators of prenatal survival were body shape and size (PI:  $W_1 = 35.50$   $P < 0.001$ , BMI:  $W_1 = 37.45$   $P < 0.001$  and AC:  $W_1 = 39.97$   $P < 0.001$ ), farrowing birth order ( $W_1 = 10.93$   $P < 0.001$ ) and placental efficiency ( $W_1 = 6.38$   $P = 0.012$ ). Important piglet postnatal survival indicators included birth weight and body shape, thermoregulation and piglet behavioural development. Gilt behaviour affected piglet postnatal survival: piglets that died had mothers that were more careless with their posture changes (unsupported lying:  $W_1 = 6.37$   $P = 0.012$ ), crushed more ( $W_1 = 5.61$   $P = 0.018$ ) and were more aggressive (e.g. Rooting piglets:  $W_1 = 4.94$   $P = 0.026$  and Biting or Mouthing piglets:  $W_1 = 6.90$   $P = 0.009$ ). In the multivariate analysis birth weight ( $W_1 = 12.21$   $P < 0.001$ ) and behavioural development ( $W_1 = 2.99$   $P = 0.084$ ), in conjunction with gilt behaviour during farrowing (support:  $W_1 = 3.91$   $P = 0.048$ , crushing behaviour:  $W_1 = 3.10$   $P = 0.078$ ) were the most important indicators. Indicators were independent of environment, but there were genotype interactions with piglet rectal temperature (2h post-birth:  $W_1 = 5.49$   $P = 0.019$ , 24h post-birth:  $W_1 = 4.92$   $P = 0.027$ ) and time to udder ( $W_1 = 3.98$   $P = 0.046$ ) as survival determinants. Genotype had the greatest influence on maternal behaviour. Regardless of farrowing environment, Control gilts showed significantly more crushing incidents during farrowing (see Figure 1; Mean Deviance Ratio<sub>1,62</sub> = 47.25  $P = 0.002$ ). In the I environment, High Survival gilts were more aggressive to their offspring and were the only genotype to show savaging ( $F_{1,63} = 21.83$   $P < 0.001$ ); 40% of the High Survival, Indoor gilts mouthed or bit their piglets.



**Figure 1: Average number of crushes performed during farrowing by High Survival and Control gilts.**

## Mortality

In the O environment genotype affected the risk of mortality at the piglet level with piglets from Control litters tending to have higher total mortality (stillborn + live-born mortality) than piglets from High Survival litters (C: 17.90% ( $\pm 3.23$ ) vs. HS: 12.21% ( $\pm 3.46$ ),  $W_1 = 3.60$   $P = 0.058$ ). There was no significant difference between genotypes with respect to live-born mortality (C: 12.50% ( $\pm 3.00$ ) vs. HS: 10.08% ( $\pm 3.15$ )  $W_1 = 1.69$   $P = 0.193$ ). In the I environment, there was no significant difference in either total mortality (C: 12.29% ( $\pm 2.69$ ))

vs. HS: 14.86% ( $\pm 3.18$ )  $W_1=0.07$   $P=0.797$ ) or live-born mortality (C: 8.13% ( $\pm 2.08$ ) vs. HS: 11.02% ( $\pm 3.15$ )  $W_1=0.04$   $P=0.842$ ) between the genotypes.

## Conclusion

The reduced mortality observed in the outdoor High Survival population demonstrates the potential for breeding to improve survival - both an economic and welfare trait. Physical, behavioural and physiological indicators of piglet survival were successfully identified, and have provided further evidence of individual characteristics of the sow and piglets that are critical risk factors for piglet mortality. The genetic selection strategy had the greatest effect on maternal ability, with High Survival gilts exhibiting significantly less crushing behaviour. Given that crushing is a major reason for the confinement of sows in crates this is an important result, promoting the use of alternative systems. However, High Survival gilts in the indoor environment showed piglet-directed aggression suggesting a genetic effect on environmental sensitivity. This highlights the importance of behavioural, as well as physiological traits when considering new breeding strategies, as well as signifying the importance of the environment. Improving piglet survival using genetic breeding programmes should be complemented with optimisation of the environment to satisfy the needs of the sow-piglet-farmer dynamic.

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### **3. Neonatal piglet mortality: crates versus indoor pen housing in relation to breeding for improved survival**

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Neonatal piglet mortality is a general problem in sow herds world wide. In DK mortality is now ranging 23 % of total born piglets, and mortality is still increasing with increasing number of born piglets (Pedersen et al., 2006; Weber et al., 2006). This large loss of piglets makes room for large improvements in the production results and thus also in the farmers economics.

So far, what have been done to reduce the neonatal mortality are amongst other thing to crate the sow during farrowing with the belief that this prevents crushing and to give the piglets additional heating in a separated creep area to prevent both crushing and hypothermia. With the latest 10 years increase in mortality these methods have not proven efficient in reducing neonatal mortality. Lately DK has changed the breeding goal from “total born piglets” to “live piglets day 5” in order to put more emphasis on survival in the breeding. However, the question is which traits have been affected by the breeding and whether these traits are equally important for survival in different environments. The aim of the present study has been to collect knowledge that can be used to answer these questions and in the long term be used to asses if the same breeding goal should be adjusted according to the farrowing environment of the sow? For example weather special breeds should be developed when sows are kept crated or penned.

In the present experiment 100 primiparous sows were selected, of which half had a high breeding value for survival until day 5 (H) and the other half had a low breeding value for survival until day 5 (L). Sows were randomly selected within breeding group to farrow in crates (C) or pens (P). Data on individual piglets were collected at birth and included amongst other inter-birth-interval (IBI), birth order, weight at birth, proportion of the piglets, rectal temperature at birth, 2h and 24h after, lactate in cordal blood as a measure of hypoxia during birth and early suckling behaviour. All dead piglets were autopsied. Causes of mortality was divided into stillborn, starvation, crushed, disease and other causes. Potential risk factors of dying were estimated using a GLIMMIXED model. There were no significant effect of housing on the risk of a piglet to be stillborn ( $F_{1,73}=0.1$ , NS), be crushed ( $F_{1,53}=1.4$ , NS) or the risk of piglets to die due to starvation ( $F_{1,53}=0.3$ , NS). More piglets die due to diseases in the farrowing house with pens due to an outbreak of endotoxemia that easily spread between neighbouring pens ( $F_{1,53}=3.3$ ,  $P=0.01$ ). There were no significant differences between the two breeding classes for any category of mortality.

