Behavioral changes of sows with changes in flattening rate

Ka-Young Yang[1], Dong-hwa Jang[1], Kyeong-seok Kwon[1], Taehwan Ha[1], Jong-bok Kim[1], Jae Jung Ha[2], Jun-Yeob Lee[1] and Jung Kon Kim[1]*

[1]National Institute of Animal Science, Rural Development Administration, Wanju 55365, Korea
[2]Gyeongbuk Livestock Research Institute, Yeongju 36052, Korea

*Corresponding author
Jung Kon Kim
National Institute of Animal Science,
Rural Development Administration,
Wanju 55365, Korea.
Tel: +82-63-238-7407
E-mail: kjk9207@korea.kr

ORCID
Ka-Young Yang
https://orcid.org/0000-0003-3232-6075
Dong-hwa Jang
https://orcid.org/0000-0003-4025-1229
Kyeong-seok Kwon
https://orcid.org/0000-0001-5656-3441
Taehwan Ha
https://orcid.org/0000-0002-3508-1897
Jong-bok Kim
https://orcid.org/0000-0001-7609-4208
Jae Jung Ha
https://orcid.org/0000-0001-6785-6346
Jun-Yeob Lee
https://orcid.org/0000-0001-8074-586X
Jung Kon Kim
https://orcid.org/0000-0001-6329-477X

Abstract

In this study, considering the difficulties for all farms to convert farm styles to animal welfare-based housing, an experiment was performed to observe the changes in the behavior and welfare of sows when the slat floor was changed to a collective breeding ground. Twenty-eight sows used in this study were between the second and fifth parities to minimize the influence of parity. Using a flats floor cover, the flattening rates were treated as 0%, 20%, 30%, 40%, and 50%. Data collection was the behavior of sows visually observed using a camera (e.g., standing, lying, fighting and excessive biting behaviors, and abnormal behaviors) and the animal welfare level measured through field visits. Lying behavior was found to be higher ($p < 0.01$) as the flattening rate increased, and sows lying on the slatted cover also increased as the flattening rate increased ($p < 0.01$). Fighting behavior wasincreased when the flattening rate was increased to 20%, and chewing behavior was increased ($p < 0.05$) as the flattening rate increased. The animal welfare level of sows, 'good feeding', it was found that all treatment groups for body condition score and water were good at 100 ($p < 0.05$). 'Good housing' was the maximum value (100) in each treatment group. As the percentage of floor increased, the minimum good housing was increased from 78 in 0% flattening rate to 96 in 50% flattening rate. The maximum (100) 'good health' was achieved in the 0% and 20% flattening rates, and it was 98, 98, and 99 in the 30%, 50%, and 40% flattening rate, respectively. 'Appropriate behavior' score was significantly lower than that of other paremeters, but when the flattening ratio was 0% and 20%, the maximum and minimum values were 10. At 40% and 50%, the maximum values were 39 and 49, respectively, and the minimum values were analyzed as 19 for both 40% and 50%. These results will be used as basic data about sow welfare for farmers to successfully transition to group housing and flat floors.

Keywords: Behavior, Floor, Group housing, Sow, Welfare

INTRODUCTION

The Korea is preparing to introduce animal-welfare-centered breeding standards for pigs to improve the breeding environment of livestock farms [1]. However, farmers are apprehensive of moving from existing stall breeding to group housing because the need to provide bedding materials on the floor increases administrative labor, and economic burden [2]. Stall breeding is a common practice for sow pig farms, except for those that are already domestically certified for animal welfare. The advantages of

Availability of data and material
Upon reasonable request, the datasets of this study can be available from the corresponding author.

Authors' contributions
Conceptualization: Yang KY, Kim JK.
Data curation: Kwon K, Ha T.
Formal analysis: Kwon K.
Software: Jang D, Ha T.
Validation: Kim J, Lee JY.
Investigation: Ha JJ, Lee JY, Kim JK.
Writing - original draft: Yang KY, Kim J, Ha JJ, Kim JK.
Writing - review & editing: Yang KY, Jang D, Kwon K, Ha T, Kim J, Ha JJ, Lee JY, Kim JK.

