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Abstract

South Korea recently revised its livestock regulations to enforce mandatory group housing for pregnant sows beyond six gestation weeks until 2030. However, group housing of pregnant sows can influence their social hierarchy and feed competition, thereby affecting their reproductive performance and welfare. Although governing regulations of minimum space requirements for group-housed pregnant sows have not yet been established in South Korea, a minimum space of 1.9 m^2 per sow is estimated to be necessary. Therefore, this study investigated the effects of space allowance (SA; 1.9 m^2, 2.3 m^2) during pregnancy and social training (ST; -, +) during the growing period on the productivity and welfare of primiparous sows. Thirty-six gilts were divided into four groups based on space allowance during gestation and social training during the growing period: 1) SA 1.9 m^2, non-ST (-), 2) SA 1.9 m^2, ST (+), 3) SA 2.3 m^2, non-ST (-), and 4) SA 2.3 m^2, ST (+). Measurements were basic performance, reproductive performance, colostrum composition, lameness score, and number of skin lesions of primiparous sows. The sow group in SA 1.9 m^2 had higher ($p < 0.05$) body weight during farrowing crate relocation, litter weight of total litter, stillbirth, and alive born, and number of skin lesions during the overall period of group housing than that in SA 2.3 m^2. However, there were no effects of SA on colostrum composition and lameness score of sows. The sow group with ST had higher ($p < 0.10$) litter size of total born and alive born and fewer ($p < 0.05$) number of skin lesions during the overall period of group housing than that without ST. However, no effects of ST were found on sow performance, colostrum composition, and lameness score. In addition, there were no interaction effects between SA and ST on all measurements in this study. In conclusion, primiparous sow aggression may be reduced by increasing space allowance during gestation with social training during the growing period.

Keywords: Group housing, Primiparous sows, Productivity, Social training, Space allowance, Welfare

Introduction

In the livestock industry, the conventional practice for managing pregnant sows involves individual confinement in gestation stalls. This is a method characterized by limited space to facilitate efficient and cost-effective individual management [1]. However, husbandry practices for sows are shifting from individual stalls to group housing driven by evolving welfare regulations, policies concerning farm animals, and growing concerns among consumers regarding animal welfare [1,2]. Recently, South Korea amended its livestock act to mandate group housing for pregnant sows from a minimum of 6 gestation weeks until transferring to farrowing crates [3]. Compliance with this regulation is required for new pig farms to seek permits and existing facilities must transfer from individual stalls to group housing for pregnant sows by 2030. In the European Union, group housing for pregnant sows has been compulsory from 4 gestation weeks until transferring to the farrowing crates since 2008 [4].

Group housing for pregnant sows offers advantages over individual stalls by allowing animals to perform normal activities and behavior [5]. However, new social group formation can produce hierarchies and feed competition among sows, potentially leading to aggression, fear, injury, pain, and stress [6,7]. Stress can adversely affect the hypothalamus-pituitary-gonadal axis, influencing ovarian progesterone and estrogen secretion, and potentially causing reproductive dysfunction [8]. Moreover, higher incidences of lameness and lesions has been occurred in sows housed in group facilities than those housed in individual stalls, ultimately impacting economic returns for farmers due to reduced productivity resulting from competition for feed and rank [9].

Facility and environmental factors, including group housing space, socialization training, group type, feeding system, and enrichment introduction, can affect aggression and stress levels in pregnant sows [5,6,10]. Socialization training involves teaching sows to be more amicable through interactions with other individuals, thereby aiming to reduce aggression during pregnancy based on previous experiences. A previous study showed that aggression of sows was decreased after 2-4 re-introductions from 10 weeks to 5 months of age [11]. Various studies have focused on reducing weaning stress in piglets by their socialization [12,13], but a notable gap exists in the research on the impact of early socialization on aggression in group housing of pregnant sows. Additionally, housing space for pregnant sows markedly influences feeding and rank competition [14,15]. While the European Union regulates a minimum housing area of 2.25 m^2 per pregnant sow, South Korea lacks specific regulations regarding space allowances for group housing of pregnant sows. The internal configuration of pig farms may vary in South Korea; however, an estimated minimum space of 1.9 m^2 that can be converted into group housing is observed. Furthermore, a noticeable absence of domestic research exists in addressing the mitigation of feed-and-rank competition that may arise in group housing. It is also unclear whether sow's housing area and socialization mutually influence productivity and welfare. Therefore, this study aimed to investigate how gestational housing space and rearing-phase socialization training affect sow productivity and welfare during the pregnancy of sows, particularly in reducing aggression.