The risk of being stillborn was higher in piglets with a low ponderal index (long skinny piglets) ( $F_{1,937}=20$ ,  $P=0.002$ ), in piglets born late in the birth order ( $F_{1,937}=30$ ,  $P<0.0001$ ) and in piglets born after a long IBI ( $F_{1,937}=7.6$ ,  $P=0.006$ ).

The lower the weight of the piglets the higher were the risk to be crushed ( $F_{1,1050}=18$ ,  $P<0.0001$ ) and to die of starvation ( $F_{1,1050}=19$ ,  $P<0.0001$ ). In addition, the lower the drop in rectal temperature 2h after birth the higher risk of being crushed ( $F_{1,1050}=4.6$ ,  $P=0.03$ ), die due to starvation ( $F_{1,1050}=16.6$ ,  $P<0.0001$ ) and die due to diseases ( $F_{1,1050}=4.9$ ,  $P=0.03$ ). Piglets

with high lactate in cordal blood at birth had a higher risk of dying due to starvation (( $F_{1,1050}=18$ ,  $P < 0.0001$ ).

Despite the fact that part of the mortality occurred after the first days of life the results emphasises that all categories of mortality were influenced by event happening during the very first hours of the piglets life. Birth weight, body temperature 2h after birth and the birth process were all of importance both for crushing, starvation and disease. Neither housing nor breeding value influenced mortality and traits of importance for the piglets' inborn viability. The results emphasise that the microclimate in the pen for the new born piglets is more important for survival than whether the sow is crated or penned. In the future, to increase survival of neonatal piglets emphasis should therefore be on factors such as breeding and/or nutrition that assures birth of heavy piglets and environmental factors that protects piglets from hypothermia *immediately* after birth. Steps to improve the microclimate at the birth site should be taken.

## **4. Piglet mortality on farms using farrowing systems with and without crates**

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### **Background**

Crating sows in farrowing systems greatly restricts their normal behaviour, which is usually justified by the assumption that piglet mortality is higher with loose-housed sows. Based on the results of small-scale experiments showing that this is not the case, farrowing crates were banned in Switzerland in 1997. Since then, many farms have introduced loose farrowing systems, enabling a comparison of piglet mortality in farrowing systems with and without crates based on a large sample size.

### **Methods**

Data of a sow-recording scheme (UFA2000) were analysed using generalised linear mixed-effects models with an underlying Poisson distribution. For the calculations, we had at our disposal all the individual litter data for 2002 and 2003 of 830 farms which took part in the UFA2000 Swiss sow recording scheme. 240 of these farms used loose farrowing pens. The pens had surface areas varying from 5 m<sup>2</sup> to 12 m<sup>2</sup>. Data stemming from farms with loose farrowing pens with an option of confining the sow were excluded before analysis.

In the UFA2000 sow recording scheme, various causes may be given for the death of piglets (crushed, runts, bitten to death, *E. coli* diarrhoea, various). In commercial farms, there is often some uncertainty as to the exact cause of loss. Crushed piglets, however, can usually be readily recognised as such. Therefore, all causes of loss were categorized as 'crushed' or 'other' reasons than being crushed.

### **Results**

Parity, age at weaning and number of stillbirths were nearly identical in both farrowing systems. Litter size at birth and at weaning were the same in both systems. The farrowing system had no significant influence on the total piglet losses. In the farrowing pens without crates, there were significantly higher losses due to crushing, but significantly fewer deaths due to other causes. Moreover, litter size at birth, parity class of the sow (first parity, 2-3, 4-6, 7-8, >8 parities) and their interaction significantly influenced piglet losses.



	Farrowing crates	Farrowing pens
Number of farms	482	173
Number of litters	44'837	8'824
Parity of sow	4,0	4,1
Suckling duration (d)	35,1	35,8
Number of piglets born dead	0,7	0,6
Litter size at birth	11,0	11,0
Litter size at weaning	9,6	9,6
Piglet losses (%)		
Total	12,1	12,1
Crushed	4,5	5,4
Other reasons of death	7,6	6,7

## Conclusion

Our evaluation of the reproductive data of commercial farms showed that no more piglet losses occur in loose farrowing pens common nowadays in Switzerland than in farrowing pens with crates, and that litter size at birth is the main influence on piglet losses.

## Original publication

Weber, R., Keil, N. M., Fehr, M. and Horat, R. (2007) Piglet mortality on farms using farrowing systems with or without crates. *Anim. Welfare*, 16: 277-279.

## **5. Research activities in Norway on sow behaviour, farrowing environment and management:**

### **Piglet mortality – importance of maternal behaviour and investment in the litter, management and factors related to the farrowing pen**

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The maternal behaviour of the sow, the farrowing environment and type of management at the time of farrowing will all have a great impact on piglet survival. In Norwegian, loose-housed sow herds, piglet mortality ranges between 5 and 24 %, and this variation between herds is largely due to differences in management. Generally, crushing and starvation may explain 50 to 80 % of the postnatal piglet mortality, and as much as 60 to 80 % of these deaths occur within the first two or three days after farrowing. An increased management effort within this period is therefore expected to increase the survival rate and give the farmer more pay-off in terms of more piglets weaned.

When sows are kept loose in a farrowing pen, the sow interacts more with the piglets and maternal motivation and protectiveness is likely to have a great impact on piglet survival. Some important behavioural indicators of maternal motivation are: increased nest building activity 5-12 hours before farrowing, degree of communication between the sow and the piglets, how the sows prepare to change posture and the carefulness of lying down movement, response to piglet distress and degree of consistency in the nursing/activity/resting pattern. Together with the more physical traits such as no. of functional teats and milk production, these behavioural traits form an important basis for piglet survival. One major factor that strongly affects piglet mortality and maternal behaviour is the size of the litter.

Increased litter size results in increased piglet mortality from birth until weaning both due to crushing and starvation, lower piglet weight and a lower weight gain throughout the lactation period. Number of piglets not getting access to a teat and not being present at the udder during milk let-down both increase with increasing litter size on day 1 after farrowing. Sows giving birth to large litters show a sharper decline in nursing frequency from the start to the middle of the lactation period and they spend more time on activities not involving the piglets, such as standing, moving, rooting on the floor/litter and are generally more active with the piglets in close proximity. Larger litters are also associated with a lower maternal response to piglet scream test and piglet handling test. Finally, because the sows give birth to larger litters than they can take care of, the farmer has to increase his effort at the time of farrowing to maintain a high piglet survival.

