Does social competition affect the reproductive performance of sows moved to group housing after weaning?

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SUMMARY

This study was undertaken to examine the effects of grouping sows immediately after weaning or 4 weeks after insemination on *i*) the occurrence of skin injuries and *ii*) reproductive parameters such as weaning-to-service interval and pregnancy and culling rates. At weaning (T0), 106 sows were allocated to multiple group housing (MG, n = 41) or to individual stalls (CG, n = 65). Sows from CG remained in individual stalls until 28 days after service, in compliance with the Council Directive 2008/120/EC, and were then mixed into static groups. The occurrence, localization and severity of skin injuries and lameness were recorded 24 h after allocation (T1) and 7 days later (T2). Sows were artificially inseminated on natural estrus, between T1 and T2. At T1, 20 of 41 (49%) sows in MG displayed cutaneous lesions. Skin injuries were localized in the regions of the head (20%) and rear legs (2%), while 24% of sows showed multiple localization; 3% of the MG sows were lame. Any lesion was recognized in CG at T1. At T2, the percentage of injured sows in MG decreased to 27%, while 1 sow from CG displayed a superficial skin lesion on the rear leg. Most MG sows showed multiple injuries (10%) and lameness (7%). Overall, 15 sows were culled for replacement, but Group had no effect on the culling rate. Among the remaining sows, 87 were inseminated with an overall 74.7% pregnancy rate (72.9% and 75.9% in MG and CG, respectively, difference $p>0.05$). According to the multivariable logistic regression, any factor significantly affected the pregnancy rate in MG and CG sows. These results suggested that housing sows after weaning in the multiple group with a reduced number of herd mates induced a stress due to competition for establishing hierarchy, even if this condition was quickly overcome and no negative effects of group housing were observed on the weaning-to service interval and pregnancy rate.

KEY WORDS

Sow; group housing; small group; fertility; skin injuries; social behavior.

INTRODUCTION

The interest in animal welfare and management in intensive breeding systems is growing in importance due to its implication for health, quality and ethics in food production[1-4].
Individual housing represents one of the main issues in intensive breeding systems, since it is related to behavioral deviations; these conditions often lead to injuries, pain and frustration, with decreased welfare and farm net return[5,6]. Moreover, European citizens have recently brought to the attention of the European Commission the "End the cage" initiative, which led to review the legislation concerning cage using in animal husbandry. Insufficient space allocation/animal and dynamic grouping are a key-factor in pig industry due to the social behavior and interaction pattern of this species; wild pigs, especially females, live in small groups and spend most of time in research for food, moving in a wide territorial area[7-9]. Space restriction and mixing social groups in intensive farming systems increase aggressive behavior and stress; the social hierarchy is more unstable in pigs kept in overcrowded conditions than in pigs kept in larger spaces. Major causes of negative and aggressive interaction between co-specifics include competition for feed and water access, mixing in different age and weight groups[10]. This condition negatively affects fertility and productive performance, thus determining economic losses[7]. Prolonged release of cortisol and catecholamines induces weight loss and immune-depression, and has been related to reduced estrus behavioral signs and to fetal losses, abortion and stillbirth in sows[8,11]. Since the reproductive efficiency is one key-factor for positive farm net return, improving sow's welfare and management should be prioritized in intensive pig industry.
The Directive 2008/120/EC establishes that sows could be kept in individual stalls for up to one month after weaning, then they must be moved to multiple housing until entering the farrowing area. The same Directive also allows sows to be directly moved into group housing after weaning, as multiple housing represents a valuable option to ensure greater space allocation per animal and the expression of social behavior. Some studies reported that group housed sows better display estrous behavior than animals in single stalls[7,8], while other authors suggested that mixing and social stress could suppress estrus in subordinate or ill animals[12]. It is also reported that fighting and injuries could compromise the reproductive performance of sows, that is increasing pregnancy loss and return to estrus, thus mak-

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ing farmers less compliant in implementing new management strategies in this species[13].

This study was undertaken to examine the effects of grouping sows immediately after weaning or 4 weeks after insemination on *i*) the occurrence of skin injuries and *ii*) reproductive parameters such as weaning-to-service interval and pregnancy and culling rates.

MATERIALS AND METHODS

Animals and husbandry

The study was conducted in 2020 in a 160-sow farrow-to-finish farm in Perugia district, Italy. Ethic review and approval was not applicable according to the directive 2010/63/EU since the procedures were performed during routine health check, it did not require us housing animals and the procedures involved on-farm routine, non-invasive practices.