Materials and Methods

The experimental protocols were reviewed and approved by the Institutional Animal Care and Use Committee of the National Institute of Animal Science (NIAS-2021-527).

Experimental design and animals

For this experimental study, 60 gilts, with an average body weight of 31.56 ± 5.31 kg, were used as the research subjects. These pigs were allocated to two treatment groups based on their exposure to socialization training during the rearing phase. The pigs were then divided into six replicates, each consisting of five pigs, adhering to a completely randomized design. Socialization training commenced at 10 weeks of age and continued for 4 months, which involved a series of 4 re-introductions occurring at 4-week intervals, aimed at fostering socialization skills. During each re-introduction session, 2 to 3 selected individuals were introduced and allowed to interact with the pigs in the pen. We carefully structured this process to introduce pigs to new individuals in each of the six pens. Furthermore, the selection of individuals for re-introduction was based on their weight to minimize dominance behaviors due to body weight. At approximately 8 months of age, 60 gilts underwent artificial insemination. Subsequently, 36 pregnant sows were selected and categorized into two subgroups based on their assigned gestational housing areas of 1.9 m^2 and 2.3 m^2. This resulted in four treatment groups following a 2 × 2 experimental design. Pregnant sows were placed into groups with nine replicates, each containing one sow, following a completely randomized design. The group-housing period was extended from 42 d after pregnancy initiation to the 110th d. All pregnant sows were relocated to the farrowing crates at the end of this period. The chemical composition of basal diet used throughout the experimental period was presented in Table 1. Diets were formulated to meet or exceed the nutrient requirements of gilts and sows recommended by the National Research Council [16].

Productivity measurements

Growth performance

Body weight and feed consumption were measured at the beginning of each of the four re-introduction sessions, which took place at 4-week intervals, starting from the 10th week of age. The weight of any remaining feed in the feeders was deducted from the total quantity of test feed provided over the trial period to determine the daily feed intake. Daily weight gain and feed efficiency were computed using recorded body weight and feed intake data.

Sow performance

Body weight and backfat thickness were measured at four time points: 42 d and 110 d after artificial insemination,

within one day after farrowing, and weaning day. Backfat thickness was measured at P2 (5 cm from the center of the 10^{th} rib on the left and right sides) using an ultrasound device (Anyscan BF, SongKang GLC, Gyeonggi-do, Korea).

Reproductive performance

Video cameras (HDR-AS50, Sony, Tokyo, Japan) were installed on every two sows before farrowing to record farrowing intervals and total farrowing time to assess the reproductive performance and welfare of sows. Postpartum management was conducted after farrowing and the birth weight and litter size of the piglets were recorded in detail. The number of piglets per sow was adjusted within one day after farrowing, considering the piglet's weight to ensure uniformity within the treatment groups. Piglets were weaned on the 28^{th} day and the weight and number of piglets were measured. The weaning-to-estrus interval was observed daily at 9 a.m. and 4 p.m. starting from the estrus period following farrowing and the daily feed intake of lactating sows was accurately measured using an automatic feeder (Automatic Feeder of Lactating Sows, Koca, Korea) for the entire lactation period.

Colostrum composition

Colostrum samples were collected to analyze its components from sows during active parturition with 2 to 4 piglets already delivered. These colostrum samples were stored in 50 mL tubes (Milkoscan FT 120, Fourier-transform infrared spectroscopy, Hillerod, Denmark) at −20°C until the time of analysis. The colostrum samples were thawed before analysis at room temperature (20 °C) and the colostrum components were analyzed using a milk analyzer (CombiScope FTIR 300 HP, Delta Instruments, JB Drachten, The Netherlands).

