Group housing for lactating sows with electronically controlled crates:

performance and behavioral parameters of sows and piglets

Dissertation
zur Erlangung des Doktorgrades
der Agrar- und Ernährungswissenschaftlichen Fakultät
der Christian-Albrechts-Universität zu Kiel

torgelegt von

M. Sc. Anna-Lena Bohnenkamp
aus Hamburg

Dekan: Prof. Dr. Rainer Horn
Erster Berichterstatter: Prof. Dr. Joachim Krieter
Zweiter Berichterstatter: Prof. Dr. Eberhard Hartung
Tag der mündlichen Prüfung: 08. November 2012

Die Förderung der Dissertation erfolgte dankenswerter Weise aus Mitteln des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE), FKZ 2807UM005.
Meiner Familie
TABLE OF CONTENTS

GENERAL INTRODUCTION .................................................................................................................................................. 1

CHAPTER ONE

Group housing for lactating sows with electronically controlled crates

1. Reproductive traits, body condition and feed intake .......................................................................................................... 4

CHAPTER TWO

Group housing for lactating sows with electronically controlled crates

2. Effect on farrowing, suckling and activity behavior of sows and piglets .................................................................................. 19

CHAPTER THREE

Comparison of growth performance and agonistic interaction in weaned piglets of different weight classes from farrowing systems with group or single housing ......................................................................................................................... 37

CHAPTER FOUR

Gruppenhaltung mit Einzelbuchtsteuerung für laktierende Sauen: 3. Auswirkungen auf Arbeitszeit und Platzbedarf ......................................................................................................................................................... 54

GENERAL DISCUSSION .......................................................................................................................................................... 62

GENERAL SUMMARY .......................................................................................................................................................... 68

ZUSAMMENFASSUNG .......................................................................................................................................................... 70
GENERAL INTRODUCTION

Group housing for gestating sows is predefined as a consequence of the European Union Council Directive 91/630/EEC amended by the Council Regulation (EC) No. 806/2003 (2003). However, the majority of lactating sows in the EU are still fixed in crates during the whole lactation period to reduce piglet losses, space and labor requirements and to ensure operator safety (Baxter et al., 2011).

Under natural conditions, sows have a huge freedom of movement. They leave their herd approximately 24 h before farrowing, return on average at day 10 p.p. and stop suckling between week 14 to 17 (Jensen, 1986). However, under commercial conditions farmers are confronted with managerial constraints and average litter sizes of more than 12 piglets, whereas litter sizes of 16 to 20 piglets are not uncommon (Andersen et al., 2011; Baxter et al., 2011; ZDS, 2010). In consequence, strict management of the sows is necessary to improve piglet survival, retain fitness and to optimize the milk supply of the piglets by e.g. balancing the litter sizes and feeding strategies (Andersen et al., 2011; Kruse et al., 2011). This strict management also results in an early and abrupt process of weaning between week 3 to 4 p.p.. Weaned piglets are exposed to different stressors (e.g. new environment, foreign pen-mates, separation of the dam, solid feed) but socializing piglets before weaning could disentangle these stress factors and enhance the growth performance of pigs (Hessel et al., 2006). However, the socialization of sows and piglets during lactation needs consequent control since instable teat order, cross-suckling or missed nursing may decrease the milk intake of the piglets (Jais et al., 2009; Maletinska and Spinka, 2001).

Single housing (SH) with crates is mostly used in conventional farms, but alternative farrowing systems still exists such as loose single housing (LSH) or group housing systems (GH). LSH and GH are distinguished from each other by their pen design, the possibility of fixation during parturition and the required building space (Bates et al., 2003; Bøe, 1993; Bünger, 2002; Kutzer, 2009; Marchant et al., 2001; Pajor et al., 2002). Furthermore, the design of an additional common area should receive attention. If piglets can not follow their sow into the shared running area, the bond between mother and offspring can weaken and weaning can occur very early (Bøe, 1993; Pajor et al., 2002).

The aim of this thesis was to investigate a group housing system which includes single pens with crates, electronically controlled gates and a common running area. The sow was motivated to visit her ‘personal’ crate, regularly, because individual feed and water were
exclusively available in the pen. Fixation in the crates was only carried out during farrowing, whereas piglets could follow the sows into the running area on day 5 p.p.. The group housing was compared to single housing with conventional crates.

The first chapter deals with the performance of sows housed in group or single housing with conventional crates. The aim of this chapter was to evaluate the farrowing systems with regard to the litter performance, piglet losses (quantity and causes) and individual weights of the piglets. Furthermore, the daily feed intake of the sows was recorded in relation to their weaning weights, loss of back fat and body condition during lactation.

The second chapter relates to behavioral aspects of sows and piglets during farrowing and lactation in two different housing systems, comparing farrowing duration, suckling and activity behavior between group housing with short-time crating during parturition and conventional crated sows. Behavioral differences in the pens and the running area of the group housing system were observed additionally during the lactation period.

The third chapter looks at the consequences of group and single housing systems for piglets on the performance and agonistic behavior of the animals after weaning. The GH- and SH-pigs were kept in separate pens, but were sorted by weight. The focus of this chapter was the interaction between the farrowing environment and weaning weight class in regard to the body weight and daily feed intake during rearing as well as the duration and frequency of agonistic behavior immediately after weaning.

The fourth chapter concerns to the space and labor requirements of the group housing system compared to conventional single housing.

