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Effects of Different Farrowing and Rearing Systems on Post-Weaning Stress in Piglets

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Received: 19 May 2020; Accepted: 13 June 2020; Published: 15 June 2020

Abstract: This study aimed to investigate how farrowing and rearing systems affect skin lesions, serum cortisol, and aggressive behavior as indicators for weaning stress of piglets. Between May 2016 and March 2018, in total 3144 weaning piglets from three different farrowing systems were examined: farrowing crates (FC), single-housing free-farrowing pens (FF), and group-housing of lactating sows and litters (GH). After weaning and regrouping, piglets were relocated to conventional rearing pens (conv; 5.7 m^2) or to wean-to-finish pens (w-f; 12.4 m^2). Skin lesions were scored 24 h after weaning. Blood samples were taken one week before and 24 h after weaning to analyze the individual difference in serum cortisol. Behavior was observed for 24 h after relocation. Animals raised in FC and FF had significantly more skin lesions than that of GH animals. Piglets born in GH showed lower cortisol differences and fought less and for shorter periods compared to FC and FF piglets. Piglets weaned to w-f pens showed greater cortisol changes and fought significantly longer than piglets in conv pens. Group housing during the suckling period reduced weaning stress for piglets in terms of skin lesions, serum cortisol, and aggressive behavior. Greater space allowance (w-f vs. conv) was not beneficial with regard to the investigated parameters.

Keywords: lactation housing; skin lesions; serum cortisol; early socialization; regrouping; agonistic interactions

1. Introduction

In many European countries, lactating sows are commonly kept in farrowing crates, altering the sow's welfare by inhibiting movement and natural nest building behavior but preventing the crushing of piglets [1]. Since it became mandatory in 2013 to house gestating sows in groups (Council Directive 2008/120/EC), many studies investigated group housing of gestating sows [2,3], and group housing of lactating sows [4,5], focusing on the welfare of the sow, and some reviewing the effects of these housing systems on the weaning piglets [4–8]. Although studies on aggression in (weaning) pigs date back to the 1970s, mixing aggression is still a persistent problem in pig husbandry [9,10]. In modern pig husbandry, weaning still poses a critical welfare-altering factor for the piglets. While (semi-)natural weaning is a gradual process that takes up to 17 weeks [11], weaning under conventional conditions is carried out earlier and abruptly. Usually, piglets are weaned at 21 to 28 days of age (Council Directive 2008/120/EC). They are separated from the sow, moved to a new environment with a change in feed, and regrouped with unknown conspecifics on the same day. The handling of the animal induces a stress reaction of the piglet by activating the hypothalamus–pituitary–adrenal axis, which leads to an increased synthesis and release of gluco-corticosteroids such as the stress hormone cortisol [12,13]. Since weaning involves multiple stressors [14], the weaning process should be improved to better meet the biological needs of the piglets. Already by 1983, Friend et al. [15] showed that mixing of litters did not affect the performance at rearing but greatly increased the incidence of fights in the first two days after weaning. The more a group was intermixed with unacquainted pigs, the more fights took place. Fights that occurred during establishment of a hierarchy resulted in a high skin-lesion score, especially in pigs that were regrouped during a fattening period [16]. Early socialization of piglets with other litters prior to weaning was found to have long-term benefits for the later social behavior [4,5,9,17]. When these pigs were mixed, a new hierarchy was formed more quickly compared to unsocialized pigs. Besides these social and physical components, there are also non-social aspects that affect how piglets respond to weaning. For example, Ewbank and Bryant [10] found that a greater space allowance at regrouping lowered the incidence of agonistic behavior. Enrichment before weaning, as well as loose-housing of sows were found to affect how piglets reacted to their environment after weaning [18].

The aim of this study was to investigate to what extent different farrowing and rearing systems affect weaning stress for piglets in regard to skin lesions, serum cortisol, and behavior.

2. Materials and Methods

2.1. Animals and Housing

The study was conducted on the research farm Futterkamp of the Chamber of Agriculture of Schleswig-Holstein in Germany. In nine batches between May 2016 and March 2018, in total 3144 crossbred ([Landrace × Large White] × Piétrain) weaning pigs (26.45 ± 0.97 days of age) were included in a 3 × 2 × 2 factorial design study from three different farrowing systems: (1) conventional single-housing in farrowing crates (FC; n = 869), (2) single-housing in free-farrowing pens (FF; n = 1087), and (3) group housing of lactating sows (GH; n = 1188) (Figure 1).