Welfare measurements

Lameness

Lameness was assessed on all pregnant sows before and after group housing at weeks 1, 3, 5, and 7. A lameness assessment protocol was established by the previous study [17] and followed in this study. All pregnant sows were allowed to engage in unrestricted movement by walking or trotting for approximately 30 m before assessing lameness. The assessment employed a four-point scale: score 0, a natural gait with no apparent posture or movement abnormalities; score 1, occasional signs of discomfort or minor alterations in gait while maintaining support from all four limbs; score 2, one or more limbs were occasionally lifted off the ground during movement; score 3, one or more limbs were incapable of bearing weight due to severe lameness, joint swelling, or pain-related vocalization. Three evaluators assessed lameness and the final scores were the average of their evaluations.

Skin lesions

Skin lesions were assessed in all pregnant sows before and after mixing at 1, 3, 5, and 7 weeks. The measurement

method by the previous study [17] involved recording the number of scratches and lesions on the entire sow skin. A single observer performed these assessments.

Statistical analyses

Data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC, USA). The experimental design was a completely randomized design and experimental units were pen, sow, and litter. Statistical model for gilt performance and sow performance, reproductive performance, colostrum composition, lameness score, and skin lesions included treatments as main effects. Contrasts were used to compare effects of space allowance, social training, and interaction between space allowance and social training. Significance was set at $p < 0.05$ and marginally significant effects were considered at $p < 0.10$.

Results

Productivity

Growth performance of gilts

The impacts of socialization training on growth performance of gilts during the growing period were presented in Table 2. There were no differences in body weight, average daily weight gain, average daily feed intake, and feed efficiency after the completion of four re-introduction sessions.

Sow performance

The effects of space allowance during gestation and socialization training during the growing period on sow performance were presented in Table 3. The sow group in the 1.9-m² space had higher body weight at the time of relocation to farrowing crates ($p < 0.05$) and within one day post-farrowing ($p = 0.052$) than that in the 2.3-m² space. However, no effects of space allowance were found on backfat thickness of sows. In addition, there were no effects of socialization training and interaction between space allowance and socialization training on sow performance.

Reproductive performance

The effects of space allowance during gestation and socialization training during the growing period on reproductive performance were presented in Table 4. Space allowance did not affect gestation length, farrowing duration and interval, wean-to-estrus interval, and average daily feed intake. Additionally, there were no effects of space allowance on litter size (total and alive born, stillbirth, mummy, cross-fostering, and weaned). However, the sow group in the 1.9-m² space had higher ($p < 0.05$) litter weight of total born, stillbirth, and alive born than that in

the 2.3-m² space. In addition, the sow group with socialization training tended to have higher litter size of total and alive born ($p = 0.095$; $p = 0.081$, respectively) than that without socialization training. However, socialization training did not affect litter weight (total and alive born, stillbirth, mummy, cross-fostering, and weaned) and average daily gain. There were no effects of interaction between space allowance and socialization training on sow reproductive performance.

Colostrum composition

Table 5 presents the effects of gestational space allowance and socialization training during the growing period on sow colostrum composition. There were no effects of space allowance, socialization training, and interaction between space allowance on colostrum composition (total solids, protein, fat, and lactose) of sows.

Welfare

Lameness score and skin lesions

The effects of gestational space allowance and socialization training during the growing period on lameness score and number of skin lesions of sows. The sow group in the 2.3-m² space had lower lameness score at the 5th week of mixing in the group ($p = 0.082$) and fewer number of skin lesions at the 1st ($p = 0.075$), 5th ($p < 0.10$), and 7th ($p < 0.05$) week of mixing in the group and total average ($p < 0.05$) than that in the 1.9-m² space. Additionally, the sow group with socialization training had fewer ($p < 0.05$) number of skin lesions at the 1st week of mixing in the group and total average than that without socialization training. There were no effects of interaction between space allowance and socialization training on lameness score and skin lesions of sows.