Pre-pubertal *Grand-parents* sows were regularly purchased and inseminated artificially to produce *Parents* sows. These were artificially inseminated after estrus detection with farm-owned boars, which were registered into the "Prosciutto di Parma" Consortium herd book. The average litter size of the farm was 13.06 ± 2,67 live piglets/sow. Piglets were weaned at 28 days of life and reared in separated areas of the same farm for fattening until 9 -10 months old when they reach 160 -170 Kg body weight, for the production of "Prosciutto di Parma" protected geographical indication (PGI) meat.

Experimental design

A total of 106 primiparous (n = 25) and multiparous (n = 81) *Parents* (Landrace x Large White) sows were included in the study from spring to summer 2020 and were divided into 4 replicates, each one consisting of approximately 26 animals. Ill sows were excluded from the study. At weaning, sows were allocated to one of the two treatments described below. Groups were homogenous for sows' back fat thickness (BF, 13.93 ± 2.02 mm), measured by ultrasonography at the level of the right inter-costal space. Groups were constituted as follows:

i) MG, multiple group (n=41): sows were transferred to the group-housing system immediately after weaning, mixed into static group
ii) CG, control group (n=65): sows remained in individual stalls until 28 days after service, in compliance with the Council Directive 2008/120/EC, and were then mixed into static groups

All sows were maintained in their treatment group until approximately 110 d of gestation, when they were moved into farrowing crates.

Three time points characterized the experiment as follows: the day of transfer of sows to group-housing (MG) or individual stall (CG) after weaning (T0), 24 h (T1) and 7 days (T2) later. At T2 all sows were already artificially inseminated.

Housing and Feeding

The sows in the MG treatment were housed in groups of 5 - 6 sows/pen, provided with a floor space allocation of approximately 2.50 m^2/sows. The floor was fully slatted. Drinking water was ad libitum, with three nipple drinkers per pen. One block of wood on a chain, one chain and a ball were provided as enrichment. The sows in the CG treatment were individually housed in 2.35 x 0.6 m (trough included) stalls with a fully slatted floor, which contained an individual nipple drinkers and horizontal bars. One block of wood on chain and one chain were provided as enrichment. Feed was distributed twice a day in the trough by an automated feeding system, mixed with water in a 3 Kg water/1 Kg concentrate ratio. Based on the nutrient requirements of each productive phase, 4 to 6 Kg concentrate/sow were provided.

Oestrus detection was performed by means of a teaser boar, starting from 3 days after weaning. The teaser boar entered twice a day into the insemination area and was free to move among the lanes without entering single or multiple stalls. Sows showing the reflex of immobility, vulva hyperemia and edema, were artificially inseminated by the same operator with 200 ml of refrigerated semen obtained from the owned boars, containing at least 3 billions of progressively motile spermatozoa. The insemination of sows in MG was performed while an operator induced immobility reflex for restraint.

Data collection

Reproductive measures were assessed for all sows in all replicates. Weaning-to-service interval (W-S) was recorded while the pregnancy rate was determined in each group as the proportion of sows inseminated that resulted pregnant. Pregnancy diagnosis was performed by trans-abdominal, real-time ultrasound (RKU10, Kaixin ultrasound scanner, Kaixin Mansion, C-01, Economic Development Zone, Xuzhou, Jiangsu, China) by the farm veterinarian at 24 d after the insemination. The number of sows culled after weaning was recorded to calculate the culling rate.

The presence of lameness, as localization and severity of skin injuries were assessed by visual inspection performed by the same operator on both sides of the sow body, at T1 and T2. The animal body was divided into areas, namely: head, rear leg, body, rump, hind leg and tail/vulva. In case more than one body region displayed skin injuries, the animal was scored as "multiple". The severity of lesions in each area was scored according to a 3-point scale (superficial lesion = 1; bleeding = 2; deep wound = 3). If lesions displayed different degrees of severity, the most severe was included into the dataset. In MG, once skin lesions on a sow were recorded, the animal was identified using a non-toxic dye stick.

Statistical analysis

Data were recorded in an Excel™ work sheet and then imported into IBM® Statistics SPSS v.23 Software for statistical analysis. The distribution of parity, BF at T0 and W-S were evaluated by the Explore function; MG and CG were compared through two-tailed ANOVA test. The distribution and severity of skin injuries were also plotted. The pregnancy rate at the first AI and culling rate were compared in MG and CG through binary logistic regression.