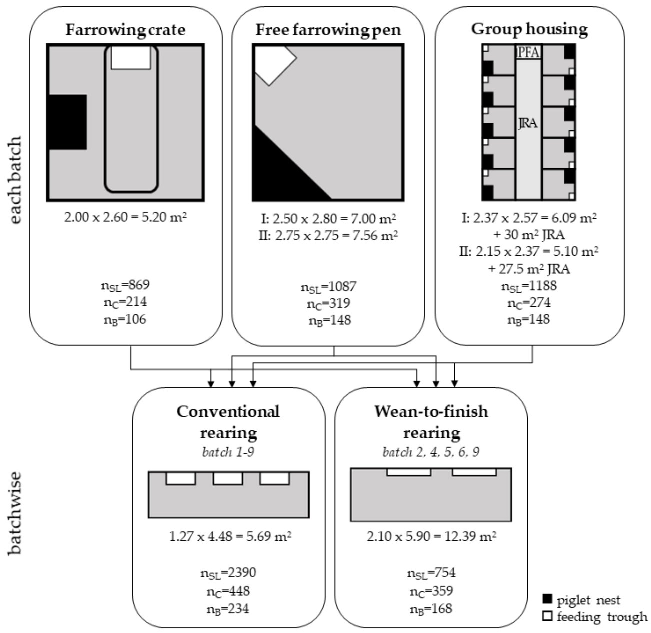

Figure 1. Schematic overview of the experimental design (n_{SL} = number of animals scored for skin lesions; n_C = number of animals sampled for serum cortisol; n_B = number of animals observed for behavior; I/II: different types of pen size; PFA = piglet feeding area; JRA = joint running area).

Sows were moved simultaneously to the farrowing system four days before the expected farrowing date. Sows in FC were confined permanently during farrowing and lactation. In two types of FF that differed in pen size (type I = 7.00 m^2, type II = 7.56 m^2), sows were housed individually but not confined permanently for the first eight batches, and confined for three days postpartum in the ninth batch to minimize the crushing of piglets. The FF pens were equipped with an open farrowing crate, so sows could be fixed temporarily. Therefore, FF sows could move freely and interact with their piglets for the whole (batch 1–8) or most (batch 9) of the lactation period of 27 days. In each of the two compartments of GH that differed in size, 10 sows were stalled in single-housing free-farrowing pens until day 5 postpartum, then, single-pens were opened and sows and their litters were able to interact freely in a joint running area (JRA) until weaning (compartment I = 6.09 m^2 pen + 30 m^2 JRA; compartment II = 5.10 m^2 pen + 27.5 m^2 JRA; for further details on lactation pens, see [19]). In all three farrowing systems, weaning took place on day 27, and piglets were regrouped and relocated farrowing-system-wise to one of two different rearing systems: (1) conventional rearing (conv; n = 2390) or (2) wean-to-finish rearing (w-f; n = 754). In conventional rearing, 13 piglets per equally balanced mixed-sex group were housed on fully slatted plastic floors with a space allowance of 0.44 m^2 per pig. In w-f rearing, groups of 14 piglets were housed on fully slatted concrete floors. Since animals in the w-f group were not regrouped for finishing, groups were sorted by sex at weaning to house single-sex groups, and the space allowance was adjusted for the finishing period to give 0.89 m^2 per pig. Also, the floor was especially customized for the study to suit the rearing of growing and finishing pigs on one floor type (conv: slat width = 10 mm, tread area = 10 mm; w-f: slat width = 13 mm, tread area = 67 mm; ethical approval code number V242-226720/2015). In both rearing systems, the same commercial diet was fed ad libitum, and nipple drinkers and manipulatable material like pieces of wood and ropes were provided. Half of the animals' tails were docked using a hot cautery iron on the first day after birth while the other half's tails were left intact (further details: [20,21]). Tail-docked and undocked piglets were not grouped together, and so tail-docking was seen as the third factor in the study design. A climate computer regulated ventilation and heating in both rearing systems, starting with 28 °C on the first days after weaning. Teeth grinding on the first day after birth as well as the raising of intact males was part of the farm management practice. The animals received a vaccination against porcine circovirus and deworming 9 days prior to weaning.