Ethics approval and consent to participate
Protocols involving the use of experimental animals were conducted in accordance the ethical and scientific guidelines of the animal Experiment Ethics Committee of Rural Development Administration (No:NIAS-2017064), Korea.

stall breeding are that the maximum number of breeding heads can be raised in the same space, feed amount can be adjusted by weight, and individual management is easy. It is also effective in protecting weaker sows [3]. However, the productivity of sows under such conditions can be reduced because of pressure and lameness caused by fewer activities during pregnancy [4]. Nevertheless, sows nurtured in group housing during pregnancy show muscle loss and lower skeletal muscle strengthening than in stall breeding [5]. This means a lower rate of accidents, such as crushing piglets or dystocia, owing to a lack of strength in the hind legs at the time of delivery [6]. Consequently, the advantages of transfers from stall breeding to group housing, relative to farm household income, are an increased re-fertilization rate and an increased conception rate in pigs, as well as a rapid recovery of body shape postpartum [7]. These results were obtained from a study of sows nurtured on flat floors and in slat-floor group-housing conditions.

For sows, the type of floor area, floor shape of the pen, and living space, as well as thermal and social environments, are linked to behavior and welfare issues. These factors also affect the quality of the final product [5]. In Korea, slatted concrete floors are commonly used in gestation barns for manure drainage, because farmers prioritize manure management and treatment when designing sow barns [8]. However, slatted concrete floors can cause foot injuries and lameness in sows [3]. By contrast, if the floor of the sow barns is altered with beddings, environmental conditions improve because of reduced emissions of ammonia, hydrogen sulfide, and carbon dioxide, providing a more comfortable environment for the sows [9]. In the case of finishing pigs, characteristics, such as productivity, efficiency, carcass quantities, and feeding activities, improve with a littered floor compared with a slatted concrete floor [10]. Therefore, it is important to provide proper floor facilities suitable for the behavioral and physiological conditions of sows following the transition to group housing. However, from the farmer's perspective, economic losses from the conversion of the existing slat floor to a littered floor are unavoidable, because of the redesign of the barn and change in the floor and manure treatment systems. It is also important to understand how the replaced facilities affect sow behavior and environmental changes. Sow behavior is also related to animal welfare. Animal welfare evaluation depends on various indicators. However, two main questions must be answered [11]: Are animals healthy, and do they get what they require? The behaviors of animals play an important role in answering both questions. Consequently, clinical and preclinical assessments as well as preference testing are needed for existing pain, injuries, diseases, and discomfort in the facility and surrounding environment provided by the breeder [12]. Therefore, from a behavioral point of view, observing wounds on the body and vulva have virus causes, such as abnormal posture, fighting, and abnormal behavior [11].

However, no experiment has examined the floors of sows in Korea. Nevertheless, although it is difficult for all farms to convert to an animal welfare-based housing system, research on the process of converting existing farms into animal welfare farms is essential.

Therefore, the situation of domestic pigs on several farms was considered in this study. Based on these factors, an experiment was conducted to observe the changes in sow behavior and animal welfare level when the existing slat floor was changed to group housing for sows.

MATERIALS AND METHODS

Experimental design and animal
The study was conducted at an experimental pig farm in Hadong County, Gyeongsangnam-do, Korea, between April 2020 and February 2021. Twenty-eight Yorkshire × Landrace F2 crossbred sows were used in this study. The sows were between the second and fifth parities to minimize the influence of parity. They entered the group-housing pen 4 weeks after mating and moved to the