To perform further analysis, skin injuries were classified as a dichotomous variable (presence *vs* absence). The influence of factors potentially contributing to pregnancy and culling rates was examined through multivariable logistic regression. The outcome (empty *vs* pregnant; non-culled *vs* culled) was set as the dependent variable, while covariates were parity, treatment group, BF in T1 and the presence/absence of skin injuries in T1 and T2.

Results were considered statistically significant when $p < 0.05$.

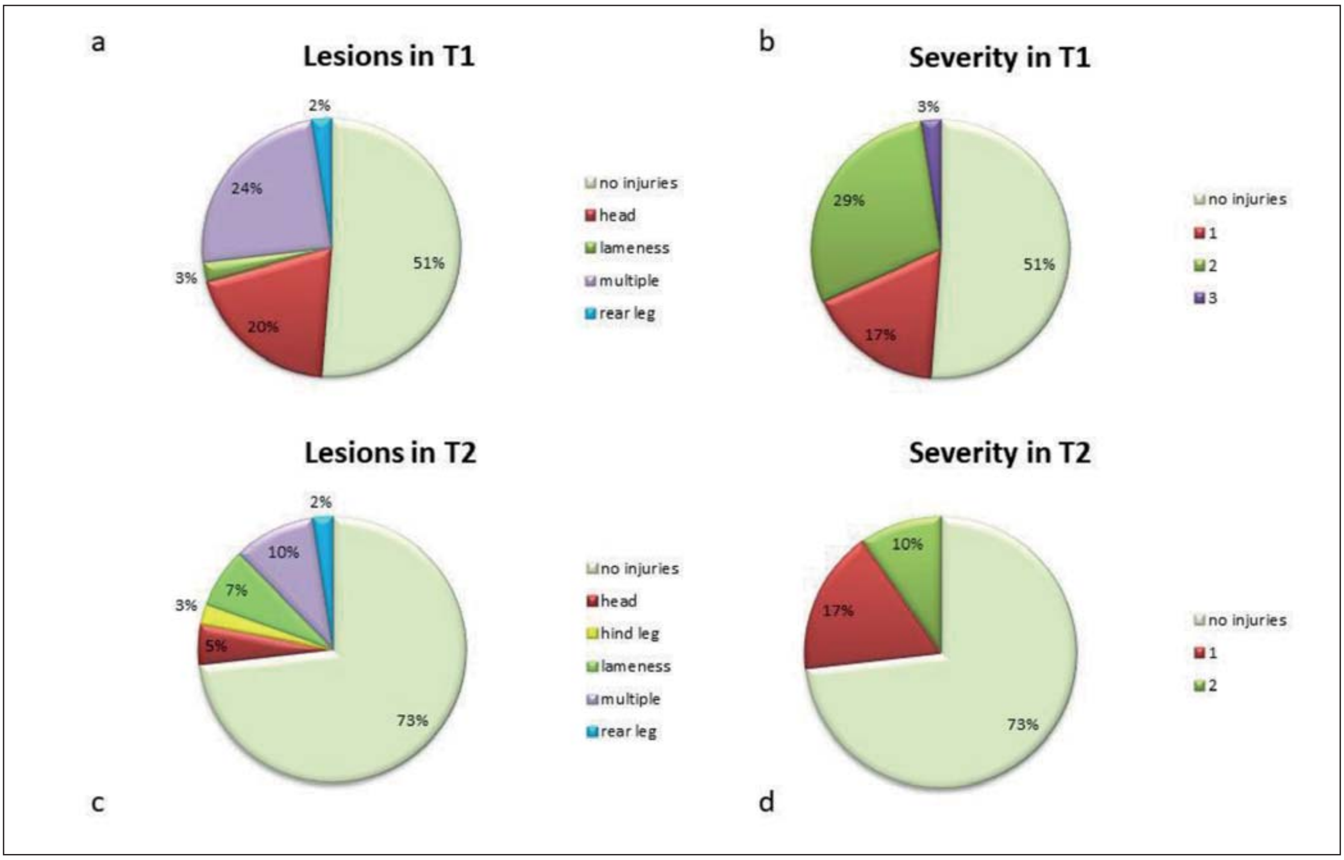

Figure 1 - Localization, frequency and severity of skin injuries and lameness in MG sows in T1 and T2. a) frequency of healthy, injured and lame sows in T1. b) distribution of the severity score of skin injuries in sows in T1. c) frequency of healthy, injured and lame sows in T2. d) distribution of the severity score of skin injuries in sows in T2. Severity of skin injuries: 1 = superficial lesion; 2 = bleeding; 3 = deep wound.

