Effects of space allowance on the welfare of dry sows kept in dynamic groups and fed with an electronic sow feeder

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Abstract

The minimal legal space allowance for grouped pregnant sows in the EU is 2.25 m²/sow. The effect of higher space per animal on agonistic behaviour and social stress of animals living in dynamic groups is not known.

Two groups of 34 pregnant Belgian Landrace sows were housed in two pens of respectively 102 m² (3 m²/sow) and 76.5 m² (2.25 m²/sow). Each sow lived there for 15 weeks. Sows were fed through an electronic sow feeder. According to the dynamic system, one third of each group (i.e. 11 or 12 nearly parturient sows) was replaced every 5 weeks by the same number of recently inseminated sows. Welfare indicators were collected during six of these 5 week-periods: performance, agonistic behaviour, skin lesion score and salivary cortisol. No differences were observed for production parameters, or for fighting activity. However, the mean number of one-way aggressions, when observed during 2 h-periods at 3 and 8 days after grouping, was significantly lower in the large pen than in the small one (respectively 16/C6 2 versus 26/C6 3, p < 0.01, and 10/C6 2 versus 20/C6 5, p < 0.05). The mean number of injuries was also lower with the 3 m² space allowance, when collected on the introduced sows one, 2 and 3 weeks after grouping. Some contradictory differences in salivary cortisol were noted 2 and 26 h after mixing, but without reaching statistical significance. An available area 33% higher than the EU legal minimum reduced agonistic behaviour and consecutive wounds and thus induced better welfare conditions for sows living in dynamic groups and fed with an electronic sow feeder. The impact on productivity and social physiological stress need further research.

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1. Introduction

Housing systems for pregnant sows are a contemporary animal welfare issue, particularly in Europe and North America (Mac Glone et al., 2004). By 2013, stall housing throughout gestation will be banned for pregnant sows in the European Union (directive 2001/88/CE) and sows will have to be kept in groups at least from 4 weeks after insemination till 1 week before parturition. The minimal legal space allowance will be 2.25 m²/sow and 1.64 m²/gilt. When the number of sows or gilts in the group is less than six individuals, this minimal legal space allowance will be increased by 10%. It can be diminished by 10% when the group is bigger than 40 animals. However, appropriate individual space allowance for sows kept in groups remains scientifically undefined (Weng et al., 1998). It encompasses different factors, i.e. physical space related to animal size but independent from group size, and behavioural space that animals must share, for social interactions involved in establishing hierarchy for example, that can depend of the group size (Nicks et al., 2002).

Housing sows in groups enables them to interact with each other, pigs being gregarious animals, and perform other natural behaviour patterns, like pen investigation (Gonyou, 2001). However, group-housing systems might bring welfare issues that should be reduced. Actually, feeding competition and social instability linked to mixing unfamiliar animals induce agonistic interactions whose consequences are detrimental for the welfare of sows (Meunier-Salaün et al., 2002).

The use of stable groups, where the sows remain together throughout gestation, reduces social instability as compared to dynamic groups, where the composition of the group changes at regular intervals (Durrell et al., 2002; Meunier-Salaün et al., 2002; Rhodes et al., 2005). However, dynamic groups allow creation of larger groups of animals (Bartussek et al., 2000) which could offer a more stimulating social and physical environment (Durrell et al., 2002).

In the early 1980s, group housing combined with electronic sow feeding (ESF) was introduced. This system provides some of the advantages of individual protection during the feeding activity, while furnishing animals with environmental diversity and freedom to move (Jensen et al., 1995). However, as sows are fed sequentially, a feeding order has to be formed and competition is still present, characterised by a waiting queue at the entrance of the ESF that can generate aggressive behaviours and vulva biting (Van Putten and Van De Burgwal, 1990).