REFERENCES


CHAPTER ONE

Group housing for lactating sows with electronically controlled crates

1. Reproductive traits, body condition and feed intake

A.-L. Bohnenkamp†*, I.Traulsen†, C. Meyer‡, K. Müller‡, J. Krieter†

†Institute of Animal Breeding and Husbandry, Christian-Albrechts-University, Olshausenstraße 40, D-24098 Kiel
‡Chamber of Agriculture Schleswig-Holstein, Gutshof 1, D-24327 Blekendorf
* Corresponding author: abohnenkamp@tierzucht.uni-kiel.de

Submitted for publication in Journal of Animal Science
ABSTRACT

The aim was to compare a group housing system (GH) and a conventional single housing (SH) for lactating sows with regard to the performance of sows and piglets. Data of 132 cross-breed sows were collected in 11 batches with 6 sows in GH and SH in each batch. The group housing system had single pens (4.7 m²) with electronically controlled crates and a shared running area (13m²). The sows in GH were retained in the crates 3 d prepartum until 1 d post partum. Piglets were able to leave the single pens on d 5 post partum. Recorded traits per litter included the number of piglets born alive and weaned, piglet losses, individual weight at birth and weaning. In addition, body condition and back fat thickness before and after lactation (26 d) and the daily feed intake of the sows were measured. Gilts and sows were analyzed separately. The reproductive traits did not differ significantly (P > 0.05) between the farrowing systems with exception of the weaning weights (GH = 7.6 ± 0.12 kg vs. SH = 8.1 ± 0.12 kg; P < 0.05). Group housed and SH sows had 14.4 ± 0.47 and 14.6 ± 0.45 piglets born alive, respectively. In both housing systems, sows weaned 11.4 piglets (SEM = 0.14 and 0.13 for GH and SH), respectively. Most piglet losses (72%) occurred during the first 3 d post partum. At this point in time, piglets in GH and SH were housed in single pens. In the single pens GH-sows could leave the farrowing crate, while SH-sows were fixed in crates during the whole lactation. In total, piglet losses were not significantly different during lactation between GH and SH treatments (2.2 ± 0.05 and 2.4 ± 0.05 piglets per litter, respectively). Sows housed in GH had a significantly lower (P < 0.05) BCS (2.2 ± 0.05) after lactation compared with SH-sows (BCS = 2.4 ± 0.05). This development could not be verified using the back fat thickness value at weaning (GH = 14.4 ± 0.25 mm vs. SH = 14.6 ± 0.23 mm). Daily feed intake was significantly greater for GH sows (6.4 ± 0.08 kg per day) than SH sows (6.15 ± 0.08 kg per day; P < 0.05). In conclusion, the performance of GH and SH sows was similar with the exception of lower weaning weights in group housing.

Key words: group housing system, farrowing, reproduction, mortality, sow

INTRODUCTION

Group housing in the gestation stage has already been implemented according to the basic legal requirements (Council Directive 91/630/EEC, 2003). However, the majority of lactating sows are still fixed in crates. Alternatives to conventional single housing (SH) have until now been loose single housing (LSH) or group housing systems (GH). Group housing can be
implemented in 1 compartment with single pens and a shared running area (Bates et al., 2003; Kutzer et al., 2009) or in 2 compartments with SH or LSH (until d 8 or 12 post partum) and an additional GH compartment (Dybjær et al. 2001; Kühberger and Jais, 2006). Sows in LSH or GH are fixed temporarily in crates or they are housed loosely (Bøe, 1994; Stanbenow and Manteuffel, 2002). Feeding techniques in SH, LSH and GH are individual troughs in the single pens while GH-sow can also be fed in free-access crates or by an electronic sow feeder station in the shared running area (Bøe, 1994; Bates et al. 2003). The crates are built to prevent piglet losses (Cronin and Smith, 1992; Lay et al. 2002), but they restrict the free movement of the sows. A compromise would be time-limited crating with additional freedom once the piglets have become established (Edwards, 2008). Furthermore, mixing sows and piglets in GH can result an in instable teat order, cross-suckling or missed nursings and may decrease the milk intake of the piglets (Arey and Sancha, 1996; Maletinska and Spinka, 2001; Jais et al., 2009).

In the present study, effect of GH vs. SH on sow and piglet performance was investigated. Group housing included single pens with crates, electronically controlled gates, and a shared running area. An individual feed intake was provided in the single pens, which motivated the sow to visit her “personal” crate regularly. The GH sows were kept in the crates only during farrowing. Sows in single housing were fixed in conventional farrowing crates in single pens during the whole lactation.

MATERIAL AND METHODS
Pigs involved were kept in pens in consideration of the Council Directive 91/630/EEC and Council Regulation (EC) No 806/2003 (2003) in accordance with the Tierschutz-Nutztierhaltungsverordnung (2006). This work is supported by the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Federal Agency for Agriculture and Nutrition (BLE), grant number 2807UM005.

Animals and housing
Data collection was carried out on the Futterkamp agriculture research farm of the Chamber of Agriculture of Schleswig-Holstein from March 2009 until August 2010. A total of 144 crossbred-sows (Large White x Landrace) in 12 batches were observed in 2 different farrowing systems. In each batch, 6 gilts or 6 sows (second to eighth parity) were kept in the GH system and in the conventional SH system, respectively. Sow ages between each batch
varied, but were equal in both SH and GH within each batch. The GH system had 6 single pens (1.8 m x 2.6 m) with farrowing crates, electronically controlled gates and a shared running area (2.4 m x 5.4 m) between the pens (Figure 1). The GH system was equipped with an individual sow identification system (ear tag) to control the entrance through the electronically controlled gates of the farrowing crates. A sow only had access to one crate. The antenna of the ear tag was immediately behind the gates at the end of the crate. If the sow was entitled to move into the crate, the gates opened. At the end of the crate, a light barrier regulated the gate openings, when the sow walked backwards into the running area. Feed and water were only available in the pen. The running area had a farrowing rail on the inner surface of the walls and included a straw self-feeder.