2.2. Scoring of Skin Lesions

All weaning pigs (n = 3144) were assessed for skin lesions on the day after weaning, following the Welfare Quality® assessment protocol applied to growing and finishing pigs [22]. The assessment was carried out by three assessors who trained together, and for each assessment, at least two of the three persons were present; one being the assessor, the other one an active observer, always ready to justify the given score. The assessor scored the animal's right side from a distance of approximately 0.5 m, dividing the pig's body into five parts (ears, front, middle, hind, and legs) and scoring each part separately. A scratch longer than 2 cm or two parallel scratches within a distance of only 0.5 cm or a small wound with a diameter of maximum 2 cm was considered one lesion. A bleeding wound between 2 and 5 cm or a healed wound greater than 5 cm was considered as 5 lesions and a deep open wound greater than 5 cm was considered as 16 lesions. Lesions were then scored from 0 to 2: according to the number of lesions, the body part was scored 0 for no or up to 4 lesions (minor lesions), 1 for 5 to 10 lesions (moderate lesions), and 2 when more than 10 lesions were visible (severe lesions).

2.3. Blood Sampling and Serum Cortisol Analysis

In 7 batches (batch 3–9), blood samples of 807 animals were collected on average 6.5 ± 1.1 days before weaning (pre; 19.88 ± 1.83 days of age) and one day after weaning (post; 27.39 ± 1.12 days of age) to assess physiological stress via the stress hormone cortisol (ethical approval code number V244-26304/2016). All samples were collected in the morning. Pre- and post-weaning samples had a time-of-day difference of 41 min on average. Pre-collection took place in the farrowing unit. For each batch, the selection of piglets aimed to achieve an equal balance of dams, sexes, and tail-docked and not docked piglets. The sampled piglets weighed 8.03 ± 1.44 kg. On average, 5.8 ± 3.9 piglets per rearing pen were post sampled (FC = 5.4 ± 4.4, FF= 6.3 ± 3.8, GH = 5.5 ± 3.7). For blood sample collection, the piglets were caught and sampled one after the other as quickly and quietly as possible by two persons (one veterinarian). One person restrained the piglet by holding it in a supine position with its neck straightened out. The other person took the blood sample from the vena cava approximately 3 cm cranial to the sternum with 18 G needles (1.2 × 40 mm) plugged onto Serum-Monovettes® (S-Monovettes®, Sarstedt AG & Co. KG, Nümbrecht, Germany) that contained a clotting activator. If blood sampling was not successful within two minutes, the piglet was released and not used for further blood sampling. The blood samples were stored in a dark and cool (7 °C) location until centrifugation, which took place on the sampling day. After centrifugation at 1500× *g* for 10 min, the serum was aliquoted and stored at −20 °C. For the determination of serum cortisol, an enzyme immunoassay kit (Cortisol ELISA, IBL International, Hamburg, Germany) was used by the same laboratory technician for all samples. Since cortisol follows a circadian rhythm [23] and differs individually between the animals, the relative difference between pre- and post-weaning serum cortisol was calculated for each piglet and used for further analysis:

$$\text{Relative cortisol difference} = ((\text{post}-\text{pre})/\text{pre})\times 100\% \quad (1)$$

When the value of the relative difference equals 100%, it doubles in value. A rise in cortisol between the two samplings was interpreted as a rise in stress.

2.4. Behavioral Observations

Immediately after weaning, when the piglets were relocated to the rearing unit, animals were marked individually on their backs. To enable an association of the behavioral observations with the other parameters taken 24 h after weaning, animals were filmed continuously for 24 h. Cameras (AXIS M3024-LVE, Axis Communications AB, Lund, Sweden) were placed above the pen, guaranteeing a full top view of the pen. Four observers were trained and passed an inter-rater reliability check in the definition and identification of fights and their duration, which were defined as physical contact of two animals lasting longer than five seconds featuring aggressive behavioral elements such as parallel/inverse parallel standing and/or pushing, biting, and head-knocks. If physical contact resulted in a fight, the duration was measured from first contact until the end of a fight, which was marked by an interruption of longer than three seconds. For each of the 402 observed animals in 30 pens (batches 4 and 5), fights and their duration were sampled continuously for the first 15 min of each hour using the Observer XT 14 (Noldus Information Technology BV, Wageningen, The Netherlands). The agonistic behavior could be assessed individually during light hours (6 a.m. until 6 p.m.). During the night, markings were indistinguishable due to insufficient lighting. Therefore, each animal's individual number of fights could only be counted for light hours, the duration of each occurring fight was measured, regardless of individual markings. In general, out of the 402 observed animals 233 individuals were involved in fights and for 355 fights, fighting duration could be detected.

2.5. Weaning Weight

The animals were weighed individually on weaning day prior to relocation and regrouping. For analysis, weaning weights were divided into three classes: light (≤7 kg), medium (>7 to ≤8.5 kg) and heavy (>8.5 kg).