Different systems of welfare assessment have been developed in recent years in Europe. These are based on welfare indicators linked to the production system, husbandry practices, health or animal behaviour (Johnsen et al., 2001). The goals of these systems can be multiple: to certify a welfare level, to compare the welfare of different systems or to develop new advisory tools to allow producers to identify, foresee or correct welfare related issues (Johnsen et al., 2001). The major categories of welfare measurements are as follow (ScVC, 1997): behavioural measurements (abnormal behaviour, aggressiveness, fear behaviour, etc.), physiological measurements (hypothalamic-pituitary-adrenocortical activity, catecholamines, heart rate, etc.), immune response (ratio of neutrophils to lymphocytes, activity of certain populations of lymphocytes, etc.), injury and disease, growth, reproduction and life expectancy.

Indicators from these four categories (performance, behaviour, health and physiology) were used to compare welfare conditions of sows housed in dynamic groups and fed with an electronic sow feeder, according to two different space allowances.
2. Materials and methods

2.1. Animals

Two groups of 34 pregnant sows (Belgian Landrace) were housed in two adjacent pens providing either 76.5 m² (i.e. 2.25 m²/sow) or 102 m² (i.e. 3 m²/sow) (Fig. 1). Each sow stayed 15 weeks in one of these experimental pens. According to the so-called “dynamic system”, one third of the sows (11 or 12 sows) were replaced every 5 weeks by the same number of freshly inseminated ones. Prior to entry, incoming sows were housed in individual stalls. Entering sows were balanced between the two pens according to age, weight and parity. Each time the new groups were constituted, one third of the sows were thus 10 weeks pregnant, another third 5 weeks pregnant (all these sows are called “resident”), while the last third consisted of “incomers”, recently pregnant. Situated in the same building, the two pens were identically divided into a straw bedded resting area and a concrete dunging area equipped with two drinkers. Sows were fed in each pen with an identical “Electronic Sow Feeder” system (ESF), situated in the concrete part of the pens and enabling each animal to take alone an adapted daily meal (NE: 8.68 MJ, CP: 14.0%) in a safe area. The sows had a visual contact with a boar living in a pen between the two groups and used to detect return to oestrus. Climatic conditions were measured automatically regarding temperature and were identical in the two pens (17.7 ± 4.7 °C). Straw was added every week.

2.2. Measurements and procedure

2.2.1. Performance

Each sow was weighed and her backfat thickness at the P2 position was ultrasonically measured when entering and when leaving the group. Prolificacy of sows living during their entire pregnancy under experimental conditions (i.e. those concerned by the four first groupings) was assessed by counting the number of piglets born alive or dead, and the number of weanlings. Litters were also weighed at birth.

Fig. 1. Experimental pens.
2.2.2. Ethology: agonistic behaviour

Grouping takes place at the beginning of the feeding cycle, i.e., 13:00 h. Fights and one-way aggressions were counted during 2-h direct observation periods (all animals and continuous recording), by two observers situated on an elevated platform. Each of them counted behavioural items occurring in one of the two pens during 2 min and the observers switched afterwards. Observation periods were programmed just following grouping and later, i.e., 24 h, 48 h, 72 h, 8 days, 15 days and 22 days after. Fights were defined as an aggressive behaviour (bite or knock) performed by a sow on another one, which answered by an aggressive behaviour. One-way aggression was defined as an aggressive behaviour (bite or knock) performed by a sow on another one, which showed a flight reaction. Actors were identified by colour marks, according to their status (‘‘resident’’ or ‘‘incomers’’). Localisation (straw or concrete area) of the agonistic encounters was also recorded.

2.2.3. Health: skin lesion score and morbidity

Skin lesions of the ‘‘incomer’’ sows were scored before entering the group and 2, 9, 16 and 23 days after grouping. Severity of these lesions was categorised as ‘‘superficial’’ (red lines, no blood) or ‘‘deep’’ (open wound, coagulated blood). All these lesions were counted following a standardized screening of predetermined body parts. Health management of sows was also assessed by recording medical treatments.