Figure 1  
Schematic view of the group housing system with six individual pens (4.7 m²) and running area (13 m²)

The sows in conventional single pens (2 m x 2.6 m) were also kept in parallel ordered crates. Cast-iron slats with traction patterns (32% perforation) with 3 centrally arranged solid surfaces in the lying area of the shoulder were fitted under the farrowing crates in GH and SH. Both housing systems had water-heated piglet resting areas (0.6 m²). The remaining floor in the pens and the running area was fitted with plastic slats (32 to 40% perforation). Manipulable material was available for the sows and piglets in both SH and GH, respectively. A climate computer regulated ventilation and heating in the compartments. Temperatures varied between 19 and 21°C. Lights (80 lx) were switched on at 0600 h and switched off at 2000 h.
The sows were housed in a dynamic group (N ≈ 200) with electronic sow feeding stations during gestation and kept in SH and GH one week before farrowing. The sows in GH were fixed in their individual crates 3 d before the calculated farrowing date until 1 d post partum. Between d 2 and 5 post partum the sows were able to walk backwards out of the crate over a flexible step into the running area, while the piglets stayed in the single pens. On d 5 post partum, the flexible step was removed and the piglets could also use the running area. After cross-fostering (within 24 h post partum) the maximum litter size was about 12 piglets in both housing systems. Boars were castrated 4 d post partum. Piglets were weaned on average at d 26 post partum. The lactating sows received a commercial lactating meal (13.4 MJ of ME per kg, 17% CP, 4.3% crude fat, 1% Lys) in accordance with the German norm (GfE, 2006). The daily feed intake of the GH and SH sows was restricted by a given feeding curve. The curve started at a low level immediately after farrowing (gilts: 25 MJ of ME; sows: 30 MJ of ME) with 1 portion per day and reached its maximum on lactation day 18 (125 MJ of ME) with 4 portions per day. One day before weaning, the sows were given half of the daily feed amount. This feeding level was designed for sows with 12 piglets per litter. Sows in GH were fed by hand and sows in SH by an electronically feeding system. In SH, dry feed was mixed with water in a rotation distributor and supplied into the trough as liquid feed. In GH feed and water were mixed in the trough of the sow. Feeding portions of 1 d were added and saved in the farm’s database. The piglets in GH and SH were given a commercial creep diet (14.6 MJ of ME per kg, 18.5% CP, 7.6% crude fat, 1.45% Lys) in the pens from 10 d of age. Drinking bowls for the sows and piglets in the farrowing pen enabled free access to water.

**Recorded traits**

The reproduction traits included the number of piglets born alive, stillborn piglets, weaned piglets, piglet losses and individual weights. A piglet was categorized as stillborn, when it was fully developed but did not breathe at birth. The number of piglet losses was documented during the whole lactation period including cause, date and weight of the piglets. Losses were divided into crushed and other (underweight, running, splay legs, etc.). The individual weights of the piglets were recorded within the first 24 h post partum and at weaning. Lactational estrus was checked during the daily routine work but did not occur in GH and SH during the period of investigation.

Body condition score (BCS) and back fat (BF) were recorded 1 wk prepartum and 4 wk post partum. The BCS was scaled in steps of 0.25 from Class 1 for very thin sows to Class 5 for fat sows. The BF was measured with an ultrasound scanner (Agroscan, Hauptner & Heberholz,
Solingen, Germany) 5 cm beside the median line at 3 defined points (behind the shoulder, middle of the back, before the hip). The mean of BF was calculated using these three measured values. The BCS and BF were recorded by 1 person. Daily feed intake was measured for SH and GH sows.

**Statistical Analysis**

The functionality of the electronically controlled gates and the management of the GH were controlled and adjusted in the first batch. Twelve sows of Batch 1 were excluded from the statistical analysis. Another 8 sows (Batches 2 to 12) were left out of the data set due to disease, death or use as a nursing sow. In total, 21 gilts and 103 sows with 1,415 weaned piglets from Batches 2 to 12 were considered in the statistical analysis. Gilts and sows were calculated separately.

Data were analyzed using a mixed model (MIXED procedure; SAS v. 9.2, SAS Institute Inc., 2008). The reproductive traits of the sow (number of piglets born alive, stillborn, weaned and piglet losses) included the fixed effects batch (gilts: 5, 9; sows: 2 to 4, 6 to 8, 10 to 12), parity (sows: 2, 3 to 5, 6 to 8) and housing system (GH, SH). Parity 2, 3 to 5, and 6 to 8 had 28, 47, and 28 observations, respectively. Fixed effects were tested for significance and were added to the model in a stepwise manner: maximum likelihood was used to test the different models. Interactions between the fixed effects that had no significant effect were removed. Comparisons of the different models were carried out using the fit statistics “Akaike’s information criteria corrected” (AICC; Hurvich and Tsai, 1989) and the “Bayesian information criteria” (BIC; Schwarz, 1978). The model with smallest AICC and BIC values was chosen to favor less complex model variants. The significance of differences in the least squares means was adjusted with the Bonferroni-correction (Westfall and Tobias, 1999). Homogeneity of variance was checked by plots of the standardized residuals against the predicted values (GPLOT procedure; SAS, 2008). The residuals were normal distributed.