Discussion

Productivity

Pigs exhibit enhanced social behaviors throughout their lives when subjected to early-stage socialization [18]. A pivotal factor in mitigating aggression during group housing is the gradual familiarization of pigs with unfamiliar conspecifics [7]. Socialization in pigs is predominantly acquired during the growing period; however, research on the impact of socialization during this period on sow aggression is limited [6]. The present study showed gilts underwent socialization training with new individuals once a month during their growing period for four months in total and the growth performance of gilts was not different between the presence and absence of socialization training. A previous study in which pigs weighing 18.63 ± 3.05 kg were divided into groups subjected to 1 and 3 mixing sessions until slaughter showed similar results to the present study, indicating no significant differences in growth [19].

Contrastingly, another previous study showed the group subjected to mixing from the 11th week until slaughter had lower body weight of pigs at slaughter than the group without mixing [20]. Although research on mixing during the growth period is limited, the present suggested that socialization training during the growth period had no negative effects on the growth of growing gilts. However, further research on the welfare indicators, such as skin lesions and plasma cortisol levels, should be conducted based on socialization training during the growing period of gilts.

The reproductive efficiency of sows is a crucial metric for assessing the profitability of pig farms [21]. Furthermore, sow performance plays a pivotal role in optimizing productivity based on factors such as weight and backfat thickness [22]. In the present study, the weights of sows, including the total and live born weights, in the 1.9-m^2 housing space on the 110th day of pregnancy were higher than those in the 2.3-m^2 housing space. However, no differences were found on other sow performances between different housing spaces. The weights of gestating sow may fluctuate depending on the number and weight of the fetuses, but sows allocated to larger housing spaces may have expended additional energy due to increased physical activity [23,24]. Furthermore, it was deduced that sows raised in a 1.9-m^2 space had additional energy compared to those raised in a 2.3-m^2 space, positively influencing piglet growth. According to previous studies, an increase in stocking density leads to elevated stress hormone levels in gestating sows, negatively affecting their reproductive capacity [14]. However, the reproductive performance of gestating sows demonstrated resilience to acute or repeated acute stress [25], maybe resulting in no effects of different space allowances on reproductive performances of sows [26,27]. On the other hand, no consistent impacts of gestating sow stocking density or available space on their reproductive performance were still observed [26,28,29].

In the present study, sow and reproductive performances following social training did not markedly differ; however, sows that underwent social training tended to have higher litter size and weight than those that did not undergo social training. An increase in skin lesions is associated with a decrease in the number of piglets born [30]. Aggressive behaviors due to social hierarchy and feed competition in pregnant sow groups can act as stressors and the stress that sows experience may have a negative impact on reproductive performance. In this study, the group that underwent social training showed a markedly lower total average number of skin lesions during the group period than the group that did not undergo social training. This can be inferred as a reduction in aggression due to social hierarchy and feed competition through socialization. Therefore, the present study indicates that socialization during the growing period may exert a positive impact on reproductive performance of sow.

Colostrum, a crucial factor that enhances the passive immunity and metabolic energy of piglets, is influenced by the diet and environment of sows during pregnancy and lactation [31]. However, the present study showed that no differences were found on colostrum composition based on space allowance and the presence of social training, which are similar results to previous studies [27,32]. This indicated that sow space allowance during gestation and the

presence or absence of socialization training during the growing period did not adversely affect the physiological characteristics of sow colostrum.

Welfare

Several studies showed no association between space allowance and lameness of sows [33-35], which is similar results from the present study. However, a study encompassing 15 groups of pregnant sows across various farms in Belgium indicated a reduction in sow lameness rates for those housed in 3.0-m^2 spaces compared to those housed in 1.7-m^2 spaces [36]. In fattening pigs, the lameness scores were higher in large groups (n = 108) but lower in small groups (n = 18) [37].

The transition from individual stalls to group housing for gestating sows implies the encounter of new individuals. Aggressive behaviors resulting from interactions with new pigs have long been a sustained animal welfare concern in the swine industry [38]. Group housing for gestating sows involves introducing new individuals owing to the replacement of candidate sows, leading to inevitable encounters with unfamiliar conspecifics. This inevitably results in stress for the gestating sows, and sows with less experience or smaller body sizes may be subordinate to other sows. Previous studies reported increased lameness levels, claw lesions, and skin lesions in sows during gestation group housing [6,39]. Recent lameness level of sows has been suggested as a crucial metric for evaluating welfare [40] and is one of the indicators in the European Welfare Quality® protocol, which is utilized for assessing sow welfare in Europe [41]. Skin lesions serve as an indicator of sow aggression and are closely associated with productivity [30]. Typically, aggression peaks immediately after mixing and diminishes as a social hierarchy is established [15]. In the present study, higher skin lesion incidences were observed during the initial mixing stages, followed by a gradual reduction over time irrespective of the treatment group.