farrowing crate a week before farrowing. The sows were housed in a group housing pen (measuring 13.5 W × 8 D, with a density of approximately 3.86 m²/sow) on a partially slatted plastic floor. The pens were equipped with a nipple drinker and an electronic sow feeder (ESF). The sows were managed in compliance with the Korean pig feeding management guidelines [13], and were fed twice a day. Water was provided ad libitum throughout the study. The sow house temperature varied by an average of 20.5 ± 2.1℃. The sow house used in the experiment was compared by processing the flattening rate simultaneously on two pens with the same structure and area. The floor of the sow group housing pen used in the experiment had a flat floor shape corresponding to concrete sheet width of 850 mm and a gap width of 80 mm (Fig. 1). Using a flats floor cover, the flattening rates were treated as 0%, 20%, 30%, 40%, and 50% (Fig. 1A). The flattening rate area was 108 m² at 0%, 21.6 m² at 20%, 32.4 m² at 30%, 43.2 m² at 40%, and 54 m² at 50%. Sow density in each treatment was 3.86 m²/sow. The flattening rate interval was changed every five weeks, considering the sow's adaptation period. The slat floor cover was manufactured by a commercial slats cover company (Bowon ENG, Gimhae, Korea), with the formworks designed by the research team. Individual slat covers were cast with widths of 700 mm, a depth of 50 mm, and a length of 20 mm (Fig. 1B).

Measurements

Sow behavior

The behavior was observed with high-definition (HD) cameras (TC-NCL214S, Tiandy by SICE & C. SRL, Milano, Italy) mounted on four sides of the ceiling (2 m above the floor) to capture video (30 frames/s with a resolution of 1920 × 1080 pixels). Videos, recoded from April 1, 2020, to February 28, 2021, were saved as avi files in a video recorder (NVR- 4839070, Tiandy SICE & C. SRL). The behavioral analysis of sows included basic behaviors such as standing, lying, fighting, excessive biting (chewing) behaviors, and abnormal behaviors such as scratching (Table 1). Among these behaviors, the basic behavior is a time sampling method that collects data every 2 min; when abnormal behavior occurs, the frequency data method is used to compare and analyze each behavioral characteristic. For behavioral monitoring, data were collected for 15 days at an average of 9.5 during the sow's pregnancy stabilization period. The total time required for analysis was 1,800 h (15 days × 24 time × 5 treatments).

Fig. 1. Experimental pen (A: 20%, 30%, 40%, and 50% the flattening rate; electronic sow feeder [ESF]; water cup [WC], B: flattening rate used slat cover).

Table 1. Ethogram used to record sow behaviors during the experiment

Category	Behavior	Description
Basic behaviors	Standing	The body weight was supported by the 4 legs. Included standing and walking
	Lying	The sow maintaining a recumbent position
	Lying to flattening	The sow lies on the flattening floor while the head is resting on the ground or is erected
Unusual behaviors	Fighting	Forceful pushing on other sows
	Chewing	Chewing actions were performed without the presence of food in the oral cavity. If performed excessively, sham chewing may be accompanied by hyper-salivation. Sham chewing occurs most frequently in confined sows fed a highly concentrated diet and is considered to be a vacuum activity
	Scratching	Any repeated or rhythmical rubbing action against objects in the surroundings (e.g., wall, ground surface, etc.) or rubbing action between two parts of a sow's own body.
	Grouping	The formation of a group of sows by natural means (e.g., herd formation as a result of social attraction) or by human action

Animal welfare level

To evaluate the welfare level of sows, the experimental farm's main management (e.g., temperature, humidity, feed, area, and density), and animal welfare level items (e.g., good feeding, good housing, good health, and appropriate behavior; Table 2) were using the assessment protocol [3]. The temperature and humidity diagnoses were measured using a temperature and humidity sensor (HOBO Temp/RH Logger, UX100-011A, HOBO data logger onset, ONSET, Bourne, MA, USA).