2.2.4. Physiology: salivary cortisol

Six incomers and six resident sows of each group were randomly selected for salivary cortisol testing. Two hours before grouping, and also 2 and 26 h after grouping, they were given a cotton bud to chew to collect their saliva. The buds were placed in special centrifuge tubes and kept on ice until centrifuged. Afterwards, saliva was stored at −20 °C until assayed for cortisol. A home-made radioimmunoassay (J. Sulon – laboratory of Physiology of Reproduction – University of Liège) was performed on 50 µl of saliva free cortisol samples in competition, with HPLC preparation of cortisol-3CMO coupled with 2-[125]Iodo-histamine as a tracer, for specific antibodies raised against cortisol-3CMO-BSA (Sulon et al., 1978). The incubation conditions were overnight at room temperature.

All these data were collected for six groupings, thus during a 30-week period. Statistical inferences were made about the data by using a mixed linear model (Mixed procedure, SAS Institute Inc., USA). This model is particularly interesting if data could exhibit some correlation, like in our study (i.e., sows of the same group and repeated measures made on the same animals or in the same groups). The effects of space allowance on different welfare measurements were thus tested by taking other independent variables into account: grouping number, surface type (aggressive behaviour), actors’ category (aggressive behaviour and salivary cortisol) and time of measure.

Differences in the frequency distribution of agonistic behaviours among pairs of sows according to space allowance and the type of surface (straw or concrete) within pens were analysed using Chi-square test. Observed and expected data were indicated in the comparative evaluation. Expected data were obtained assuming interactions are equally likely to occur between incoming and resident sows (balanced according to number of resident and incoming sows). When a group is made of 11 ‘‘incomers’’ and 23 ‘‘resident’’ sows, the numbers of possible pairs are 55 (11 × 10/2) for ‘‘incomer-incomer’’, 253 (23 × 22/2) for ‘‘resident-resident’’ and 253 (11 × 23) for ‘‘incomer-resident’’. Considering that the total number of possible encounters is 561 (34 × 33/2), the proportions of expected encounters are about 10% (55/561) for ‘‘incomer-incomer’’, and 45% (253/561) for ‘‘resident-resident’’ or ‘‘incomer-resident’’. The same calculation can be done for expected data between straw and concrete area, balanced according to surface (concrete or straw area divided by total pen surface, i.e. 76.5 or 102 m²).

3. Results

All the results are given as ‘‘mean ± standard errors’’. 
3.1. Performance

There were no significant differences in performance according to the available area (Table 1).

3.2. Ethology: fighting activity

Fighting activity was not significantly different between sows of the two pens ($F = 0.07$, $p = 0.79$, Fig. 2). A greater available surface did thus not have any impact on fighting.

The effect of the observation time was significant ($F = 45.00$, $p < 0.001$). Most fights occurred the day of grouping, i.e. $11 \pm 1.5$ fights/2 h, compared with only $1 \pm 0.1$ fight/2 h from the day after grouping till 3 weeks after grouping ($p < 0.001$).

The actors’ type had a significant impact on fighting activity ($F = 14.93$, $p < 0.001$). The day of mixing, observed fight proportions (OF) amongst types of sows were significantly different

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Table 1
Zootechnical performances of sows kept either with a 3 m²/sow or a 2.25 m²/sow space allowance (mean ± standard error between sows)

<table>
<thead>
<tr>
<th></th>
<th>3 m²/sow</th>
<th>2.25 m²/sow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sows</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>Weight gain (kg)</td>
<td>$61 \pm 1.7$</td>
<td>$57 \pm 1.51$</td>
</tr>
<tr>
<td>Backfat thickness gain (mm)</td>
<td>$7.3 \pm 0.5$</td>
<td>$6.9 \pm 0.6$</td>
</tr>
<tr>
<td>Piglets born alive</td>
<td>$11.3 \pm 0.4$</td>
<td>$11.5 \pm 0.4$</td>
</tr>
<tr>
<td>Piglets born dead</td>
<td>$0.4 \pm 0.1$</td>
<td>$0.7 \pm 0.2$</td>
</tr>
<tr>
<td>Weaned piglets</td>
<td>$10.2 \pm 0.4$</td>
<td>$9.8 \pm 0.3$</td>
</tr>
<tr>
<td>Litter weight at birth (kg)</td>
<td>$17.323 \pm 0.472$</td>
<td>$16.851 \pm 0.580$</td>
</tr>
</tbody>
</table>

* During group housing.