The present study showed increasing space allowance demonstrated a trend toward decreased lameness scores around the fifth gestation week. Aggression in sows has been suggested to predominantly arise from the establishment of social hierarchy or in the context of feed competition [5]. Aggression related to social hierarchy establishment and securing feed is characterized by lower frequency but higher intensity or by shorter duration and higher frequency. The timeframe for establishing a social hierarchy after introducing unfamiliar individuals through mixing has been reported to be 2 to 10 d [26]. Pregnant sows introduced through mixing may require additional space to establish a social hierarchy and the offering additional space could potentially assist in reducing injuries resulting from conflicts during the period of social hierarchy establishment [26].

Sows housed in a space allowance of 2.3 m^2 during gestation exhibited fewer skin lesions than those housed in 1.9 m^2, excluding the third week of mixing. Similar to the findings in our treatment groups for skin lesions, sows housed in the 3.0-m^2 space exhibited fewer skin lesions than those housed in the 2.25-m^2 space [29]. Additionally, sows housed in 1.4 m^2 spaces consistently demonstrated higher lesion scores than sows housed in 2.3- or 3.3-m^2 spaces

[14]. However, the impact of space on overall skin lesions was shown to be minimal or nonexistent when pregnant sows were housed in space levels ranging from 1.4 through 3.0 m² [15,26].

Social experience is widely known to considerably influence aggressive behaviors. Aggression relies on social experience in pigs mixed at a similar age. When piglets from different sows underwent socialization tests, they approached unfamiliar pigs more quickly [42] and inflicted fewer injuries [43] than those that did not undergo the tests. It may mean socialized pigs formed a stable social hierarchy more quickly [44]. Furthermore, individuals re-introduced by mixing with piglets from different litters during the lactation period had less mammary damage [18] and the subsequent re-mingling positively influenced pig behavior and welfare. Research on the impact of socialization during the growing period on sow aggression in group-housed settings is limited. A previous study suggested that exposing individuals to others during the growing period can reduce aggression during group housing [6]. Similar to the results of our study, a reduction in aggressive behavior was observed in the treatment group, where primiparous sows were introduced to a new group after acquiring affiliative behaviors through 2 to 4 re-introductions from 10 weeks to 5 months of age, compared to the control group [11]. The results of the present study showed a reduction in aggression during the 1- to 2-week period when a social hierarchy was established in the treatment group that underwent socialization training. However, no influence on aggression was noticed among sows within the group after social hierarchy establishment. Nevertheless, socialized sows had a positive impact on skin lesions throughout the gestation period.

Conclusions

Expanding gestational housing space and incorporating socialization training during the growing period had positive impacts on reducing sow aggression.

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Tables and Figures

Table 1. Chemical composition of the experimental diets (on an as-fed basis)

Ingredient, %	Growing period	Gestation	Lactation
Corn	73.09	58.80	59.47
Lupine seed	-	6.00	-
Wheat bran	5.00	11.00	8.00
Soybean hull	-	4.00	-
Soybean meal	16.50	9.00	21.10
Rapeseed meal	-	3.00	3.00
Animal fat	1.00	2.50	3.60
Molasses	2.00	1.80	0.50
L-Lysine	0.20	0.33	0.57
Threonine	-	0.02	0.15
Tryptophan	-	0.10	0.05
Mono-dicalcium phosphate	0.58	1.50	1.20
Limestone	0.78	1.38	1.67
Salt	0.30	0.40	0.40
Vitamin and mineral premix[1]	0.50	0.15	0.15
Phytase	0.05	0.02	0.02
Total	100.00	100.00	100.00
Chemical composition, %			
Digestible energy (kcal/kg)	3,300	3,300	3,480
Crude protein	15.20	14.31	17.31
Calcium	0.64	0.93	0.96
phosphorus	0.54	0.67	0.64
Lysine	0.94	0.79	1.05
Methionine	0.30	0.22	0.33
Threonine	0.57	0.53	0.78