2.6. Statistical Analysis

Skin lesions were primarily found on the ears, front, and middle part and to a negligible amount on hind-quarters and legs (score 1 = 31.92%, 36.43%, 29.18%, 11.97%, 3.99%, respectively; score 2 = 16.46%, 29.65%, 4.24%, 0%, 0.75%, respectively; frequencies calculated with the FREQ procedure in SAS®

(SAS Institute Inc., Cary, NC, USA)). Only lesions for the first three body parts were included in the analysis, as it is a common method to examine skin lesions after fights for rank [17,24]. To analyze the frequency of the skin lesion scores, a general linear model assuming a multinomial distribution was applied using the statistical language R (R core team, 2016). Fixed effects were tested with vector generalized linear models within the VGAM package in R [25] and determined as batch (1–9), rearing system (conv, w-f), farrowing system (FC, FF, GH), weaning weight class (light, medium, heavy), and tail-docking (yes/no). An additional possible fixed effect (sex) and interaction (farrowing system×rearing system) were tested, but not included in further analysis because parameters showed no significant influence on the model ($p > 0.05$) and increased the AICC (Akaike's information criterion corrected, [26]) and BIC (Bayesian information criterion, [27]). Afterwards, the glht (general linear hypothesis testing) function of the multcomp R-package [28] was used to allow a Tukey post-hoc comparison on all marginal models simultaneously. Fitted values of the glht function are presented in the results section.

The data on cortisol differences were analyzed using the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA). The model included the fixed effects batch (3–9), rearing system (conventional, wean-to-finish), farrowing system (FC, FF, GH), weaning weight class (light, medium, heavy), and tail-docking (yes/no). Other effects like sex, sampling time, difference between sampling time pre- and post-weaning, and interactions were excluded if no significant effect could be found and the AICC and BIC were increased. Pen type was added as a random effect.

The behavioral data (number of fights, duration per fight) were normalized using the log transformation [5,29] and then analyzed with the MIXED procedure in SAS® 9.4 (SAS Institute Inc., Cary, NC, USA) including the fixed effects batch (4–5), rearing system (conventional, wean-to-finish), and farrowing system (FC, FF, GH). For the number of fights, sex was included as a fixed effect in the model. Other possible fixed effects and their interactions (sex, tail-docking, farrowing system×rearing system, weaning weight class,) were tested but not included in further analysis because parameters showed no significant influence on the model ($p > 0.05$) and increased the AICC and BIC.

For all three MIXED models, the significance of differences for multiple comparisons between the least square means was adjusted using the Bonferroni correction. Residuals fulfilled requirements to assume variance homogeneity as well as a normal distribution.

The results of the log-transformed behavioral data were back transformed by the rise of 10 to the power of the estimates.

3. Results

3.1. Skin Lesions

The batch, the farrowing system, and weaning weight class had a highly significant effect on all body parts 24 h after weaning ($p < 0.001$). The rearing system differed only for the body part ears significantly ($p < 0.01$), and the docking status did not affect the frequency of skin lesions at all ($p > 0.05$). On average, more than half of the animals had only minor lesions: 55% of single-housed animals (FC and FF) vs. 85% in GH piglets.

Animals raised in the single-housing systems (FC and FF) had a significantly higher incidence of skin lesions than animals raised in GH ($p < 0.05$; Figure 2). For all three body parts, GH piglets differed significantly from FC and FF piglets ($p < 0.05$).

W-f animals showed significantly more severe lesions on the ears than conv piglet, although the difference was small (conv: 7.99% vs. w-f: 10.74%; standard error 0.16; $p < 0.05$; Figure 3).

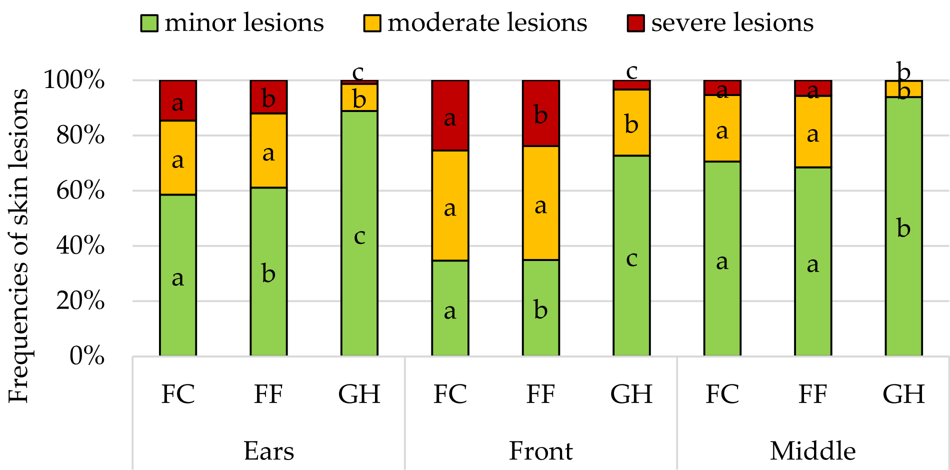

Figure 2. Estimated frequencies (%) of skin lesions per body part and farrowing system on the first day after weaning (FC: farrowing crate; FF: free farrowing pen; GH: group housing of lactating sows; a–c: different letters indicate significant differences within body part and score level ($p < 0.05$)).