Helping the piglets to get colostrum immediately after birth reduces mortality significantly, whereas other routines such as closing the piglets inside the creep area while feeding the sow do not appear to have any significant effect. Drying and warming the piglets immediately after birth tend to reduce piglet mortality, especially due to crushing. Because of the relatively large potential these rather simple routines may have to improve piglet survival, different types of management or human interference around the time of farrowing should be compared on a larger scale both experimentally and on commercial farms.

Size, width and length of farrowing pens in Norway (on-farm registrations in 113 Norwegian farms) do not appear to affect piglet mortality significantly. However, specific functional elements of the environment are important. Use of farrowing rails along all the sides of the pen results in lower piglet mortality than when no rails are present. Herds that hardly used any bedding in the sow area at the time of farrowing have significantly higher piglet mortality than herds that use a moderate or large amount. There is still a great need to do more systematic work concerning the quality and attractiveness of the creep area and to design a farrowing pen that stimulates the sow to show good maternal behaviour. However, piglet survival is likely to depend more on the maternal traits of the sow and the farmer's effort in saving piglets than on the design of the farrowing pen itself.

## **6. Important pen features and management in farrowing pens for loose housed sows**

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Growing interest of the public in animal welfare issues may in the future lead to a ban on farrowing crates. Development of farrowing pens are therefore needed. Pens that on the one hand side can meet the public and consumers' demand for more welfare friendly housing of farrowing sows and on the other hand side meet the pig producers' demand for an efficient production with low piglet mortality at a low cost.

The birth process itself is one of the largest challenges of the yet unborn piglet. Stillborn piglets have often suffered from lack of oxygen during birth due to prolonged farrowing. Stress of the periparturient sows may be a major contributor to prolonged farrowings. A way to reduce birth problems and thus reduce the number of stillborn piglets may thus be to limit typical stressors around parturition. Two such are when the sows are introduced to the farrowing pen close to the time of farrowing and/or if sows are moved to crates from a loose housing gestation system. Late introduction and crating may also influence maternal behaviour and maternal behaviour may influence the risk of crushing. Pedersen and Jensen (2008) investigated the influence of late versus early introduction to farrowing pens on the progress of parturition and on maternal behaviour. The late introduced sows were not moved to the farrowing pen until day 114 of pregnancy whereas the early moved sows were moved no later than 10 days before expected parturition. The only significant difference found was that sows introduced late showed more postural changes during nest building than sows introduced early whereas there was no effect on maternal behaviour of importance for crushing after birth. Pedersen and Jensen (2008) also investigated if late introduction affected parturition and maternal behaviour more or less when sows were moved to pens compared to crates. The results were clear. The primiparous crated sows had longer birth intervals and more stillborn piglets when moved late to crates compared to pens. This was not the case for multiparous sow experienced with crating from previous farrowings. Thus crating of sows introduced late has negative effects on the progress of parturition and the risk of stillborn piglets, most likely since they experience crating for the first time in their life.

Besides stillbirth, hypothermia and starvation are other major causes of mortality. These causes of death may also be influenced by features in the pen environment. In order to find ways to reduce hypothermia at birth, aspects of the microclimate at the birth site need to be investigated. For newborn piglets heat loss is very critical. In order to prevent this heat loss all farrowing pens are equipped with a heated creep area away from the sow. The piglets however tend to stay close to the sows' udder to get colostrum and the consequence is that they do not stay in the creep area until a few days after farrowing (Hrupka et al., 2000a,b). However at this time heat loss is less critical for their survival. Malmkvist et al (2006) therefore investigated if neonatal survival could be increased by heating up the floor in the whole pen area during the first critical 2 days of life. The floor was heated from 10h into the nest building phase and the heat was turned off 2 days after birth of the first piglet. Since this may cause heat stress of the sows, it was also investigated if floor heating affected stress hormones, oxytocin, the birth process and neonatal viability at birth (Damgaard et al., 2008; Malmkvist et al., submitted). The results showed that in pens with floor heating, earlier

establishment of normal body temperature after birth took place. The normal drop in temperature right after birth recovered faster in the piglets born on the heated floor. The piglets with heated floor also had an earlier colostrum uptake. The time taken before all 15 piglets had suckled for the first time was shorter in piglets with heated floor than without. Also mortality was reduced from 2.6 piglets per litter in pens without floor heating to 1.4 piglet per litter with floor heating. However, when using full floor heating, sows had increased cortisol during parturition, whereas neither oxytocin, the birth process nor neonatal piglet viability were affected. To avoid any negative effect of heat stress only part of the pen should be heated. This is possible when the sow is loose and can choose herself where to lie. However, to be of any help to the piglets, the sows must choose to farrow on the heated floor. Pedersen et al. (2007) therefore investigated if floor heating affected the sows' choice of nesting area in pens with partly heated floor. These pens were divided into a dunging/activity area and a resting area that could be heated or left neutral. The results showed that an equal number of sows farrowed in the two areas. The sows' choice of nest site was not affected by heating of the resting area. However, after farrowing the sows chose to lie more in the resting area when the floor was heated compared to when the floor was unheated, which indicates that the heated floor was not aversive to the sows during parturition. It was therefore concluded that establishment of floor heating can save piglets. However if the floor is only heated in zones, it is necessary to make this area attractive as resting area using other pen features in order to assure that the piglets are born in the heated area.

It has been shown that support during lying down events reduced the risk of piglets being crushed. Marchant et al. (2001) showed that the risk of crushing was only 0.5 % when the sows used support compared to 14 % during unsupported lying down events. Thus, pen features that may reduce crushing has to allow the sow to lie down using support. The question is then how to develop pens that minimize the occurrence of unsupported lying down events. Many pens are equipped with so called farrowing rails that prevent the sows from crushing the piglet against the wall when lying down. In a choice experiment Damm et al. (2006) showed that sows actually avoided lying down against walls equipped with rails whereas they preferred solid walls. By using sloping walls instead of rails it may be possible to avoid many of the unsupported lying events that are risky for the piglets and at the same time the walls still have the same function as the farrowing rails in preventing the sows from crushing the piglets against the wall when lying down there. An attractive lying wall may at the same time be able to guide the sow to lie in a certain part of the pen that contains good pen features for the piglets, for example floor heating as mentioned earlier. Another way to attract the sows to a specific nest area may be to isolate part of the pen in that sows may prefer to nest in enclosed areas. This was investigated by Damm et al. (submitted). Half of the pen area was covered by a roof of artificial leaves and the other half was left open. They observed if sows preferred to nest build and farrow under the roof. There was a strong tendency for the sows to farrow under the cover, however, the effect was not significant. They also showed that the choice of nest site was unaffected by access to straw. Even though sows did not show a strong motivation to farrow under the cover, the experiment did show that sows choose a specific nest site in the pen where they stay continuously during the first 24h after parturition. It was therefore concluded that sows do divide the pen into zones if given the opportunity but the choice of nest site was only mildly affected by nest covering. However other types of isolation or nest cover may be more attractive and further investigations are needed.