Statistical analysis

All data were analyzed using the R package (R version 3.31, R Foundation for Statistical Computing, Tokyo, Japan). The effects of flattening on animal welfare levels and qualitative behavior were analyzed using ANOVA. Data on animal welfare levels were investigated using the mean and standard deviation. The data for qualitative behavior were not normally distributed, as per the Shapiro-Wilk test. To calculate significant differences between the days of observation, the Kruskal-Wallis test was used and confirmed post hoc. Significant results ($p < 0.05$) were examined using post-hoc Scheffé tests to further describe the relationship between the tested interactions.

RESULTS

Sows behavior

The difference in the behavior of sows according to the ratio of the floor was shown in Table 3. The

Table 2. Animal welfare levels items by the welfare quality animal welfare assessment protocol for sows and piglets [18]

Measurement items	Welfare criteria	Principal
Body condition score	Absence of prolonged hunger	Good feeding
Water supply	Absence of prolonged thirst	
Bursitis, shoulder sores, manure on the body	Comfort around resting	Good housing
Panting, huddling	Thermal comfort	
Space allowance	Ease of movement	
Lameness, wounds on the body, vulva lesions	Absence of injuries	Good health
Mortality, coughing, sneezing, skin condition, ruptures and hernias	Absence of disease	
Social behavior	Expression of social behaviors	Appropriate behavior
Stereotypies, exploratory behavior	Expression of other behaviors	
Fear humans	Good human-animal relationship	

Table 3. Effects of the flattening rate on sows behavior

| | Sow behavior in the ratio of the flat floor | | | | | | |
	0%	20%	30%	40%	50%	F-value	p-value
Standing	39.64^a	26.82^b	20.53^c	19.11^d	27.84^b	2.451	0.001
Lying	60.36^d	73.95^c	82.01^b	89.89^a	88.97^a	2.451	0.001
Lying to slat cover	-	12.43^c	17.96^c	38.89^b	56.58^a	2.653	0.001
Fighting	0.03^b	0.01^a	0.00^a	0.00^a	0.00^a	2.451	0.001
Chewing	0.03^b	0.03^b	0.05^b	0.06^{ab}	0.14^a	2.451	0.016
Scratching	0.10	0.00	0.92	0.00	0.00	2.451	0.074
Grouping	2.28	1.13	19.96	1.26	0.06	2.451	0.062

$^{a–d}$Means with different superscripts in the same column differ significantly ($p < 0.05$).

sows in 0% spent a higher time standing behavior (an average of 39.64%) compared with 26.82%, 20.53%, 19.11%, and 27.84% per day in 20%, 30%, 40%, and 50% flattening rate treatments, respectively. Moreover, sows in the 20% and 50% treatments showed an increased standing behavior compared with the 30% and 40% treatments and the lower standing behavior was observed in the 40% flattening rate treatment. Lying was found to be higher as the flattening rate increased, and sows lying on the slatted cover also increased as the flattening rate increased ($p < 0.01$). Fighting behavior was higher when the flattening rate was 0%, and chewing behavior was increased in the 50% flattening treatment compared with 0%, 20%, and 30% ($p < 0.05$). No significant differences were observed in scratching and grouping behaviors.

Welfare level of sows

Table 4 shows the effect of the animal welfare level of the sows based on the flattening rate. In "good feeding," the maximum and minimum values of all treatment groups for body condition score (BCS) and water were good at 100 ($p < 0.05$). The BCS of the sows was modified by the farmer using a caliper to set the average BCS to 2.5, and the feed was limited to each individual.

Table 4. Effects of diffrent the flattening rate the welfare quality scores and assessment

Welfare principles assessment	0%	20%	30%	40%	50%	p-value
Good feeding						
Socre min	100	100	100	100	100	0.001
Socre max	100	100	100	100	100	
SD	0	0	0	0	0	
Good housing						
Socre min	78	87	89	94	96	0.157
Socre max	100	100	100	100	100	
SD	13.9	7.98	6.75	3.48	2.13	
Good health						
Socre min	75	96	95	96	94	0.076
Socre max	100	100	98	99	98	
SD	13.46	2.19	2.02	1.77	2.25	
Appropriate behavior						
Socre min	10	15	18	19	19	0.240
Socre max	10	15	22	39	49	
SD	0	0	2.83	14.14	21.21	

The welfare principle assessment items 'good housing' were bursitis, shoulder sores, manure on the body, panting huddling, and space allowance ($p > 0.05$). The maximum value in each treatment group was 100, and as the percentage of floor increased, the minimum increased from 0% to 78, from 20% to 87, from 30% to 89, from 40% to 94, and from 50% to 96%, respectively.