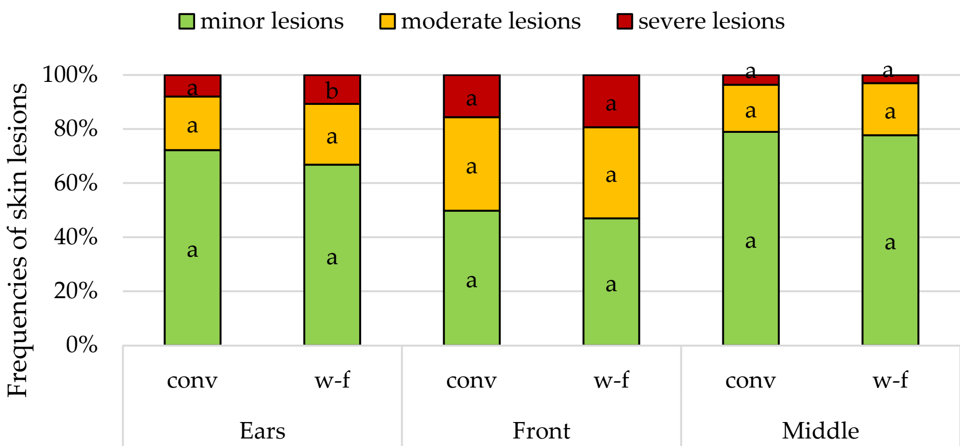

Figure 3. Estimated frequencies (%) of skin lesions per body part and rearing system on the first day after weaning (conv: conventional rearing pen; w-f: wean-to-finish rearing pen; a,b: different letters indicate significant differences within body part and score level ($p < 0.05$)).

On all three body parts, the frequency of the three lesion scores differed significantly for all three weight classes, where heavy animals showed higher lesion scores than medium and light pigs ($p < 0.05$; Table 1).

Table 1. Estimated frequencies of skin lesions in percent and standard errors (*se*) for the three body parts and weaning weight classes.

	Ears			**Front**			**Middle**		
	Weaning Weight Class			**Weaning Weight Class**			**Weaning Weight Class**		
	Light	**Medium**	**Heavy**	**Light**	**Medium**	**Heavy**	**Light**	**Medium**	**Heavy**
Minor lesions	85.64 [a]	70.25 [b]	52.49 [c]	72.91 [a]	46.95 [b]	26.24 [c]	90.73 [a]	77.91 [b]	64.92 [c]
se	0.15	0.19	0.14	0.12	0.18	0.14	0.17	0.20	0.14
Moderate lesions	11.27 [a]	21.33 [b]	29.01 [b]	21.27 [a]	36.34 [b]	41.99 [b]	8.18 [a]	19.04 [b]	25.41 [b]
se	0.15	0.19	0.14	0.12	0.16	0.12	0.18	0.21	0.15
Severe lesions	3.09 [a]	8.42 [b]	18.51 [c]	5.82 [a]	16.71 [b]	31.77 [c]	1.09 [a]	3.05 [a]	9.67 [b]
se	0.27	0.30	0.18	0.20	0.23	0.15	0.44	0.46	0.24

se: standard error; a–c: Different letters indicate significant differences within body part and score level ($p < 0.05$).

3.2. Serum Cortisol

The individual relative difference in serum cortisol differed significantly within all tested fixed effects ($p < 0.05$). Piglets raised in GH showed a lower cortisol difference than FC piglets, and animals weaned into w-f pens had a higher relative difference than piglets weaned into conv pens (Figure 4). The relative cortisol differences also differed significantly between tail-docked and undocked animals ($p < 0.05$): serum cortisol of undocked piglets rose about 86.5% compared with the pre value versus 25.72% for docked piglets. Piglets with low weaning weights showed a higher relative cortisol difference than piglets in the heavy weight class ($p < 0.05$).