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Fig. 2. Fights between sows given either 3 m²/sow or 2.25 m²/sow.
(\(p < 0.001\)) than expected ones (EF). This was especially the case for incoming sows who fought between themselves more frequently than expected (43% (OF) versus 10% (EF)) and for resident sows who in contrast fought between themselves less frequently than expected (7% OF versus 45% EF). The difference was less pronounced for fights between an incoming and a resident sow (50% OF versus 45% EF).

Fighting activity was significantly influenced by surface type \((F = 9.25, p < 0.01)\). Fight distribution according to the type of surface (straw or concrete) within pens was not different for the sows given 3.0 m\(^2\) (29% OF versus 24% EF on concrete and 71% OF versus 76% EF on straw, \(p > 0.05\)). However, fights were more frequent than expected on concrete (and thus less on straw) for the sows given 2.25 m\(^2\) (41% OF versus 24% EF on concrete and 59% OF versus 76% of EF on straw, \(p < 0.01\)).

### 3.3. Ethology: one-way aggressions

One-way aggression frequency was slightly different according to the grouping number \((F = 2.43, p < 0.05)\).

The effect of the observation time was also significant \((F = 18.62, p < 0.001)\). Most one-way aggressions occurred the day of grouping and 2 days after, i.e. respectively 50 ± 5 and 43 ± 8 aggressions/2 h, compared with the other days 16 ± 1 aggressions/2 h \((p < 0.01)\).

Living on a greater surface reduced sows’ aggressive behaviour significantly \((F = 5.28, p < 0.05)\). As shown in Fig. 3, one-way aggressions were not different between the two pens neither the day of mixing nor the 2 following days. However, they were more frequent 3 days \((26 ± 3 \text{ versus } 16 ± 2, F = 18.48, p < 0.01)\) and 8 days \((20 ± 5 \text{ versus } 10 ± 2, F = 8.07, p < 0.05)\) after mixing for the group allowed 2.25 m\(^2\)/sow. There were no more differences 15 and 21 days after mixing.

![Fig. 3. One-way aggressions between sows given either 3 m\(^2\)/sow or 2.25 m\(^2\)/sow.](image-url)
The actors’ type had a significant impact on aggression frequency ($F = 58.90, p < 0.001$). This was the case for each observation time ($10.07 < F < 35.95, p < 0.001$). From the day of mixing till 3 weeks after, one-way aggressions were more frequent than expected between two incoming sows (15% of observed aggressions (OA) versus 10% of expected ones (EA)) and between an incoming sow and a resident sow (60% OA versus 45% EA), but less frequent than expected between two resident sows (25% OA versus 45% EA) ($p < 0.001$).

Aggressive behaviour was significantly influenced by surface type ($F = 26.36, p < 0.001$). This was especially the case for the day of mixing and 2 days later ($F = 27.97$ and $29.12, p < 0.001$), and on a lesser way 3 and 15 days after ($F = 6.92$ and $4.68, p < 0.06$). One-way aggressions were more frequent than expected on concrete floor (and thus less frequent on straw) for the smaller pen throughout the experiment except on day 2 (39% OA versus 24% EA on concrete, 61% OA versus 76% EA on straw, $p < 0.001$). For the bigger pen, one-way aggressions were more frequent than expected on the concrete area (and thus less frequent on straw) 1, 3, 8, 15 and 22 days after mixing but not the day of mixing and 2 days after (Table 2).

### 3.4. Health: skin lesion score and morbidity

The superficial skin lesion score was significantly influenced by the available surface ($F = 7.03, p < 0.05$) and the observation time ($F = 15.57, p < 0.001$). Deep lesion score was only affected by the observation time ($F = 12.26, p < 0.001$).