The same model was applied to the BCS and BF measurements 1 wk prepartum. Models for BCS and BF 4 wk post partum were completed with BCS and BF 1 wk prepartum as linear continuous variables.

The final model of the daily feed intake per sow was conducted with the fixed effects batch, parity, housing system, lactation day (1 to 26) nested within the housing systems and the random effect of the sow. Residuals were not normally distributed due to the given feeding curve. Therefore the error covariance needed to be modeled. Acceptable residuals were
performed with the first-order heterogeneous autoregressive structure (Littell et al., 2006; Kramer et al., 2008, Kruse et al., 2010).

The analysis of birth weight in kilogram per piglet was performed with the fixed effects batch, parity and housing system and the random effect of the sow. The model of the weaning weights was added to the lactation length (21 to 26 d) as a linear continuous variable.

RESULTS

Reproductive traits
The housing system did not influence the reproductive traits of the gilts and sows with the exception of the weaning weights. Group housing sows had 14.4 (SEM = 0.47) piglets born alive and the SH sows 14.6 (SEM = 0.45; Table 1). At the end of lactation, a similar numbers of weaned piglets per litter were assessed with 11.4 in GH (SEM = 0.14) and SH (SEM = 0.13; P > 0.05), respectively. Most piglet losses in GH and SH (72%) occurred during the first 3 d after farrowing. The total percentage of piglet losses during the whole lactation period was 14.7% in GH and 15.7% in SH. In GH, 6.5% of the piglets were crushed in the single pens and 1.2% in the running area (SH = 4.8%). Piglet losses due to other causes (underweight, runting, splay legs, etc.) were greater in SH at 10.9% vs. GH at 7.0%. The piglets in GH and SH had similar birth weights. The weaning weights were 500 g lower in GH at 7.6 kg (SEM = 0.12) per piglet compared with piglets in SH at 8.1 kg (SEM = 0.12; P < 0.05). The results of the gilts showed the same tendency of lower weaning weight in GH with 6.5 kg (SEM = 0.31) compared with SH with 7.2 kg (SEM = 0.34). However, this difference was not significant (P = 0.25) with a sample size of 21 gilts.
Table 1.
Least squares means (± SEM) of the reproductive traits and daily feed intake of sows and gilts in group and single housing (GH and SH, respectively)

<table>
<thead>
<tr>
<th></th>
<th>GH</th>
<th>SH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sows</td>
<td>Gilts</td>
</tr>
<tr>
<td></td>
<td>(n = 51)</td>
<td>(n = 11)</td>
</tr>
<tr>
<td>Piglets born alive/ litter</td>
<td>14.4 (0.47)</td>
<td>13.4 (1.05)</td>
</tr>
<tr>
<td>Stillborn piglets/ litter</td>
<td>1.4 (0.22)</td>
<td>1.6 (0.46)</td>
</tr>
<tr>
<td>Individual birth weight, kg</td>
<td>1.46 (0.04)</td>
<td>1.27 (0.07)</td>
</tr>
<tr>
<td>Piglets losses/ litter</td>
<td>2.2 (0.24)</td>
<td>2.5 (0.47)</td>
</tr>
<tr>
<td>Piglets weaned/ litter</td>
<td>11.4 (0.14)</td>
<td>11.0 (0.38)</td>
</tr>
<tr>
<td>Individual weaning weight, kg</td>
<td>7.6a (0.12)</td>
<td>6.6 (0.31)</td>
</tr>
<tr>
<td>Daily feed intake, kg</td>
<td>6.40a (0.08)</td>
<td>5.36 (0.13)</td>
</tr>
</tbody>
</table>

a-b Values with different superscripts differ significantly within sows and gilts (p < 0.05).

Change of body condition and back fat

The housing system had an effect on the BCS of gilts (P = 0.05) and sows (P < 0.05) 4 wk post partum. Both GH and SH sows had a similar BCS of 3.2 (SEM = 0.04) and 3.1 (SEM = 0.04), respectively 1 wk prepartum (Figure 2). After weaning, the GH-sows had a lower BCS of 2.2 (SEM: 0.05) compared to SH-sows of 2.4 (SEM: 0.05; P < 0.05).

The development of BCS 4 wk post partum could not be verified by the decrease of BF thickness during lactation. The housing system did not affect the BF thickness of gilts and sows. Week-1 BF thickness in GH and SH was 18.1 mm (SEM = 0.53) and 18.3 mm (SEM = 0.50), respectively and BF thickness 4 wk post partum for GH and SH sows was 14.4 mm (SEM = 0.25) 14.6 mm (SEM = 0.23), respectively (P > 0.05). In contrast to the sows, gilts had a greater BCS [GH: 3.4 mm (SEM = 0.11) vs. SH: 3.6 mm (SEM = 0.11)] and BF [GH: 19.0 mm (SEM = 0.88) vs. SH: 20.8 mm (SEM = 0.75)] one week before farrowing. The BCS of the gilts at weaning was equal to the sows, while the thickness of BF was enhanced at 15.5 mm (SEM = 0.57) in GH and 15.0 mm (SEM = 0.48) in SH treatment groups.
Figure 2

Body condition (BCS) and back fat (BF) of sows in group and single housing (GH, SH) 1 wk prepartum and 4 wk post partum

![BCS and BF graphs]

\(^{ab}\) Values with different superscripts are significant different (p < 0.05).

Daily feed intake

The feeding curve restricted the voluntary daily feed intake of the sows in both housing systems from lactation d 1 through 14 (Figure 3). Afterwards the voluntary feed intake of GH and SH sows was restricted by the feed intake capacity of the sows. The daily feed intake of GH sows followed the feeding curve until d 14 of lactation.