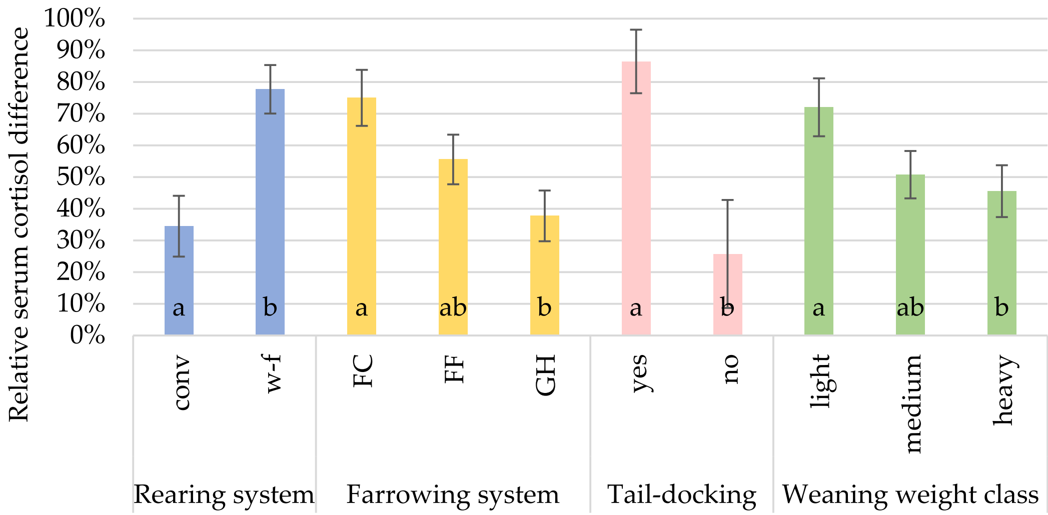

Figure 4. Estimated relative difference of serum cortisol before and after weaning, in percent, for the fixed effects rearing system, farrowing system, tail-docking, and weaning weight class (least square means with standard error bars; conv: conventional rearing pen; w-f: wean-to-finish rearing pen; FC: farrowing crate; FF: free farrowing pen; GH: group housing of lactating sows; a,b: different letters indicate significant differences within the tested effect ($p < 0.05$)).

3.3. Behavioral Observations

For the number of fights, only farrowing system and sex differed significantly ($p < 0.01$), batch and rearing system had no significant effect. For the duration of fights, all tested effects (batch, rearing system, farrowing system) differed significantly ($p < 0.01$).

Piglets born in GH fought significantly less than piglets born in FC and FF and fought for shorter periods than FC piglets ($p < 0.01$; Table 2). Although piglets weaned into w-f pens did not fight more often than conv piglets, they fought significantly longer than conv piglets ($p < 0.01$). Also, females showed significantly more fights than males ($p < 0.01$).

Table 2. Least square means and standard errors (*se*) of fights per animal and fighting duration (s) during the 24 h after weaning.

	Farrowing System			Rearing System		Sex	
	FC	**FF**	**GH**	**conv**	**w-f**	**m**	**f**
Fights per animal	3.11 ^{a}	2.37 ^{a}	1.61 ^{b}	2.09 ^{a}	2.48 ^{a}	2.00 ^{a}	2.59 ^{b}
se	0.04	0.03	0.04	0.03	0.03	0.03	0.03
Fighting duration (s)	41.08 ^{a}	24.63 ^{ab}	17.76 ^{b}	20.11 ^{a}	34.11 ^{b}	-	-
se	0.07	0.06	0.08	0.06	0.06		

FC: farrowing crate; FF: free farrowing pen; GH: group housing of lactating sows; conv: conventional rearing pen; w-f: wean-to-finish rearing pen; m: male; f: female; se: standard error; -: effect was not included in the model; a,b: Different letters indicate significant differences within the tested effect ($p < 0.05$).

4. Discussion

Mixing of unfamiliar conspecifics, which is common following weaning in commercial farms, forces pigs to establish a new hierarchy, which is accompanied by aggressive behavior like biting and pushing, resulting in skin lesions [4,5,9,16,30], a weakened immune system, and impaired productivity [31]. Consequently, weaning together with mixing are considered as the first major stressful events in a piglet's life [14]. It is well known that mixing of litters increases the incidence of fights, and the more a group is intermixed the more fights may occur [15]. While these fights result in skin lesions, an early socialization was found to have long-term benefits for later social behavior and performance [4,5,15–17,32]. Taking these findings into account, we hypothesized that piglets in this study that could interact with loose-housed sows or were socialized with other conspecifics during the suckling period would show fewer skin lesions after weaning, a lower pre- to post-weaning difference in serum cortisol, and overall less agonistic behavior compared to piglets farrowed in conventional housing systems with confined sows. Increased space allowance was found to lower the synthesis of corticosteroids, the incidence of aggressive behavior, and skin lesions [10,13,29,33]. For this study, a greater space allowance at weaning was assumed to reduce weaning stress with regard to fewer skin lesions, a lower cortisol difference, and less agonistic behavior compared to a higher stocking density.