As shown in Fig. 4, superficial skin lesion score was not different between the two groups neither the day before grouping nor 2 days after. However, this score was higher for the sows given 2.25 m$^2$/sow 1 week after mixing ($9.7 \pm 1.2$ skin lesions/sow versus $5.2 \pm 0.6$ lesions/sow, $F = 6.67, p < 0.05$) and 2 weeks after ($8.8 \pm 1.2$ lesions/sow versus $4.9 \pm 0.7$ lesions/sow, $F = 6.94, p < 0.05$), but this was not the case 3 weeks after.

Deep skin lesion score showed nearly the same pattern (Fig. 5). The day before grouping, these scores were very low but sows living on the larger surface showed a slightly greater score than the other ones ($0.52 \pm 0.12$ versus $0.33 \pm 0.09, F = 5.71, p = 0.06$). However, no differences were observed 2 days after. One week after mixing, this score was higher for the sows given 2.25 m$^2$/sow ($5.3 \pm 0.7$ lesions/sow versus $2.4 \pm 0.4$ lesions/sow, $F = 8.69, p < 0.05$), but there were no more differences afterwards.

<table>
<thead>
<tr>
<th>Expected and observed aggressions on the concrete part of the pen, for sows kept either with a 3 m$^2$/sow or a 2.25 m$^2$/sow space allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.25 m$^2$/sow (Chi-square test)</td>
</tr>
<tr>
<td>Expected aggressions (%)</td>
</tr>
<tr>
<td>Observed aggressions (%)</td>
</tr>
<tr>
<td>Grouping day</td>
</tr>
<tr>
<td>Day 1</td>
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<tr>
<td>Day 2</td>
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<td>Day 3</td>
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<td>Day 4</td>
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<tr>
<td>Day 5</td>
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<tr>
<td>Day 6</td>
</tr>
</tbody>
</table>
When differentiating wounds from the front part (head, ears and shoulders), the mid part (back and flanks) or the rear part (back quarters, tail and vulva) of the body, they showed the same pattern (higher scores for small pen from 1 week after mixing and onwards). Front lesions, mid lesions and rear lesions represented respectively 53%, 32% and 15% of the total. Vulva biting

Fig. 4. Superficial skin lesion score of sows given either 3 m²/sow or 2.25 m²/sow.

Fig. 5. Deep skin lesion score of sows given either 3 m²/sow or 2.25 m²/sow.
occurrence was low: only 7.25% and 2.17% of the sows showed respectively a superficial or a deep wound at the vulva.

Pathologies and treatment were not different between the two groups.

3.5. Physiology: salivary cortisol

The influence of grouping time on salivary cortisol was only significant for measurements made 2 h before grouping ($F = 17.32$, $p < 0.01$), i.e. for control measures. Salivary cortisol concentrations were significantly influenced by the time of measure ($F = 6.61$, $p < 0.01$).

The impact of the available surface on salivary cortisol is weak. As shown in Fig. 6, salivary cortisol levels were not different between the two groups before mixing. Two hours after, they seemed to be higher for the sows living in the small pen (368 ± 79 ng/100 ml versus 206 ± 21.44 ng/100 ml), but the difference was not significant ($F = 2.36$, $p = 0.19$). On the contrary, 26 h after mixing, salivary cortisol concentrations tended to be higher for the sows of the greater pen (243 ± 41 ng/100 ml versus 130 ± 14 ng/100 ml, $F = 4.31$, $p = 0.09$).

Salivary cortisol concentrations were although significantly influenced by the actors’ category ($F = 8.81$, $p = 0.01$). As shown in Table 3, resident sows had a stable salivary cortisol level from 2 h before grouping till 26 h after. On the contrary, incomer sows showed a peak in salivary cortisol, coming back to basal values 26 h after mixing. These patterns were the same in the two groups (2.25 m$^2$/sow and 3 m$^2$/sow). Differences between resident and incomer sows were actually only significant during the peak, 2 h after grouping ($F = 8.25$, $p = 0.01$).