The 'good health' aspect of animal welfare includes lameness, wounds on the body, vulvar lesions, coughing, sneezing, skin condition, and ruptures and hernias ($p > 0.05$). The maximum value of the 0% and 20% treatment groups with the flattening rate was 100, and it was 98 at 30% and 50%, and 99 at 40%. In contrast, the minimum values were 75 at 0%, 96 at 20%, 95 at 30%, 96 at 40%, and 94 at 50%.

Appropriate behavior, which is the last item in animal welfare evaluation, includes social behavior, stereotypes, exploratory behavior, and human fear behavior ($p > 0.05$). The score was significantly lower than that of the other items, but when the flattening ratio was 0% and 20%, the maximum and minimum values were 10. At 30%, the maximum value was minimum values were 18 and 22, respectively. At 40% and 50%, the maximum values were 39 and 49, respectively, and the minimum values were 19 for both 40% and 50%. As a result of observing the level of animal welfare, 'Appropriate behavior' for 'fear of humans' involved avoiding people on a flat floor ratio from 0% to 20%, but when it was 30%, animals approached curiously, and when it was 40%, the reaction involved running and then approaching again.

DISCUSSION

The aim of this experiment was to determine the changes in the behavior and animal welfare level of sows when the existing slat floor was changed to group housing. These data will be used as basic data in terms of the health of group housing sows for farms that wish to convert from conventional farms to animal welfare farms and will become the basis for animal welfare farms in Korea in the future.

Sows behavior

The sows behavior varied with the proportion of the floor type. According to a previous study [3], as a result of observing the behavior of sows on a concrete floor and a rubber mat, the lying behavior of sows on the rubber mat was longer, indicating that the lying behavior of sows is affected by floor type. This supports our findings. Similar results have been reported in another study [14]. When the floor was flattened in the group housing system, the number of lying and standing positions increased because sows who gained weight felt less discomfort when their feet and legs were fatigued if the mat was flat. In this study, in terms of standing behavior as a ratio of lying time, as the ratio of the flattening rate increased, standing behavior decreased as lying behavior increased. This is also expected to be significant.

Fighting behavior in sows comes from group housing and food competition during mixing due to limited feeding and competition for positions for sows to rest [15,16]. In this study, it was confirmed that the fighting behavior decreased as the area of flattening rate increased, which is considered to result from the process of competition for a place for sows to rest rather than competition for food. In addition, although not feeding, the behavior of chewing with saliva is a kind of abnormal behavior that occurs when the sow does not consume enough food or is stressed due to dissatisfaction [11]. It is a behavior that can become chronic once started because continuous chewing produces a kind of narcotic morphine in the sow [17]. In this experiment, it was judged to be the behavior of sows that have become chronic about the restricted feeding rather than the effect of the floor.

Welfare level of sows

The Welfare Quality® protocol was designed to not only reliably assess animal welfare on farm but also provide standardized information about a product and thus to be used for certification purposes [9,18]. The protocol contains indicators concerning the four Welfare Quality® principles of good feeding, good housing, good health, and appropriate behavior. Therefore, it meets the requirements for studying the effect of flattening rate on the sow animal welfare level test. The Welfare Quality® protocol defines 32 indicators for use with sows. Of these, 81.3% are animal-based indicators, with management-based -and resource-based indicators each accounting for 9.38% of the remainder [18]. Good feeding is an important factor for animals [19]. In particular, sows can enter a negative energy balance during lactation when adequate fat and muscle body reserves are mobilized to support piglet growth through milk production [20]. In this study, we found that proper feed intake, water management, and breeding satisfied welfare standards. It was found this it was not affected by changes in flattening rate.