Figure 3

Feeding curve and least-square-means of the daily feed intake of lactating sows (N = 103) in group and single housing (GH, SH)
Due to the electronic feeding system, the increase in daily feed intake in SH was 1 d later compared with the given feeding curve. This delayed increase in daily feed intake continued through lactation d 15. Overall, sows in GH had an enhanced daily feed intake during lactation of 6.40 kg (SEM = 0.08) compared with SH sows at 6.15 kg (SEM = 0.08; P < 0.05; Table 1).

**DISCUSSION**

*Reproductive traits*

No differences concerning the total number of piglet losses were detected in the present study, but the percentage of crushed piglets was greater in GH (pen: 6.5% and running area: 1.2%) compared with SH (4.8%). The reason was seen in the size of the pens. Piglets in GH had less space (1.8 x 2.6 m) to react to the sows’ posture changes compared with the piglets in SH (2.0 x 2.6 m). Likewise, Kutzer (2009) assessed more crushed piglets in GH (pen size: 1.8 x 2.5 m) with 1.13 piglets per litter compared with SH (2.0 x 2.5 m) with 0.59 piglets per litter (P < 0.05), whereas the total number of piglet losses was not different in GH, LSH and SH. In contrast to the present study, Kutzer (2009) did not fix the sows during farrowing. The absence of a crate might be the reason of more crushed piglets. Lay et al. (2002) and Edwards (2008) verified greater piglet losses due to crushing in non-crate systems and detected simultaneously a lower incidence of other mortality causes (rumping, biting, diarrhea, etc.). Blackshaw et al. (1994) added that the entire absence of a farrowing crate resulted in enhanced total piglet losses (pen = 32% piglet losses vs. crate = 14% piglet losses; P = 0.05). Especially until the third day of life, piglets have comparatively poor mobility and are vulnerable to crushing (Marchant et al., 2001; Stabenow and Manteuffel, 2002). Baxter et al. (2012) assessed that group systems had relatively high mortality levels, with the exception of systems which include a crate during farrowing. These statements lead to the conclusion that the presence of a farrowing crate could be an effect of the number and causes of piglet losses. Birth weight, the birthing process, a microclimate and milk intake are as important for piglet survival (Pedersen et al., 2011; Vasdal et al., 2011) as the interaction between disease, thermoregulation and nutrition (Lay et al., 2002). Furthermore, in the present study, the GH-pens with 1.80 m width were too small and resulted in an enhanced numbers of crushed piglets.
The lower weaning weights in the GH presented seem to be caused by a greater amount of missed nursing events and by enhanced playful behavior. Bates et al. (2003) mixed piglets 7 d post partum and detected similar results with a lower litter weaning weight for GH sows (55.5 kg per litter) compared with SH sows (58.4 kg per litter). They explained the weight differences by the decreased milk consumption of the GH piglets, which was caused by less nursing events. Likewise, Wattanakul et al. (1997) and Weary et al. (1999) confirmed reduced nursing frequencies for mixed piglets. In contrast to the present study they housed piglets in SH and mixed the piglets first on d 10 or 11 post partum. However, they were not able to ascertain any differences in the weight gain of mixed and unmixed piglets during lactation. Likewise, Kutzer (2009) investigated GH, LSH, LSH with mixed litters (10 d post partum), SH, and SH with mixed litters (10 d post partum) and revealed an ADG of 0.25 kg, in the investigated farrowing systems, respectively. In consequence, the time of mixing the piglets might account for the reduced weaning weights in GH. Bünger (2002) and Hessel et al. (2006) verified that the subsequent mixing of piglets between d 10 to 12 post partum did not result in disadvantages with regard to growth performance due to an established teat-order. According to these results, the time of mixing and the stability of the teat-order seemed to be the major cause of the total milk intake and weight differences between GH and SH piglets. Missed milk flow phases could not be regained by subsequent teat-sucking activity or by a second milk ejection soon after the first (Fraser, 1980). Valros et al. (2002) ascertained that one additional nursing over 24 h increased ADG during lactation by 5 g (p < 0.05). Olsen et al. (1998) indicated that it might be important to use sows with a high milk yield when sows were kept in groups during lactation. Piglets with low milk intake spent more time and energy reserves initiating the milk flow (Klaver et al., 1981; Algers and Jensen, 1990). In conclusion, disturbances during suckling due to early mixing on d 5 post partum might result in enhanced cortisol levels in the sow. Cortisol has been reported to increase blood glucose (proteolytic and lipolytic activity), insulin secretion and food intake (Mormède et al., 2007), and if this redundant energy is not used in the stress response the results are an increase in the fat depot at the expense of tissue protein (Mormède et al., 2007). This could explain lower weaning weights and a greater loss of body condition without having an effect on the BF although the daily feed intake was enhanced in GH. Further research is needed to confirm this assumption.

Gilts had similar tendencies concerning the reproductive traits and weaning weights compared with the sows. In addition, 9 of 12 gilts in GH had to be weaned before d 26 of lactation because of injured teats. In the conventional single pens, only 3 of 12 gilts left the farrowing
system before the weaning date. In contrast to the udders of the sows, teats of gilts were softer and did not adapt to the sucking activity of the piglets. Accordingly, the teats were more vulnerable to being injury.