4. Discussion

Agonistic behaviours observed during this experiment were similar to those observed by Jensen (1980, 1982). They are important in the formation of the sows’ social organisation and for its

![Fig. 6. Salivary cortisol of sows given either 3 m$^2$/sow or 2.25 m$^2$/sow.](Image)
stability. Social stability of a pig group depends upon development of a stable hierarchy which is 
habitually established soon after grouping the animals, as shown by decreased aggressiveness after 
a few hours (Spoolder et al., 1999). This diminution was observed in this experiment as the number 
of aggressions was highest the day of mixing in comparison with the following days. Nevertheless, 
we also observed an increase of one-way aggressions 2 days after mixing. This is probably due to 
the adding of straw on that day. Adding litter can indeed induce a competition for this 
 supplementary resource (Jensen et al., 2000). Differences in agonistic behaviour observed between 
the two groups tend to show that social stability is acquired more rapidly in the larger pen. Although 
space allowance does not seem to have an influence on fights and one-way aggression at the time of 
mixing, it could thus have a positive influence some days later. These results are in accordance with 
Weng et al. (1998), who concluded to a better welfare for sows allowed 3.6 m² instead of 2 m², for 
small stable groups of six animals. Remaining aggressiveness, lasting several weeks after grouping, 
might also be due to the group size. In natural or semi-natural conditions, sows form habitually 
small groups of about 2–6 individuals where aggressions are rare (Graves, 1984). Moreover, time 
for aggression to subside and for social stability within groups of sows to be established have been 
reported between 3 and 10 days in small group (Van Putten and Van De Burgwal, 1990) whereas 
much longer periods are needed for recently introduced sows to be integrated into dynamic groups 
(Moore et al., 1993; Spoolder et al., 1996).

Aggressiveness linked to mixing concerned essentially recently introduced sows, as already 
reported by Moore et al. (1993). Indeed, these sows have to enter an existing social organisation 
and have to find their place particularly in the feeding order at the electronic sow feeder. This 
implies stress indicated by higher cortisol levels for incoming sows. Another source of stress for 
these sows could be the transfer from individual to group housing. Durell et al. (2003) have 
proposed to pre-mix incoming sows to reduce aggression in large dynamic groups.

Essentially, observed skin lesions arise from agonistic behaviour linked to the hierarchy 
settlement, particularly when competing to enter the “Electronic Sow Feeder”. Some skin 
lesions could also come from the infrastructure, particularly scratches on the back coming from 
the bars of the ESF for the taller sows, but access to the ESF was identical in the two pens. Lesions 
due to fights and aggressions are mostly located on the front part of the sow (head, ears, 
shoulders), but also at the rear (vulva, tail, back quarters) especially when related to competition 
for food. Injury scores showed that establishment of the group hierarchy and particularly the 
feeding order (more agonistic interactions than expected occurred on the concrete area of the 
smaller pen the day of mixing) could take more time in the smaller pen. Smaller space allowance 
might prevent sows from performing appropriate flight behaviour in the feeding area, a 
particularly competitive zone. The limitation of these behaviours might contribute to a social 
instability. Although no lesion observed in this experiment was considered as serious, any 
increase in the frequency of injuries can be considered as an indication of an inadequate 
environment. The frequency of vulva biting can be a problem with ESF since the sows are fed 
sequentially and not simultaneously (Van Putten and Van den Burgwal, 1990). In our study, it 
was very low probably because the access to the ESF was controlled at the entrance and not at the

| Table 3 | Salivary cortisol for incoming and resident sows |
|-----------------|-----------------|-----------------|-----------------|-----------------|
|                | 2 h before grouping | 2 h after grouping | 26 h after grouping | Significance |
| Incoming sows   | 163±15           | 402±78           | 203±39           | *              |
| Resident sows   | 144±16           | 172±20           | 169±20           | NS             |

place of food distribution, improving the physical protection of sows during the eating time as shown by Anil et al. (2006). The size of the group could also explain the low frequency of vulva biting as, according to the manufacturer, the electronic sow feeders are designed to host 50 sows, thus more than the 34 sows used in our study. Lesion scores staying higher in the group given 2.25 m²/sow 2 weeks after mixing when the one-way aggressions have become similar in the two groups can be explained by the healing process: indeed lesions have not been differentiated between fresh and older wounds.