The occurrence of risky behaviour for crushing in relation to straw was also investigated. Many studies have shown that sows are highly motivated to nest build (e.g. Jarvis et al.,

2001). It is known that high activity during the nesting phases are related to low risk of crushing (Andersen et al., 2005, Pedersen et al., 2006), and that access to straw can stimulate activity during nest building (e.g. Thodberg et al., 1999). Damm et al. (submitted) showed that the number of near crushing situations was reduced in sows that had freed access to straw. Herskin et al. (1998) found that sows were calmer during parturition when given access to straw and Pedersen et al. (2003) showed that feedback from a nest resulted in earlier colostrum uptake by the piglets. Pedersen and Damm (unpubl) investigated the amount of straw used by sows before, during and after nest building. They showed that sows removed on average 0.5 kg long straw from a rack daily before farrowing and on the days after farrowing. On the day of nest building they removed on average 2 kg straw ranging from below 0.5 kg to 7.6 kg. per sow. According to EU legislation sows must be given access to suitable nesting materials unless the dunging systems prevents this. However due to the above mentioned positive effects of straw it must be recommended that new farrowing pens are designed in a way that allows the use of more than 2 kg. long straw during the days around farrowing.

In order to prevent crushing and assure good access to the sow's udder it is also important that there is space enough in the pen for the sow to lie down freely and for the piglets to nurse undisturbed at the udder and rest in the heated creep area. Moustsen and Poulsen (2004a,b) and Moustsen et al. (2004) therefore measured the physical dimension of 368 sows and piglets. The length (95 % quantile: 200 cm), shoulder (95 % quantile: 47 cm) and depth (95 % quantile: 71 cm) of the sows and piglets was measured and it turned out that today's sows are both heavier and longer than for 15 years ago. Besides the dimension of the sows the space they need for lying down and getting up should also be considered. These were estimated to an average of 32 cm in width and 16 cm in length (Moustsen and Duus, 2006). These space requirements should be included in new pen designs in order to allow free movements of the sows during lying down, getting up and turning around. The space for the piglets should allow free access to the sow's udder. The length of the piglets at 4 weeks of age was on average 56 cm. The lying area should therefore allow space enough for the sow to lie laterally plus the length of a piglet which equals at least 134 cm. The space of the heated creep area should allow at least 10 piglets to lie in partly lateral position at 5 weeks of age. To allow this the creep area needs to be at least 1.3 sqm. This is much larger than today's creep areas that are usually around 0.4-0.6 sqm. The new pens should be designed to incorporate enough space in the creep area for all piglets and space enough to allow piglets' free access to the udder.

Based on this series of experiments on pen features and established knowledge the next step has been to design prototype pens that incorporate all the pen features found important for sows and piglets (Moustsen et al., 2008a,b). Four areas of interest were identified as important to consider in farrowing pen designs. These are, besides the sow and piglets, the hygiene that would be improved through a slatted floor area. Thus, the pens should ensure that the sows' use this area for dunging and not for nesting and resting. Also the ease at which management can be performed should be considered. The pens should allow easy access to the piglets from outside the pens and should be equipped with pen features that can protect the handler from the sow during handling of the piglets. The pens should also be incorporated in the building in a way that minimises unused space in the house in order to reduce building cost.

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## 7. Prototype pens and functional systems

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### Introduction

The final part of a joint research project between the University of Aarhus, the University of Copenhagen, the Danish Society of Animal Welfare and Danish Pig Production was to test a number of prototype pens. The development of the pens was based on the research activities in the first part of the project (Pedersen et al., 2008).

The design focused on the different users of the pen – the sows, the piglets and the staff. For the sows it was important that they could perform nestbuilding, that they could seek ‘isolation’ from other sows at farrowing, that they were calm after the farrowing was initiated and that they when lying down used a sloping wall to help control the movement. For the piglets it was important that they spent the first hours of their life on solid floor close to a source of heating. A few days after birth the piglets were expected to use the creep area. For the staff, safety/protection from sows which might be aggressive is considered important, as well as easy access to the creep areas without having to enter the pens, and high level of hygiene especially on the solid floor, so the time needed to keep the pens clean were minimal.

Five prototype pens for loose farrowing and lactating sows were investigated. The prototypes differed in regard to e.g. available space (square meters), dimensions and size of area with solid floor, number of sloping walls within a pen, position and dimensions of the creep area etc. The aim was to evaluate the function of the pens, and, on the basis of this evaluation, select pen types for further investigation in production facilities where the level of piglet mortality can be established.

### Materials and methods

There were six pens of each design and 9 to 22 sows farrowed in each design. The behaviour of sows and piglets were recorded on a 24 hour basis (MSH-video recording system). In addition, the hygiene of the pens was recorded daily. The production level was not recorded. There was an even distribution of age of the sows between the different pen designs. Data were analysed by generalized linear models, non-parametric test and analysis of variance (Moustsen et al., 2008).

### Results

Sows are very active before farrowing. In this trial, the sows laid down up to 100 times a day before farrowing – regardless of pen type. Half of the sows laid down up to 50 times a day before farrowing. The sows were calmer during farrowing when they had had the opportunity to display nesting behaviour. In the first 24 hours after giving birth to the first piglet, the sows laid down 1-18 times – regardless of pen type.

Sows prefer to farrow isolated and away from other sows. Four of the pen types had a solid floor area with closed pen sides on 2-3 sides. In 80% of the farrowings in these pens, the entire litter was born on the solid floor. In less than 2% of the farrowings in these pens, the entire litter was born on the slatted floor.