RESULTS

At the time of weaning, there was no difference between the groups for BF (13.5 mm in MG and 14.2 mm in CG, respectively, $p > 0.05$). The two housing systems had no effect on the culling rate due to replacement (Table 1). Among the remaining sows (n=91), no effect of housing or mixing stress on reproductive efficiency was observed (W-S interval and pregnancy rate) and 95.6% of them were recognized as being in estrus within 8 days after weaning and then inseminated, with an overall 74.7% pregnancy rate after the first AI (72.9% and 75.9% in MG and CG, respectively).

At weaning (T0) any skin lesions were observed. Localization and severity of the lesions observed in MG sows are shown in Figure 1. At T1, 20 of 41 (49%) sows in MG displayed at least one body region affected by skin lesions. Skin injuries due to fighting were localized in the regions of the head (20%) and rear leg (2%), while 24% of sows showed multiple localization. Only a limited number of sows displayed deep injuries (3%) and lameness (3%). Any animal from CG showed lesions at T1. At T2, the percentage of injured sows in MG decreased to 27%, with 11 of 41 animals involved, while 1 sow from CG displayed a superficial skin lesion on the rear leg. Most of MG sows showed multiple injuries (10%) and lameness (7%).

Tables 2 and 3 summarize the results from the multivariable

Table 1 - Effect of housing sows after weaning in groups (MG) or in stalls (CG) on reproductive performance and culling rate.

	Group			All
	MG	CG	p-value	
N	41	65		106
Parity	2.07 ± 1.23	3.18 ± 1.47	< 0.01 [1]	2.75 ± 1.48
Culling rate (%)	9.8 (4/41)	16.9 (11/65)	n.s. [2]	14.2 (15/106)
N after culling	37	54		91
W-S (d)	5.26 ± 1.15	5.59 ± 1.15	n.s. [1]	5.46 ± 1.16
Pregnancy rate (%)	72.9 (27/37)	75.9 (41/54)	n.s. [2]	74.7 (68/91)

MG: multiple housing group; CG: control (individual stalls) group; BF: back fat thickness; W-S: weaning to service interval; mm: millimeters; d: days; n.s.: the difference between MG and CG was not significant.
[1] p-value from ANOVA test.
[2] p-value from binary logistic regression.

Table 2 - Factors affecting the positive pregnancy diagnosis. Results from multivariable logistic regression.

Covariates	p-value	OR	95% C.I. Lower	Upper
Parity	0.101	1.512	0.922	2.478
Group				
MG	Referent			
CG	0.744	0.763	0.150	3.870
BF in T1	0.169	1.283	0.899	1.831
Lesions in T1				
No injury	Referent			
Injuries	0.333	0.366	0.048	2.799
Lesions in T2				
No injury	Referent			
Injuries	0.098	9.006	0.665	121.977

MG: multiple housing group; CG: control (individual stalls) group; BF: back fat thickness; T1: 24 hour after moving to MG or CG; T2: 7 days after moving to MG or CG; OR: odds ratio.

Table 3 - Factors affecting the culling decision. Results from multivariable logistic regression.

Covariates	p-value	OR	95% C.I. Lower	Upper
Parity	0.048	1.553	1.004	2.402
BF in T1	0.327	1.210	0.827	1.770
Group				
MG	Referent			
CG	0.308	1.884	0.557	6.372
Lesions in T1				
No injury	Referent			
Injuries	0.221	3.694	0.457	29.893
Lesions in T2	Not enough cases			

MG: multiple housing group; CG: control (individual stalls) group; BF: back fat thickness; T1: 24 hour after moving to MG or CG; T2: 7 days after moving to MG or CG; OR: odds ratio.

logistic regression for evaluating factors affecting the outcome of the first insemination (pregnant) and culling decision (culled). According to the model, any examined factor significantly affected the pregnancy rate in MG and CG sows. Concerning culling, any factor significantly influenced the decision, except for parity ($p = 0.048$).

DISCUSSION

Concerns for animal welfare in intensive breeding systems are growing in importance globally, while management strategies that improve the expression of social behavior, including fighting, could be perceived by farmers as having a negative impact on animal productivity and fertility[5]. This study was undertaken to evaluate whether grouping sows of different parities from weaning to the first month of pregnancy could affect the occurrence of skin injuries and the interval from weaning to the first insemination and to conception.