Mixing is perceived as a highly stressful event by animals introduced in the groups, as shown by increase in salivary cortisol observed 2 h after mixing. This was not the case for resident sows. Introduced sows could thus perceive mixing as a more stressful event than resident sows. This is in accordance with the fact that new sows are more often involved in agonistic interactions than resident sows. Such increases in cortisol have been observed by other authors (Ekkel et al., 1997; Merlot et al., 2004) but were not differentiated between incoming and resident animals. Later however (26 h after mixing), salivary cortisol levels of freshly introduced sows came already back to basal values. This result is in accordance with De Groot et al. (2001) who demonstrated that a social conflict had no long term effect on plasmatic cortisol. Sows with a space allowance of 2.25 m²/sow seemed to show higher cortisol level 2 h after grouping than sows with a space allowance of 3 m²/sow, but differences were not statistically significant. The high variability of the collected data would need some further methodology adaptation, like a higher number of measurements and a better standardisation. Surprisingly, 26 h after the mixing, sows from the larger pen tended to show higher salivary cortisol level than sows from the smaller pen. This could be interpreted as a consequence of the negative feedback effect of cortisol on the hypothalamic-pituitary axis, as proposed by Merlot et al. (2004). This could also be due to the fact that sows freshly introduced in the smaller pen might be more exhausted by fights that could occur after the observation period.

Results of the present study on aggressions and skin lesion scores, and on a lesser way on cortisol, corroborate that mixing sows is an important factor of stress, as widely reported in literature. A space allowance of 3 m²/sow seems to offer better welfare conditions than a space allowance of 2.25 m²/sow, not at the time of mixing but in the middle term (2–8 days after grouping). In the longer term, the benefit of a higher space allowance seems to disappear. Any attempt to generalize these results should be prudent. Firstly the frequency of mixing, i.e. every 5 weeks, even if not unusual, could not be the most common practice everywhere. Agonistic interactions and skin lesions consecutive to mixing could be more frequent in systems with more frequent mixing, for example once a week, when social stability is never reached. On the contrary in stable groups, agonistic interactions are less frequent (Weng et al., 1998). Secondly, even if a competition does exist for the access to the electronic sow feeder, this feeding system allows sows to eat when being protected from her pen mates. In a system where the sows are fed simultaneously without being isolated, feed competition is higher and leads to more aggressions and skin lesions as well as higher plasmatic cortisol levels (Barnett et al., 1992). So the required space for floor fed sows could be different as suggested by Weng et al. (1998). On the contrary, in a system of closed stalls, feed competition is minimal. Thirdly, the use of a straw litter could also influence the results. Indeed, some studies have demonstrated that a forage supply reduces aggression in group-housed sows (Edwards, 1995; De Leeuw and Ekkel, 2004) while others have shown that it can induce a competition for this supplementary resource (Jensen et al., 2000). Finally our results were obtained for a group size of 34 sows. In larger groups and for constant space allowance per animal, the total surface increases. This allows a larger choice of association with other sows and probably facilitates avoidance of dominant sows, but there are more
hierarchical positions to establish. On the other hand, subgroups get formed in larger groups and animals in different subgroups may not meet frequently. Do these subgroups socially work independently or does the hierarchy embrace all the animals? Other factors that might influence our results include the beginning time of the feeding cycle, as indicated by Jensen et al. (2000), and the replacement rate in dynamic groups (O’Connell et al., 2004).

5. Conclusion

Present results show that a space allowance of 3 m²/sow induces better welfare conditions for sows housed in dynamic groups and fed through an electronic sow feeder than a space allowance of 2.25 m²/sow. This greater available surface reduced aggressive behaviour and consecutive wounds after sows’ groupings, a frequent situation in dynamic systems. However, there was no effect on productivity, and the impact on physiological stress needs further research.

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References