As the solid floor in the sows' activity area was heated, the majority of the piglets were born on a warm floor. Previous studies have shown that this has a positive effect on the piglets' chances for survival (Malmkvist et al., 2006).

There is a significantly smaller risk of the piglets being crushed if the sow is supported when she lies down (Marchant et al, 2001). The pens were equipped with sloped lying walls on 1-3 sides to support the sow when she lies down (Damm et al, 2006). In all the pens, 50 pct. of the sows laid down by a sloping wall more than half the times.

In terms of, for instance, labour, it is important to have a good level of hygiene in the pens. In this trial, it was possible to affect the sows' position in the pens when dunging. The sows dunged away from the lying area and partly away from feed and watering places. Furthermore, the sows often oriented towards the inspection alleys when dunging.

This meant that it was possible to a certain extent to influence the direction of the sow's head, whereas the direction of the hind quarters was not affected sufficiently, which contributed to the poor hygiene.

## **Conclusion**

The trial of the proto types generated a great deal of knowledge on the importance of various pen elements to the way the sows, piglets and staff use the pen.

Four of the pen types had different dimensions and were significantly larger (6.5-7.3 m<sup>2</sup>) than, for instance, the recommended traditional farrowing pen with a crate (4.9 m<sup>2</sup>). However, it is essential that the potential be evaluated under Danish production conditions. In order to gain large-scale experiences, the principles and results from the studied pen types should be implemented in farrowing pens in production herds.

In 2008, a new project was initiated aiming at development of production-safe farrowing pens for loose sows in co-operation between Danish Pig Production, pig producers, the equipment industry and Aarhus University, the Faculty of Agricultural Sciences.

In addition to this co-operation-project, Danish Pig Production is developing, evaluating or testing different pen designs for loose (farrowing and) lactating sows in eight-ten production herds.

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## 8. Trends and developments of farrowing pens

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### **Introduction**

During the last decades, there has been a debate whether farrowing sows need access to nest building material and space to be able to perform nest building. In a recent report from EFSA (2007) it is 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 an 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 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 paper is to describe some housing systems that are in line with the conclusions stated above and also how national regulations recently emphasize some of these aspects using Sweden as an example.

### *Changes in regulations*

Since 2007, new regulations on the keeping of farrowing sows apply in Sweden. These new regulations do emphasize the importance of the sow to be 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 is a threat to injury of the manager 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” (autor translation).

§8: “During the week before farrowing sows and gilts shall have access to litter which allows them to carry out nest building behaviour” (author translation).

§10: “At least  $\frac{3}{4}$  of the lying area in a pen with litter for a nursing sow shall be flooring which is not drained. This part of the lying area shall be a homogenous 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 with of minimum 11mm. If the drained floor is made of concrete, the slat with should be minimum 80mm” (author translation).

§11 “Before farrowing, sows and gilts shall be able to use the area in the farrowing pen so that they can perform nest building behaviour” (author translation).

§19 Minimum area for farrowing pen: Lying area 4 m<sup>2</sup>, total area 6 m<sup>2</sup>.

### ***Recent trends in piglet production in Sweden***

Today, farmers commonly choose to use drained flooring on 25% of the lying area, often by the use of 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 is piglet mortality, feet and leg injuries in piglets and their consequences as well as shoulder lesions in sows.

In the piglet production, piglet mortality decreased between 1993-2000 but has since increased (PigWin, 2008), figure 1. The application of crating of sows in some farms has not positively affected piglet mortality.

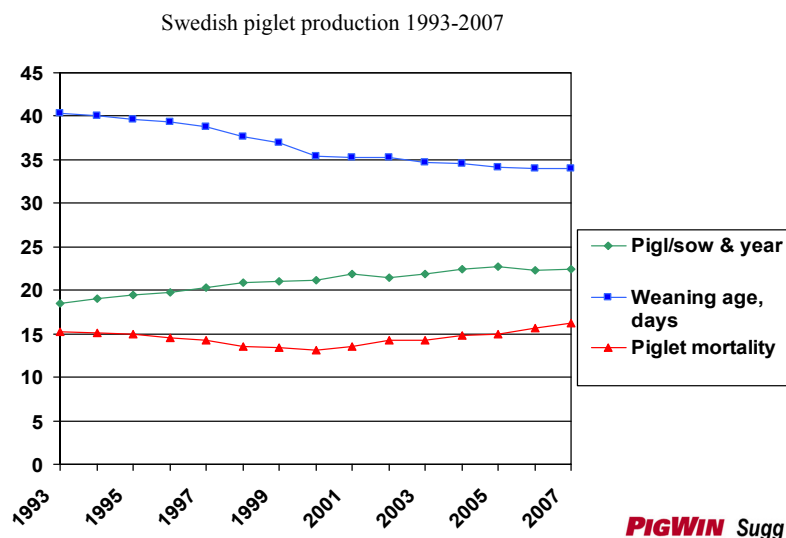


Figure 1.

There is considerable variation between farms in production records (PigWin, 2008) showing a potential for improvements by the application of better housing and management, table 1.

**Table 1.**

<b>Piglet production - averages</b>		<b>2007</b>		
In total 68008 sows		<b>2007</b>	<b>Best 25%</b>	<b>Worst 25%</b>
Average nr of sows and gilts		234	251	178
Produced piglets/sow and year		<b>22,4</b>	<b>24,8</b>	<b>19,0</b>
Nr of litters/sow and year		2,19	2,25	2,06
Proportion of gilt litters, %		25,9	22,4	29,2
Live born/litter		12,3	12,8	12,0
Born dead/litter		0,90	0,91	1,0
Nr of weaned/litter		10,3	10,9	9,6
Weaning age, days		34,0	33,4	36,2
Piglet mortality, birth-weaning		16,2	14,4	19,5
Returns, %		9,0	6,2	12,2
Daily growth from weaning-delivery, g		426	463	407

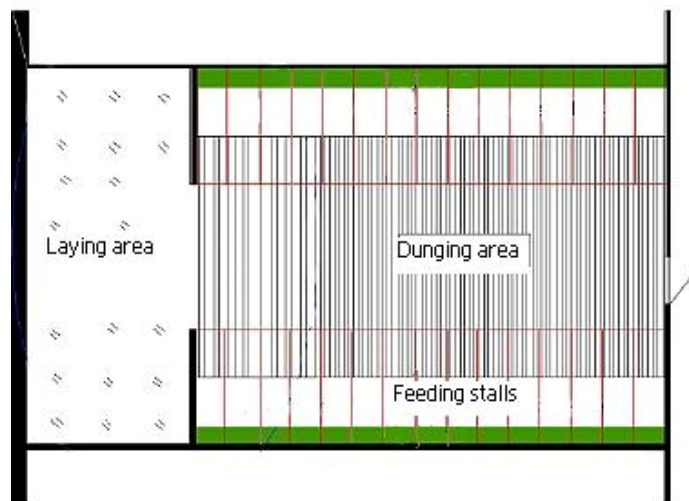
### ***Housing systems***

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 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 are present.