[1]Supplined per kilogram diet: vitamin A, 9600.00 IU; vitamin D_3, 1800.00 IU; vitamin E, 24 mg; vitamin K_3, 1.5 mg; vitamin B_1, 1.5 mg; vitamin B_2, 12 mg; vitamin B_6, 2.4 mg; vitamin B_{12}, 0.045 mg; pantothenic acid, 24 mg; niacin, 45 mg; biotin, 0.09 mg; folic acid, 0.39 mg; Fe, 150 mg; Cu, 06 mg; Zn, 72 mg; Mn, 46.5 mg; I, 0.9 mg; Se, 0.3 mg.

Table 2. Effects of social training during growing periods on growth performance of gilts

Item	Social Training		SEM	*p*-value
	-	+		
Post 1st mixed				
Initial BW, kg	31.59	31.52	2.26	0.985
Final BW, kg	56.58	56.90	2.96	0.940
ADG, g	833.00	845.89	25.20	0.727
ADFI, g	1,825.78	1,808.45	39.80	0.766
G:F, g/g	0.46	0.47	0.01	0.439
Post 2nd mixed				
Initial BW, kg	56.58	56.90	3.06	0.942
Final BW, kg	84.28	86.39	3.56	0.689
ADG, g	1,026.17	1,092.35	38.95	0.318
ADFI, g	2,598.76	2,604.94	64.39	0.951
G:F, g/g	0.39	0.42	0.01	0.156
Post 3rd mixed				
Initial BW, kg	84.28	86.39	3.66	0.696
Final BW, kg	116.81	116.34	2.78	0.907
ADG, g	1,084.22	998.22	50.30	0.260
ADFI, g	3,051.89	2,998.11	30.38	0.239
G:F, g/g	0.36	0.33	0.02	0.344
Post 4th mixed				
Initial BW, kg	116.81	116.34	2.96	0.913
Final BW, kg	141.98	140.23	3.15	0.704
ADG, g	1,144.02	1,085.76	25.33	0.135
ADFI, g	3,484.33	3,433.33	27.94	0.230
G:F, g/g	0.33	0.32	0.01	0.153
Overall				
Initial BW, kg	31.59	31.52	2.26	0.985
Final BW, kg	141.98	140.23	3.15	0.704
ADG, g	1,021.85	1,005.55	11.51	0.353
ADFI, g	2,740.19	2,711.21	28.83	0.496
G:F, g/g	0.38	0.38	0.01	0.825

BW, body weight; ADG, average daily gain; ADFI, average daily feed intake; G:F, gain to feed intake ratio; SEM, standard error of means.

389 **Table 3.** Effects of space allowance and social training on basic performance of primiparous sows

Item	**Treatments**							
Space Allowance, m²	**1.9**		**2.3**		**SEM**	***p*-value**		
Social Training	**-**	**+**	**-**	**+**		**SA**	**ST**	**SA × ST**
Body weight, kg								
Gestation								
At d 42	179.50	181.71	180.29	180.75	2.80	0.976	0.651	0.767
At d 110	232.13	235.43	218.00	222.88	4.05	0.004	0.342	0.854
Post farrowing	229.88	231.71	222.29	225.63	3.16	0.052	0.448	0.825
Weaned	201.75	205.00	200.43	204.38	4.42	0.828	0.426	0.938
Backfat thickness, mm								
Gestation								
At d 42	20.19	20.93	21.79	20.81	0.75	0.353	0.883	0.284
At d 110	21.94	22.00	22.29	22.50	0.72	0.588	0.859	0.923
Post farrowing	23.00	23.93	23.57	22.69	0.68	0.648	0.895	0.222
Weaned	18.75	18.64	18.36	19.31	0.94	0.887	0.832	0.587

390 SEM, standard error of means; SA, space allowance; ST, social training; SA × ST, interaction between space
391 allowance and social training.