**Body condition, back fat and daily feed intake**
The greater daily feed intake of GH sows from lactation d 10 to 16 was caused by the effect of the feeding system. The electronic feeding system in SH updated the feeding curve at the end of the day (night time), whereas feeding by hand in GH had already adapted the daily feed amount in the morning. Concerning the lower BCS of GH-sows at weaning, a restrictive feeding curve might be not the optimal feeding strategy to optimize milk production. The sows mobilize their body reserves (Algers and Uvnäs-Koberg, 2007) and enhance their feed intake (Eissen et al., 2000) to increase energy demand during lactation. However, the loss of body condition could not be confirmed with the loss of BF thickness. If the sows were weighed before farrowing and after weaning, a more detailed explanation of the change in body condition may have been possible.

**CONCLUSION**
Group housing had no influence on reproductive traits of pigs compared with SH. The greater numbers of crushed piglets in GH were caused by the narrow pens. The lower weaning weights of GH piglets were a result of mixing the piglets too early, which disturbed the teat order. A less restricted feeding strategy of GH sows may positively affect the weaning weights of the GH piglets. Group housing was less attractive for the gilts, because of injured teats at the end of lactation. A longer fixation of GH gilts with their own piglets could incidences of teat injury caused by the sucking activity of foreign piglets.

**LITERATURE CITED**


CHAPTER TWO

Group housing for lactating sows with electronically controlled crates
2. Effect on farrowing, suckling and activity behavior of sows and piglets

Anna-Lena Bohnenkamp\textsuperscript{1*}, Christian Meyer\textsuperscript{2}, Karin Müller\textsuperscript{2}, Joachim Krieter\textsuperscript{1}

\textsuperscript{1}Institute of Animal Breeding and Husbandry, Christian-Albrechts-University, Olshausenstraße 40, 24098 Kiel, Germany
\textsuperscript{2}Futterkamp Agriculture Research Farm, Chamber of Agriculture Schleswig-Holstein, Gutshof, 24327 Blekendorf, Germany

* Corresponding author: Tel.: +49 4318804537; fax: +49 4318802588.
E-mail address: abohnenkamp@tierzucht.uni-kiel.de

Submitted for publication in Applied Animal Behaviour Science
ABSTRACT
The aim of the present study was the analysis of behavioral parameters of sows and piglets in two different farrowing systems. Data of 132 crossbred-sows were collected. Conventional single housing with farrowing crates (SH) was compared to a group housing system (GH) with six single pens, electronically controlled gates (ear tag) and a shared running area. GH-sows were fixed in their crates from day 3 ante partum (a.p.) until day 1 post partum (p.p.). The piglets remained in the pens until lactation day 5 (flexible step) and were weaned on lactation day 26.

The behavior of the sows and piglets was recorded by videotape. Under investigation were the parameters ‘farrowing duration between each piglet’, ‘the number and duration of sucklings’, ‘missing and foreign piglets during suckling (only GH)’, ‘the duration and frequency of the sows’ activities (lying, sitting, standing, walking)’ and ‘the number of GH-piglets in the running area (suckling, resting, walking)’. The farrowing duration was not different for the piglets in GH (11 min) and SH (10 min; p > 0.05). Likewise, the suckling duration was equal with 17 min/ observation unit in GH and SH, respectively (p > 0.05). The frequency of suckling did not vary significantly (GH: 3.9 vs. SH: 3.6/ time period of three hours).

However, the suckling behavior of the GH-piglets changed during nursing. Fewer than one GH-piglet was missing during milk flow, while this proportion rose during udder massages before and after milk flow (p < 0.05). The number of foreign piglets was not influenced by the udder massages or milk flow phases (0.3 to 0.4 piglets/ 30 s scan; p > 0.05). Furthermore, suckling in the running area resulted in higher numbers of missing and foreign piglets (p < 0.05). With reference to the activity behavior, the farrowing system had no effect on the sows’ periods of lying, sitting and standing (p > 0.05). The sows’ time in the GH-pens decreased from lactation day 5 (20.6 h/ d) until it reached a nearly constant level on lactation day 11 (11.6 h/ d; p < 0.05). GH-piglets used the running area primarily for walking and playing while they preferred the heated piglet nests for resting. In conclusion, suckling frequency and duration were similar in both farrowing systems whereas suckling in GH resulted in enhanced disturbances during udder massages. GH-sows remained in the crates with their piglets during the first five days p.p. and the running area was used for defecating.

Key Words: milk flow, missing and foreign piglets, resting place, running area, udder massage
INTRODUCTION

The increase in animal welfare due to enhanced freedom of movement is very common in discussions on farrowing systems. Well-being is a social issue with ethical, scientific and political properties (Swanson, 1995). Especially the fixation in crates is in contrast to the biological needs of the sow (Baxter et al., 2011).

Under natural conditions, sows can choose to walk and rest without restrictions. These sows leave their herds approximately 24 h before farrowing (Jensen, 1986), return to the herd and mix with other non-littermates on average at day 10 p.p. (Jensen and Redbo, 1987; Pitts et al., 2000). Under commercial conditions, different alternative farrowing systems utilize single pens and the socialization of sows and piglets once the piglets have become established. These alternatives include loose single housing (LSH) with short-time crating (Bünger, 2002; Weber et al., 2009), LSH without crating (Danbolt et al., 2011; Gu et al., 2011; Kutzer, 2009), LSH with an additional running area (Devillers and Farmer, 2008; Pajor et al., 2002) or group housing systems (GH) with different pen designs and common area (Bates et al. 2003; Bøe, 1994; Marchant et al., 2001, Weary et al., 2002). An additional common area expands the sows’ possibilities of coming into contact with other sows and litters and improves the structure of different functional areas (lying, feeding and defecating). Furthermore, allowing sows to move freely decreases their parturition length (Gu et al., 2011; Oliviero et al., 2008). The studies of Gu et al. (2011) and Oliviero et al. (2008) focused on farrowing durations of penned or crated sows, but the consequences of short-time crated sows were not investigated.