**Figure 2. Group housing system for sows with individual feeding stalls and communal laying and dunging area.**

**a) Group housing with individual feeding stalls**

Individual feeding stalls confine the sows temporarily during feeding preventing dominant individuals to chase 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 itself 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 2. Feeding stalls can also be used in combination with deep straw bedding. Total free space available (excluding feeding stalls) is commonly 2,25 – 2,8 m<sup>2</sup> per sow depending on group size. If stall width is minimum 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.

***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.

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-crushing rails around the walls and a heated creep area for the piglets (figure 3.). Traditionally the pens had access to a dunging alley with scrapes

but in newer systems the floor is mostly partly slatted. Beneath the slatted flooring scrapes 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 temporary crate structure made by moving a partition into place at the time of farrowing (figure 3.) This reduces the total space available when the sow is loose.



**Figure 3. To the left: Farrowing pen with anti-crush rails. To the right: Farrowing pen with gates that can be used for contemporary fixation of the sow.**

In the mid 80ies, 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 as these systems operate very differently compared to conventional ones, 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 out. Thus, many that did not find practical ways of managing the herd re-converted to conventional systems but those that found out how to manage stayed on. The knowledge required needed to manage the system is different that for conventional systems as is the need for large quantities of straw (1000 kg – 1500 kg per sow and year (Algers, pers. comm.) why there is no “natural” spread of the use of these

systems. There has been a knowledge transfer of the operation of such systems to the USA (Halverson, pers. comm.) why many such systems now are used in the USA. 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. In this system the sows are moved to the big pen some days before farrowing and along the walls a cubicle for each sow is put up. 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 prevent 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.

The systems are described in detail by Algers et al. (1991), Braun and Algers (1993) and by 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 4 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 is abandoned by the 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) found that grouping sows before farrowing caused considerable less aggression than when grouping after farrowing. Wülbers-Mindermann (1992) found that cross suckling occurs in group housed sows with litters, but that it did not cause any detrimental effects as refers to mortality or piglet growth but it could be stressing 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 the 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 single in individual pens. In the study it was concluded that group housed sows had a slightly higher piglet production per sow and year at 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 housing group reached 25 kgs at average 5,3 days earlier (see Table 2). This is probably due to the significantly lower incidence of weaning diarrhoea in group housed sows (Table 3).

**Table 2. Herd average comparisons: The Swedish deep-bedded group housing system for lactating sows versus loose housing of single sows.**

	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 kgs, 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)

From Mattsson, 1996

Several of the farms with group housing produce successfully at 22-25 piglets per sow and year which show the potential for the system. It should also be born 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.

**Table 3. Incidence of weaning diarrhoea and consumption of antibiotics and chemotherapeutics in different pig weaning systems.**

	Group housing	One unit pen	Weaning pen
No of herds	14	18	17
% treated piglets	21a	59b	71b
Kg medicated feed/sow and year	78a	278b	277b

Differences a-b,  $p < 0.05$ .

From Holmgren & Lundeheim, 1994

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

## Conclusions

Farrowing systems should allow for the handling of destructible nest material to enable investigation and manipulation activities. They should further allow for the sow's nest building behaviour to be performed and also if possible to keep sows in stable groups.

## References

EFSA report



## 9. Welfare and economic aspects of non-crate farrowing systems

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### Introduction

Farrowing and lactating sows are usually kept in crate systems. The restriction of the sow's movement causes a number of welfare problems e.g. no opportunity for nest building and a high prevalence of teat lesions. Keeping sows in free farrowing systems may result in higher pre-weaning piglet mortality and higher work time requirements. In our study we compared eight types of farrowing systems (3 pen systems and 5 crate systems) with regard to behaviour, animal health, performance, working time requirements, economic aspects and compliance with the animal welfare legislation. The results of the free farrowing systems will be presented in this paper.

### Materials and method

Data were collected from June 2005 to December 2006 in an Austrian commercial sow unit. The herd (n=600 sows; LW x LR x Duc) was batch farrowed in a four-week cycle. Piglets were weaned at 3 weeks of age. Three types of free farrowing pens (FS1-FS3) were investigated using a balanced incomplete bloc design:

- FS1:** 7.6 m<sup>2</sup>, lying area with concrete floor, separate dunging area with slatted floor; anti-crushing bars, provision of a minimum of straw
- FS2:** 4.9 m<sup>2</sup>, rectangular, slatted floor, no provision of straw, anti-crushing bars and bars to direct lying behaviour of sows
- FS3:** 4.2 m<sup>2</sup>, trapezoid, slatted floor, no straw, anti-crushing bars

The behaviour of sows and litters (FS1: 20, FS2: 23, FS3: 24) was observed indirectly by means of a digital video recording system. Generalized Mixed Models (SAS 9.1) were used for statistical analysis of the general activity (walking, standing, sitting, lying). Additionally lying down and standing up of sows, use of creep area and situations (n=156) in context to crushing of piglets were analysed.

The skin of 170 sows and litters (FS1: 50, FS2: 52, FS3: 68) was inspected for lesions on days 1 and 26 and on day 3 after farrowing. Mean focus was given to injuries on legs, spine and udder. Data were analysed by Logistic Regression (sows) and PROC GLM (litters). Piglets which died during the experimental period (n=507) were analysed for cause of death by post-mortem analysis and Logistic Regression. Additionally the cleanliness of sows, piglets and the pens were evaluated.

System related work time requirements were measured on the level of work elements. Production data collected from the farm recordings (piglets born, piglets weaned per litter, weaning weight, pre-weaning mortality) were analysed by GLM and GENMOD. Economic key data (system related costs, output and gross margin) were calculated.