In this study, the mean parity of sows allocated in MG and CG was statistically different, with a significant greater amount of primiparous allocated to MG in our study. Jansen et al.[10] suggested that mixing gilts could exacerbate fights and stress. In the experiment here, the farm routinely mixed younger animals with a smaller percentage of older sows to facilitate hierarchy stabilization, as primiparous sows show lesser body weight compared with older herd mates[14]. It should also be considered that in farms where both multiple and single stalls are available, farmers could choose to move younger and healthy sows in the former, and to allocate older, lame, low body condition score ones into the latter to avoid detriment of their condition and culling[15]. However, it is reasonable to suggest that mixing animals and competition could negatively affect the health of post-weaning sows, while single stalls could be beneficial to recovery their clinical condition before moving to group housing.

Previous research tried pointing out the effect of stress and fear in the multiple group housed sows on reproduction, and even if some results showed inconsistency[14,15], there is some indication that high stocking density can impair fertility[5], especially when stress occurs during the first 3 weeks of pregnancy[8,16]. In our study, an average of 2.50 m^2/sow was ensured in multiple housing and a maximum of 7 sows were allocated in multiple stalls. The limited number of animals per multiple group is closer to the naturally formed family group in wild pigs[7], while the high space allocation agrees with recommendations from Verdon et al.[17]. These factors likely contributed to reducing, even if not to eliminate, the stress due to social grouping and competition in our experiment. According to Jansen et al.[10] social fights usually last for 2 or 3 days after mixing unfamiliar animals, while Brajon et al.[9] observed agonistic behavior up to 1 month after grouping. However, in their study each group contained 90 sows on average and this large amount likely contributed to exacerbating fights even after hierarchy establishment. In this study, we observed that fights for hierarchy reached their maximum intensity in the first 24 h after grouping, similarly to what reported by Peltoniemi et al.[8]. In fact, the observation of skin injuries confirmed a decrease in the number of sows displaying lesions yet in T2 in MG, that is, from 20 to 11 of 41 animals allocated in multiple group. Comparing T1 and T2, the overall amount of injured sows decreased, as a lower incidence of injuries in the anterior regions of the sows body was noticed; however, an increase in lameness and hind leg lesions was observed. This was likely due to mounting behavior in relation to pro-estrus and estrus in MG animals during the time interval from T1 and T2, rather than to social competition.

The 74.7% of inseminated sows were pregnant after the first AI, and this result agrees with the average reproductive performance reported by other authors[15,16,18-20]. Fertility was not influenced by factors such as parity, type of housing, occurrence of skin lesions, as no differences were found in W-S and W-Conc intervals. Studies which evaluated the impairment of fertility in group-housed sows often involved larger groups, that is 7 to more than 10,[21] or 20 sows with 4.3 m^2/sow[22,23], or even greater groups with individual electronic feeders[24,25], compared to our study. Einarsson et al.[7] reported that weaned sows housed in groups with sufficient space allocation showed a shorter weaning-to-oestrus interval, that is 4 -5 days. Even though differences in W-S intervals were not significant in our study, these results suggested that housing sows after weaning in the multiple group with a reduced number of herd mates led to increased stress due to competition for establishing hierarchy, but this condition was quickly overcome.

CONCLUSIONS

Our results suggested that housing sows after weaning in the multiple small group, that is 6 -7 subjects, with a space allowance of 2.50 m^2/sow, led to social competition and fighting, as demonstrated by the incidence of skin injuries in the anterior areas of sows body at 24 h after mixing. However, this condition was quickly overcome and 7 days later, the percentage of injured sows already decreased. Moreover, no negative effect of grouping sows was observed on the weaning to service interval, pregnancy and culling rates. In conclusion, mixing sows into small groups after weaning could improve the expression of social behavior with no damaging effect on fertility, thus representing a compromise between the need of farmers and the demands of consumers.

Ethics statement

Ethic review and approval was not applicable according to the directive 2010/63/EU since the procedures were performed during routine health check, it did not require us housing animals and the procedures involved on-farm routine, non-invasive practices.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare no competing interest.

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Author contribution

Di Muzio and Paoluzzi carried out the study, Galli designed, directed the study and corrected the manuscript, Crociati performed the statistical analysis, drafted the manuscript, Sylla drafted and critically corrected the manuscript.

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