The design of a running area in LSH or GH can also result in disadvantages such as increased piglet losses due to crushing or cross-suckling (Damm et al., 2005; Danbolt et al., 2011; D’Eath, 2005; Maletinska and Spinka, 2001). The bond between mother and offspring can be weakened and weaning can occur very early, when the piglets cannot follow the sow in the running area (Bøe, 1993, 1994; Pajor et al., 2002). A combination of individual farrowing pens with crates and a group-housed multisuckling system may optimize the prevention of piglet losses due to crushing and the freedom of movement of the sows (Wattanakul et al., 1997). However, group housing systems needed careful attention with regard to feeding and management in order to prevent social stress (Edwards, 2008).

In the present study, a group housing system with single pens, electronically controlled crates, and common running area was compared to single housing with conventional crates. In GH, feed was only available in the single pens. The GH-sows were fixed only during parturition whereas the piglets remained in the GH-pens until day 5 p.p.. Under investigation were the reproductive traits during lactation (Bohnenkamp et al., 2012a) as well as the growth
performance and agonistic behavior of weaned piglets during rearing (Bohnenkamp et al., 2012b). The present study deals with the behavior of sows and piglets at farrowing and during lactation (suckling, resting).

**MATERIAL AND METHODS**

*Animals and housing*

The study took place at the *Futterkamp* agriculture research farm of the Chamber of Agriculture of Schleswig-Holstein over a period from March 2009 until August 2010. In total 144 crossbred-sows farrowed in two different housing systems and were tested in 12 batches. Gilts and sows (2nd to 8th parity) were kept separately within the farrowing systems. The conventional single housing with farrowing crates (SH) consisted of six pens (2.00 m x 2.60 m). The group housing system (GH) had six single pens (1.80 m x 2.60 m) with crates, electronically controlled gates and a shared running area (13 m²) between the pens. The sows had access to their “personal” farrowing crate due to an individual sow identification system (ear tag) at the electronically controlled gates. Feed and water (drinking bowls) were only available in the pens. The floor design included cast-iron slats (crates), water-heated piglet nests and plastic slats in the pens and running area. The temperature in the farrowing compartments was 19 to 21°C and the lights (80 lx) were on between 06:00 h to 20:00 h. Dim light was provided during the night.

Gestating sows were kept in a group (N=200) with electronic sow feeding stations. The sows were housed in the farrowing compartments (GH, SH) one week before the calculated farrowing date. Farrowing was inducted with PGF2α one day before the calculated farrowing date. The application of oxytocin was carried out when the piglet birth intervals were delayed (40 % of the GH- and SH-sows). GH-sows were fixed in their crates during farrowing from day 3 ante partum (a.p.) until day 1 post partum (p.p.). Due to a flexible step the sows could use the running area and the piglets remained in the pens. This step was removed on lactation day 5. Within the first day after farrowing the litter size in GH and SH were balanced (max. 12 piglets/ litter). The average weaning age of the piglets was 26 days. Management and housing systems used in the present study were in accordance to the Council Directive 91/630/EEC and Council Regulation (EC) No 806/2003 (2003) through the Tierschutz-Nutztierhaltungsverordnung (2006).
Recorded traits

The behavioral parameters included the farrowing, suckling and activity of the sows and piglets recorded on video (HeiTel Digital Video GmbH, Kiel, Germany) and supplemented by randomly direct observations. GH-sows were marked on their sides and backs when they were kept into the farrowing system. GH-piglets received marks before the flexible steps were removed (5 days p.p.). Every GH-piglet within one litter had the same sign. The marks were renewed every second day with a commercial livestock-marking spray.

The videotapes of the farrowing started 12 h a.p. and continued until the last piglet was born. The farrowing duration between each piglet was measured. Furthermore, the vitality of the piglets was divided into piglets born alive and stillborn piglets. If it was necessary to assist at birth, this was noted additionally. The suckling and activity behavior were recorded hourly on selected lactation days (Table 1).

Table 1
Overview of the recorded behavioral parameters farrowing, suckling and activity of sows and piglets in group and single housing (GH, SH)

<table>
<thead>
<tr>
<th>Event</th>
<th>Farrowing system</th>
<th>Number of batches</th>
<th>Animal</th>
<th>Lactation day</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrowing</td>
<td>GH, SH</td>
<td>N=4</td>
<td>Sow (N=36)</td>
<td>1</td>
<td>12 h a.p. – p.p. (continuous sampling)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piglet (N=536)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suckling(^a)</td>
<td>GH, SH</td>
<td>N=5</td>
<td>Sow (N=60)</td>
<td>5, 8, 11, 14, 18, 22, 25</td>
<td>3 x 1 h (continuous sampling)</td>
</tr>
<tr>
<td>Suckling(^b)</td>
<td>GH</td>
<td>N=3</td>
<td>Gilt (N=6)</td>
<td>5, 6, 8, 11, 14, 18, 22, 25</td>
<td>2 x 1 h, 2 x 2 h (continuous sampling)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sow (N=12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suckling(^c)</td>
<td>GH</td>
<td>N=3</td>
<td>Piglet (N=205)</td>
<td>5, 6, 8, 11, 14, 18, 22, 25</td>
<td>2 x 1 h, 2 x 2 h (30 s-scan sampling)</td>
</tr>
<tr>
<td>Activity(^a)</td>
<td>GH, SH</td>
<td>N=5</td>
<td>Sow (N=60)</td>
<td>5, 8, 11, 14, 18, 22, 25</td>
<td>3 x 1 h (continuous sampling)</td>
</tr>
<tr>
<td>Duration in the crate</td>
<td>GH</td>
<td>N=2</td>
<td>Gilt (N=12)</td>
<td>-6, …, 26</td>
<td>24 h (light barriers)</td>
</tr>
<tr>
<td>Activity: running area</td>
<td>GH</td>
<td>N=6</td>
<td>Sow (N=36)</td>
<td>-6, …, 26</td>
<td>24 h (light barriers)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Piglet (N=684)</td>
<td>5, 6, 8, 11, 14, 18, 22, 25</td>
<td>2 x 1 h, 2 x 2 h; (5 min-scan sampling)</td>
</tr>
</tbody>
</table>