## Results

Sows in the enriched pen (FS1) were more active during the farrowing and lactation period compared to sows in FS2 and FS3. The activity of the sows was highest during the last 24 hours before farrowing indicating nest building behaviour. The lowest activity was found in the 24 hours after farrowing irrespective of the type of farrowing pen. In FS1 less changes of lying postures were observed during the first 24 hours ante partum. Sows in FS1 tend to recover more quickly after farrowing. Slipping when standing up and lying down was frequent (35-45 %) and did not differ between pen systems. The use of the creep area was significantly better in FS1 compared to FS2 and FS3. From 60 to 80 % of situations dangerous to piglets were observed during farrowing (up to 37 % in FS1) and within 24 hours post partum. In FS3 more than 37 % of the critical situations happened later than 24 hours after farrowing. Changes of lying postures are most dangerous for piglets. In all systems the centre of the lying area is the most critical sector for piglets.

The lowest prevalence of severe lesions of sows at the udder and the legs was found for FS1 (solid floor in the lying area); no difference was found between both free pens with slatted floors (FS2+FS3) and crate systems. The prevalence of claw lesions in piglets was lowest in FS1. However, skin lesions at the legs proximal of the claws were more frequent in this system (especially at carpal joints). Piglets from fully slatted pen systems (FS2-FS3) did not differ from crate systems in the number of claw lesions of piglets.

No difference between the free farrowing systems were found in the number of piglets weaned per litter (FS1: 8.87; FS2: 9.05; FS3: 9.29), in piglet loss (23.12/20.96/19.09) and in proportion of crushing (49.1/52.1/53.0). The number of piglets weaned per litter was higher (9.43-9.73) and piglet loss was lower (15.54-18.83) in crate systems compared to free farrowing systems. The pen related work load ranged from 41.9 (FS3) to 63.1 (FS1) minutes per sow and lactation period. Fully slatted pen systems (FS2+FS3) did not differ from crate systems in work time requirements. The gross margins (output minus direct and other variable costs) of FS1-FS3 were 318/375/377 EUR per sow and year (crate systems: 382-412 EUR).

## Discussion and conclusions

Pre-weaning piglet mortality in the free farrowing systems investigated was high due to a high risk for piglet crushing. In order to minimize overlaying of piglets the pen layout has to be optimized in terms of size, arrangement and micro climatisation of lying area and creep area. Care at farrowing has to be adapted to free farrowing conditions. Restlessness and stress of sows must be avoided. Frequent interventions during and after birth provoke posture changes of sows with high risk for piglet crushing.

In order to avoid injuries at claws and carpal joints of piglets special attention has to be given to the quality of both concrete and slatted floor elements. The activity of sows prior to farrowing indicates nest building behaviour. An adequate amount of straw should be provided in this period. From an animal health and welfare point of view fully slatted free farrowing pens with less than 5.0 m<sup>2</sup> and no provision of straw is no alternative to crate systems. Specific conditions (management, climate, attitudes of stock persons, etc) of the experimental farm could have a considerable effect on the results of comparative studies on crate and non-crate systems. Further research should be focussed on the improvement of non-crate farrowing systems rather than on comparison of crate and non-crate systems (apples and oranges).



## **10. A producer's perspective on farrowing pens for loose housed sows**

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### **Summary**

50 years ago loose nursing sows were common. A crate made of wood or iron was placed in the pen during the actual farrowing which usually was watched over day and night. During the last 30-40 years the farrowing pen with crates has been dominant. With constant adjustments and improvements the farrowing pen has helped improve the production in the sow unit. Due to the society's growing focus on animal welfare, it is no longer up to the farmer alone to decide how to design his housing systems.

In more and more countries, laws about loose, gestating sows are imposed. There is no doubt about the fact that soon a law demanding loose, nursing sows will be imposed as well. The wage costs/expenses and the number of sows in each individual herd, makes it unrealistic to go back to the old-fashioned day and night surveillance.

My idea of what future will bring is tethering of the sow only during a small period of time that is 4-7 days after the farrowing. This will increase the security for the staff as far as aggressive sows concern. It should be possibly the win the society's acceptance in this area. On the other hand there are no good arguments for using crates the last 3-4 weeks of the nursing period.

When the dung behaviour of the sow can no longer be controlled, it is not realistic to use solid floor in the pen. The time is not right for bringing back the broom and the shovel. Therefore the pen floor is the big challenge. A drained floor better than the solid floor must be developed.

Several opposing interests require compromises. But if the same amount of resources that has been used over the last 30-40 years to develop the farrowing pen with crates, will also be used in the future to develop a farrowing pen for loose, nursing sows, I believe we will succeed.





## **11. The Danish Animal Welfare Society's perspective on farrowing pens for loose housed sows**

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The Danish Animal Welfare Society (DAWS) is currently running a campaign promoting a ban on crates (April to October 2008). As documented by numerous scientific investigations and reviews e.g. by AHAW the welfare of the crated sow is extremely poor. So far the only valid argument from a welfare perspective in favour of crates has been the concern for piglet survival. This argument is no longer valid. In particular, DAWS has noted that a very large Swiz investigation using over 50.000 litters from over 600 farms showed the same piglet mortality rates in pens and crates (1). And that AHAW using this investigation and others in their 2007 report state that piglet mortality need not be larger than in crates, if pens are sufficiently large and well designed (2).

As alternatives to crating DAWS suggest that sows are loose either outdoors on pasture, or indoors in good pens. In our campaign we have chosen not to give specific suggestions for alternative pens. It is clear that with the current very limited level of experience in Denmark, loose housing of farrowing and lactating sows is a challenge. And sensitive to e.g. management and other factors beyond those associated with the specific pen designs. In order not to take responsibility for important choices that farmers need to make, we have kept our recommendations very general.

Housing sows outdoors in huts gives sows many welfare benefits. Therefore the meat-product label administered by DAWS ("Anbefalet af Dyrenes Beskyttelse", i.e. "Recommended by DAWS") requires that sows farrow and lactate on pasture. DAWS is aware that outdoor production also involves many challenges in relation to animal welfare. We are currently undergoing a thorough review of the label demands and we are establishing a development centre in collaboration with Friland (distribution company) in order to meet some of these challenges.

Housing farrowing and lactating sows in indoor pens is currently not a housing method that is included in the label. So far, in Denmark there is a very limited production using indoor loose housing of farrowing and lactating sows. And from a welfare perspective pens have been of extremely varied quality. DAWS wants to keep high demands to the labelled production, and therefore currently maintains the requirement that sows need to farrow and lactate outdoors.