4.1. Farrowing System

In general agreement with the present results, early socialization of piglets has been found to lead to a reduction in the number and duration of fights and lowers the incidence of skin lesions post-weaning [4,5,17]. Piglets raised in group housing showed fewer skin lesions, a lower cortisol difference, and fewer and shorter fights after weaning. Regarding the measured parameters of the present study, piglets raised in the free farrowing housing did not fully benefit from the farrowing system, showing only marginal differences in skin lesions and no significant differences concerning cortisol differences and the duration of fights per animal post-weaning compared to piglets raised in farrowing crates. In other studies, dams showed a lot of nose-to-nose contacts with their piglets immediately after farrowing prior to lying down [34,35] and loose-housing of the sow during farrowing and lactation was shown to have an effect on how piglets deal with their post-weaning environment, suggesting differences in maternal care between loose-housed sows and confined sows [18]. Loose-housed sows have the opportunity to interact with their piglets, probably improving maternal behavior and also social behavior of the piglets [36]. Still, we cannot make a statement for the sows' behavior in this study in terms of whether the loose-housed sows interacted more with their piglets than did confined sows. For the milder reaction to weaning of GH piglets concerning serum cortisol, it might be possible that piglets raised in group housing showed higher pre-weaning cortisol due to overall higher energy demands caused by the greater space allowance and the interactions with other litters when compared to that of FC and FF pigs. Arey and Sancha [37] found a nine-fold increase in play behavior in group-housed suckling piglets and de Jong et al. [38] found a higher baseline salivary cortisol of pigs housed under enriched conditions. In a study of Grimberg-Henrici et al. [19], which was completed in part with the same animals as in the present study, GH piglets had more skin lesions on week 4 of the suckling period, close to weaning, than that of piglets from a single-housing system, therefore suggesting higher activity levels in GH piglets during the suckling period. Yet, the present results show that these GH piglets had fewer skin lesions after weaning than that of FC and FF piglets.

4.2. Rearing System

In this study, the rearing system did not affect the incidence of skin lesions and the number of fights per animal, but it did affect the duration of the fights after weaning. The two rearing systems in this study differed in space allowance, floor type, and gender mixing, but there were no differences in management. Although Cornale et al. [13] found higher fecal corticosteroid levels in animals kept at higher stocking rates, w-f animals in this study had higher cortisol differences than piglets in the conv rearing pen. This suggests that with greater space allowance in w-f pens came a rise in fighting duration, which did not affect the amount of skin lesions, but the perceived stress. Beattie et al. [39] found that a greater space allowance led to more aggressive behavior in the pen compared to pens with a lower space allowance. This is in agreement with a study by Jensen [40], who showed that with increasing stocking density, the number of social activities decreased. In contrast, Meese and Ewbank [41] found that with higher space allowance, the number of negative interactions halved, but it has to be mentioned that pigs were raised at 22.5 m^2/pig, which far exceeds common commercial farming conditions. Baxter [42] observed that a certain circular space is required for pigs to allow anti-parallel pressing, a crucial element of pig fights. Wean-to-finish pens in the present study were 0.83 m wider than conventional pens, which meets Baxter's space requirement for anti-parallel pressing better than the rather narrow conv pens. Turner et al. [43] focused on injurious aggressive behavior and suggested that there are aspects in aggressive behavior that do not lead to lesions but could still cause stress to the pig such as pushing during fights. It is therefore possible that pigs in w-f rearing, that fought longer than conventional pigs, showed more harmless but still stressful fighting elements such as pushing. In addition, the high activity (longer fights) in w-f pens probably stimulated metabolism and therefore the synthesis of gluco-corticoids, such as cortisol [12]. As Turner et al. [44] found in their study, the longer fights in w-f pens might be beneficial for a more stable hierarchy, as fights for rank were not interrupted by pen structure and pen mates.