Table 4. Effects of space allowance and social training on reproductive performance of primiparous sows

Item	Treatments				SEM	*p*-value		
Space Allowance, m^2	1.9		2.3					
Social Training	-	+	-	+		SA	ST	SA × ST
Gestation length, d	115.38	115.57	114.71	115.88	0.51	0.762	0.381	0.224
Farrowing								
Duration, min	336.44	263.82	243.57	263.71	33.23	0.362	0.555	0.793
Interval, min	31.44	20.48	23.34	21.02	2.88	0.693	0.100	0.552
Wean-to-estrus interval, d	5.63	5.86	5.57	5.88	0.26	0.968	0.258	0.660
Average daily feed intake, kg	4.71	5.34	5.35	5.61	0.19	0.228	0.246	0.914
Litter size, n								
Total born	11.13	12.71	10.71	12.88	0.93	0.390	0.095	0.701
Stillbirth	1.00	0.57	0.86	0.88	0.37	0.234	0.129	0.186
Mummy	0.13	ND	0.57	1.38	0.42	0.260	0.727	0.539
Alive born	10.00	12.14	9.29	10.63	0.91	0.185	0.081	0.235
Cross-fostering	10.13	10.71	10.14	10.25	0.54	0.706	0.557	0.684
Weaned	9.38	9.71	10.00	9.88	0.55	0.513	0.858	0.698
Litter weight, kg								
Total born	16.05	18.26	13.23	14.73	1.23	0.015	0.253	0.086
Stillbirth	1.15	0.74	0.76	0.83	0.41	0.043	0.179	0.657
Alive born	14.89	17.52	12.47	13.91	1.10	0.024	0.122	0.379
Cross-fostering	14.60	15.49	14.24	13.97	0.88	0.322	0.739	0.536
Weaned	78.39	82.17	85.72	79.33	4.34	0.616	0.771	0.261
Average daily gain, g/pig	258.45	252.04	242.14	244.69	11.24	0.586	0.581	0.967

SEM, standard error of means; SA, space allowance; ST, social training; SA × ST, interaction between space allowance and social training; ND, not detected.

Table 5. Effects of space allowance and social training on colostrum composition of primiparous sows

Item	Treatments				SEM	*p*-value		
Space Allowance, m^2	1.9		2.3					
Social Training	-	+	-	+		SA	ST	SA × ST
Total solids, %	115.38	115.57	114.71	115.88	0.51	0.762	0.381	0.224
Protein, %	336.44	263.82	243.57	263.71	33.23	0.362	0.555	0.793
Fat, %	31.44	20.48	23.34	21.02	2.88	0.693	0.100	0.552
Lactose, %	5.63	5.86	5.57	5.88	0.26	0.968	0.258	0.660

SEM, standard error of means; SA, space allowance; ST, social training; SA × ST, interaction between space allowance and social training.

Table 6. Effects of space allowance and social training on lameness score and number of skin lesions of primiparous sows

Item	Treatments				SEM	*p*-value		
Space Allowance, m^2	1.9		2.3					
Social Training	-	+	-	+		SA	ST	SA × ST
Lameness score								
Initial	ND	ND	ND	ND	.	.	.	.
At week 1	ND	0.11	ND	0.11	0.06	1.000	0.167	1.000
At week 3	0.11	0.22	ND	0.22	0.12	0.703	0.257	0.703
At week 5	0.33	0.33	ND	0.11	0.13	0.082	0.722	0.722
At week 7	0.11	0.33	ND	0.11	0.11	0.248	0.248	0.697
Total average	0.11	0.20	ND	0.11	0.07	0.275	0.275	0.903
Skin lesions, n								
Initial	0.44	0.44	0.56	0.11	0.18	0.546	0.231	0.231
At week 1	65.78	40.67	56.67	20.44	7.81	0.075	0.001	0.491
At week 3	22.44	16.33	18.56	11.78	4.05	0.332	0.142	0.938
At week 5	13.67	12.00	10.67	6.11	2.31	0.074	0.205	0.552
At week 7	14.78	13.56	8.56	2.67	2.80	0.014	0.286	0.482
Total average	23.42	16.60	19.00	8.22	2.81	0.033	0.004	0.497

SEM, standard error of means; SA, space allowance; ST, social training; SA × ST, interaction between space allowance and social training; ND, not detected.