For DAWS it is important to emphasise the fact that "loose-housing of farrowing and lactating sows" covers a great number of accommodations and designs. There are many different kinds of pens - each making more or fewer compromises on various aspects of the designs - and hence on the welfare considerations. In Denmark there is a special challenge in that Danish Pig Production is very intensive and has great competing ability on the global market. Important contributors to this competing ability are very low time use per animal, very limited use of space per animal and extremely large litters. Which in turn means e.g. use of slatted floors, little use of straw, small pens, more vulnerable piglets etc. The previously mentioned Swiss investigation has shown that sows can be loose housed without (more) piglets dying because of it. But it is a challenge to implement this in a Danish production setting.

In the current campaign DAWS is working for a legislative demand for loose housing. Not a demand to the individual farmer that he/she let his/her sows loose tomorrow or next week. But a demand that within a set date in the (not too far) future crating must no longer be practised. DAWS believes that this will put pressure on the pig industry (and other parties such as authorities, funds, researchers etc.), and that it will speed up the development of a system that can work in a Danish production setting.

That this is realistic is indicated by a recent investigation in a Danish herd showing no difference in piglet mortality rate between crates and pens and a mortality rate below the national average. However, should it not be possible to maintain the position as one of the world's largest pig meat exporters, DAWS would rather see a reduction in competing ability than a continued use of farrowing crates.

DAWS is continuously involved in projects aiming at loose housing of Danish sows. In these projects we try to influence the working processes to include the following considerations:

#### *Main principles*

- Use "carrot rather than stick" to control behaviour
- Stimulate and allow sow and piglet behaviour important to the animals
- Stimulate and allow behaviour of particular relevance for piglet survival

#### *More specifically*

- Space (e.g. for zones within the pen and for sow turning)
- Solid floor (for comfort and to facilitate straw provision, nesting etc.)
- Floor quality (material, surfaces, bedding for comfort, non-slip properties, and reduced risk of shoulder sores)
- Zones (e.g. for resting and eliminating)
- Nesting materials (biologically relevant amounts and types, appropriate slurry system)
- Support for lying down (no rails as sow so not like to lie down on rails)
- Possibility for thermoregulation

#### *Other considerations*

- Safety for stockpeople (also an animal welfare issue)
- Sow control over nursings (space, sow area)
- Group housing
- Birth to slaughter pens

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## 12. Challenges regarding pen design, productivity and experiences related to production of pork for the global market

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In Denmark, 75 pct. of the pregnant sows are housed in loose-housing systems. For the lactating sows, it is only approximately five percent, which are housed in loose-housing systems – including outdoor and organic production.

So 95 pct. of the lactating sows are housed in crate systems. However, in recent years there have been efforts in assuring sow and piglet welfare in the crate systems, and this work is intensified in the last year. There are recommendations for the dimensions of the crates, the creep areas, the solid floor and the pen size, and there is an ongoing dialogue with the inventory companies.

If the lactating sows are to be loose housed in Denmark, it is likely to be in an indoor design. For the last five years the number of sows outdoors has decreased. The reasons are e.g. increased interest rate, increasing herd sizes, lower production level outdoors, more strict regulation of fencing, available area, regular movement of huts etc. The organic production has increased. However, the number of sows in organic production is less than one percent of the Danish sow population.

In Denmark, the population has been stable and approximately 5 mill people for many years. In contrast, the pig production has increased significantly during the last 30 years. In 1970, the production of pigs in Denmark was 11.7 million a year. In 2001, it was 22.9 million and by 2007, this had increased to 25.8 million. At the same time, the number of pig herds has decreased from above 45,000 herds in 1985 to less than 10,000 herds in 2005. So herd-sizes have increased, and in 2006 25 pct. of the sow herds had more than 400 sows.

The litter size and production levels are high (Table 1), which is important for Denmark in order to compete on the global market, and the global market is important for a country which produces approximately 5 pigs a year per inhabitant.

**Table 1. Production level in Danish sow herds, 2007 (Sloth & Berthelsen, 2007), Sloth (2008))**

	<b>Average</b>	<b>25 pct. best</b>	<b>Best 5 herds</b>
Weaned/sow/year, no.	26.0	28.8	31.2
Litters/sow/year, no.	2.23	2.31	2.4
Liveborn/litter, no.	13.6	14.2	14.7
Stillborn/litter, no.	1.7	1.7	1.7
Weaned/litter, no.	11.7	12.5	13.8
Total mortality/litter, pct. <sup>1</sup>	23.5	21.4	15.9

<sup>1</sup> Calculated as:  $(100 * (1 - \text{weaned per litter} / (\text{total born per litter})))$

Pig producing countries can be divided in to three groups according to the average cost per kilo deadweight. The group with the lowest costs includes Brazil, US and Canada. The middle group consists of Denmark, Holland, Belgium, France and Spain, and the group with the highest costs includes Germany, Ireland, Sweden, Austria, UK and Italy. Given the size of the population in Denmark, the export is very important, and the most important competitors for

Danish pork at the export markets are Brazil, US and Holland. For Denmark, in order to be able to meet these competitors, focus on costs is crucial.

A comparison of production results between Denmark, Austria, Germany, Sweden and UK showed that 'piglets born alive per litter' is 1.3 to 2.6 higher and the number of piglets weaned/sow/year is 3.2 to 4.5 higher in Denmark compared to the other countries. In Denmark, the average work hours per sow/year is 10.4, whereas it is 15 hours/sow/year in Sweden and 19 hours/sow/year in the UK.

### Challenges

Herd sizes are expected to increase from 400 sows to may be 2,000 or more sows per herd. The labour force is changing from Danish to a majority from e.g. Eastern European countries. The costs have increased significantly more than the return per sow. If costs and return was indexed to '100' in 1981, the cost-index in 2006 was '196' whereas the return-index was 89.

### Summary

Crates are the most common housing system for sows in Denmark, where 95 pct. are housed in crates. With a population of approximately 1,000,000 sows - we have about 295,000 crates. The competition on the global market increases the focus on costs which causes increases in herd sizes to obtain large-scale benefits. The farmers can't afford large risks, so they are reluctant to implement loose housing systems, until these systems have been tested in large scale – and it is difficult to find producers to test systems in large scale because so few herds have experiences with loose housing of lactating sows.

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