4.3. Tail-Docking

Although the routine use of tail-docking is prohibited by law (Council Directive 2008/120/EC), tail-docking is still applied and prevents tail-biting [45,46], an abnormal behavior that reduces production efficiency and animal welfare [47]. In the context of the present study, tail-docking was analyzed as a side-effect on weaning stress. Tail-docking affected the relative serum cortisol difference after weaning but not skin lesions. Skin lesions on the anterior body are associated with aggressive behavior concerning fights over dominance rank [24,43] more so than is tail-biting [46]. Animals with docked tails had a lower serum cortisol difference than animals with undocked tails. A study of Gentz et al. [21] showed that around 15–20% of undocked piglets were weaned with tail lesions. Minor tail-biting events during the lactation period might cause higher serum cortisol values of undocked piglets before weaning and lead, therefore, to a smaller difference overall. On the other hand, studies of Sutherland and Tucker [48] showed a temporary stress reaction to tail-docking and suggested that long-term studies are still needed to examine chronic stress in tail-docked pigs. Simonsen et al. [49] found traumatic neuromas in the tail stumps of docked pigs, weighing about 90 kg, which are known to be painful. As already proposed by Scollo et al. [50] tail-docked pigs seem to have higher cortisol values than that of undocked pigs in weeks 7, 19, and 28 of the fattening period. De Jong et al. [38] found a blunted circadian rhythm and lower levels of cortisol in barren housed pigs, explaining those results with chronic stress. It might be possible that piglets with docked tails suffer from chronic stress from the docking procedure and thus do not react as sensitively to weaning in terms of cortisol levels as undocked pigs do. Still, the effect of tail-docking on weaning stress has to be taken with caution.

4.4. Weaning Weight

Piglets who were classified as heavy showed more skin lesions and lower cortisol differences than those of light piglets, but weight classes did not affect the number nor the duration of fights. Prunier et al. [29] also found a significant increase in the number of skin lesions with increasing live weight. Although Andersen et al. [51] could not find any effect of weight asymmetry on the number of skin lesions, they also did not detect any impact of weight on the number of fights, which is in line with the findings of the present study. As well, Turner et al. [43] found no significant correlation between the fighting duration and weight, but did find a significant correlation between the duration spent being bullied and body weight: Lighter pigs were bullied for longer time periods. To sum up, although light and heavy piglets in this study fought the same amount and duration, heavier piglets ended up with more lesions, but light piglets seem to suffer more stress in terms of higher cortisol levels in the first 24 h after weaning. The present results indicate that there might be a difference in the fighting behavior of smaller and larger piglets, although Bolhuis et al. [52] found no significant influence of weaning weight on fighting behavior. Still, Jensen and Yngvesson [53] showed a tendency for longer fights with high-weighted opponents. Future behavioral observations will be undertaken to detect more detailed differences.

Findings of Meese and Ewbank [41] and Scollo et al. [50] confirm the findings of the present study that gender did not affect skin lesions or serum cortisol differences.

5. Conclusions

The present study showed that piglets housed in a group housing system during lactation profit from the early socialization across multiple litters, resulting in lower weaning stress in the form of agonistic interactions and consequently skin lesions. Apart from other possible positive effects of loose-housing on sow and piglet welfare, piglets in this study born in free-farrowing pens showed only marginal benefits on weaning stress compared to that of piglets raised in pens with a farrowing crate. The greater space allowance in wean-to-finish pens did not have an additional positive effect on weaning, but resulted in positive effects on the incidence of tail biting, which was not part of the present study. Furthermore, the wean-to-finish housing system also avoids stress during the course of the rearing and finishing period, as no further rehousing and regrouping before finishing was conducted.

Author Contributions: Conceptualization, A.L. and I.T.; methodology, A.L. and I.T.; software, A.L.; validation, A.L., M.G. (Maria Gentz), M.H., C.L., M.G. (Matthias Gauly), O.B., and I.T.; formal analysis, A.L.; investigation, A.L., M.G. (Maria Gentz), and M.H.; resources, I.T., O.B., M.G. (Matthias Gauly), and C.L.; data curation, A.L., M.G. (Maria Gentz), and M.H.; writing—original draft preparation, A.L.; writing—review and editing, A.L., M.G. (Maria Gentz), M.H., C.L., M.G. (Matthias Gauly), O.B., and I.T.; visualization, A.L.; supervision, I.T. and M.G. (Matthias Gauly); project administration, I.T., O.B., M.G. (Matthias Gauly), and C.L.; funding acquisition, I.T., O.B., M.G. (Matthias Gauly), and C.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Federal Office for Agriculture and Food of Germany and the Landwirtschaftliche Rentenbank (project no.: 2817205413; 758914).

Acknowledgments: The authors would like to thank the Chamber of Agriculture of Schleswig Holstein for their support during the project. We acknowledge support from the Open Access Publication Funds of the Göttingen University.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

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