When evaluating the level of animal welfare, a good housing environment was divided into three welfare criteria. First, items related to animal comfort during rest were bursitis, shoulder sores, and body manure. Second, items related to animals' thermal comfort, that is, neither too hot nor too cold, were panting and huddling. Third, there should be sufficient space for animals to move freely according to breeding density. In this experiment, bursitis and claudication, classed under 'good health', showed no significant difference in the flattening rate. This is consistent with the finding that bursitis is correlated with lameness regardless of production and management systems [21]. However, for shoulder sores, judged as pressure injuries, at 0%, flattening rate, evidence of an old injury (scar tissue formed), evidence of a recent injury that was healing, or reddening of the area without penetration of the tissue was found to be > 30%. Reviews suggest that when sows lie down, the location and anatomy of the protruding tubers put pressure on the tissue above them, making this area prone to pressure sores [22]. This, in combination with other factors within the environment, including the floor surface, environmental temperature, and the health and comfort of the sow [22, 23], can influence the development of shoulder lesions and affect the behavior of sows. This is consistent with the result that the lying behavior of sows also increased as the flattening rate increased in this experiment. Space allowance is related to the size of an animal but includes various factors, such as independent physical space. It is involved in establishing the group size and action space that animals must share for social interaction, that is, a hierarchical structure that can vary depending on the group size and affects wounds and fighting behavior [24]. Therefore, in this study, the minimum total floor space of the animal welfare act was based on 3.5 m^2/sow and 2.5 m^2/gilt [1].

There are two major measures of good health. First, animals should be free of injuries, such as skin damage and locomotor disorders (lameness, wounds on the body, and vulvar lesions). Second, animals should be free from disease; that is, animal unit managers should maintain high standards of hygiene and care (for coughing, sneezing, skin conditions, ruptures, and hernias). We were not specific about the results related to injury according to the flattening rate; however, for skin conditions in the absence of disease, inflammation, discoloration, or spots appeared on less than 10% of the skin when the flattening rate was 0%. This is presumed to be because the conventional slat floor has a greater influence on the development of skin conditions than the flat floor because of the induction of pressure in combination with the weight, leg strength, movement control, and lying behavior of sows [25].

Appropriate behavior can be observed in three ways. First, animals should be able to express other normal behaviors; that is, it should be possible to express species-specific natural behaviors such as foraging or exploring (stereotypes, exploratory behavior). Second, animals should be handled well in all situations; that is, handlers should promote good human-animal relationships (HAR). This

experiment measured only items related to the HAR. The condition of a sow when it was placed in its pen and about 0.5 m away from other sows when it was still or its ear was touched was regarded as being caused by the relationship with the existing farm manager rather than the flattening rate. The rationale is that in a study comparing the responses of pigs to two different stock persons with markedly different contact characteristics with pigs [26], the pigs were unable to distinguish the two, and one person's rude treatment made animals fear everyone. This is consistent with the conclusion that because regular positive human contact is a powerful and reliable way to alleviate stress and fear responses in pigs, the key to HAR is closely related to farmers [27,28]

CONCLUSION

These results can serve as basic data on sow welfare for farmers to successfully transition to group housing and flat floors. However, since this study was conducted on a controlled experimental farm, there may be limitations in drawing firm conclusions about the application of various breeding management methods and environments under diverse conditions according to the characteristics of the farmer. Therefore, to ensure the increased conversion of existing farms to animal welfare farms, it is necessary to study the number of live pigs, weaned pigs, and difficult deliveries through follow-up of the sows used in this experiment. Furthermore, studies related to the welfare of sows according to the appropriate ratio of flat floor and flooring materials need to be appropriate to the Korean situation.

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