\(^a\) Suckling/ activity duration and frequency in SH and GH

\(^b\) Suckling frequency of gilts and sows in GH

\(^c\) Number of missing and foreign GH-piglets during suckling
The duration and number of sucklings per observation unit was counted (continuous sampling). The location of the GH-sows was divided into pen and running area. In addition, the numbers of foreign and missing piglets were counted every 30 s during nursing (scan sampling). Suckling started with udder massage and was followed by milk flow. The suckling ended if fewer than 5 piglets massaged the udder after milk flow or if the sow stopped lying on her side. The maximum suckling duration was limited to 10 min.

A sow’s activity was categorized by lying (side and belly), sitting, standing and walking (only in GH). The duration and also the number of these activities were established by continuous sampling. In GH, the videos of the sows’ activities were supplemented by measurements of the sows’ daily duration time in the pen. This duration time was obtained by counting contact between the sow and one of two light barriers. These light barriers were fixed at both sides of the crate and registered the sow in a lying, sitting or standing position. The videos of GH-piglet activity were analyzed with 5 min scan samples. The number of GH-piglets suckling, resting or walking in the running area was assessed for every scan. The videotapes were analyzed by one trained observer.

Statistical Analysis
The functionality of the electronically controlled crates in the GH-system were tested and adapted in the first batch. In consequence, Batch 1 was excluded from the data evaluation. The statistical analysis was performed with the statistical software package SAS 9.2 (SAS Institute Inc., 2008). The procedure MIXED was used for the data with normal distribution whereas GLIMMIX and GENMOD were applied for count data (poisson-distribution). Due to technical problems with the video recordings the numbers of evaluated batches in GH and SH varied between the different parameters (Table 1).

The fixed effects were added to the models, stepwise (maximum likelihood). Interactions between the fixed effects were not significant. Comparisons of the different models were performed with the fit statistic Akaike’s information criteria corrected (AICC; Hurvich and Tsai, 1989) and the Baysian information criteria (BIC; Schwarz, 1978). The model with the smallest AICC and BIC values was chosen. The variance-homogeneity was checked by plots of the standardized residuals against the predicted values (approximately normal distributed). The final models with their fixed and random effects are given in Table 2.
Table 2
Statistic models of the behavioral parameters of sows in group (GH) and single housing (SH) with fixed effects: batch (BA), parity (PA), housing system (HS), lactation day (LD), vitality of the piglet (VP), assistance at birth (AB), location (LO), daytime (DT), scan number (SN), pen number (PN), order of born piglets (OBP) as linear continuous variable and the random effect sow

<table>
<thead>
<tr>
<th></th>
<th>data</th>
<th>BA</th>
<th>PA</th>
<th>HS</th>
<th>VP</th>
<th>AB</th>
<th>LD</th>
<th>LO</th>
<th>DT</th>
<th>SN</th>
<th>PN</th>
<th>OBP</th>
<th>sow</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farrowing duration</td>
<td>normal (log(x+1))</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Suckling duration</td>
<td>normal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Activity duration</td>
<td>normal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Activity frequency</td>
<td>normal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Duration GH-pen</td>
<td>normal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Piglet</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suckling: missing piglets</td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Suckling: foreign piglets</td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Activity: running area</td>
<td>count (poisson)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Batch (BA): variation due to technical problems (Table 1)
Parity (PA): 2\textsuperscript{nd}, 3\textsuperscript{rd} to 4\textsuperscript{th}, 5\textsuperscript{th} to 8\textsuperscript{th}
Housing system (HS): group and single housing
Vitality of the piglets (VP): born alive, stillborn
Assistance at birth (AB): with, without
Lactation day (LD): variation between the parameters (Table 1)
Location (LO): GH-pen, running area
Daytime (DT): morning, midmorning, midday, afternoon
Scanumber (SN): 1=suckling start, …, 20=suckling end
Pennumber (PN): 1, 2, 3, 4, 5, 6
Order of born piglets (OBP): 1\textsuperscript{st}, …, 20\textsuperscript{th} (linear continuous variable)
RESULTS

Farrowing
Sows were fixed immediately before (GH: 3 days a.p. vs. SH: 7 days a.p.) and during farrowing. No differences were detected between the activities of GH- and SH-sows 12 h before farrowing. These activities (lying, sitting and standing) increased 9 h a.p. and decreased in hour 1 a.p. Afterwards, the sows remained in a sideways position, which was the basic position during farrowing. The farrowing duration between each piglet was not influenced by the housing system with intervals of 11 and 10 min (back-transformed; p > 0.05) between GH- and SH-piglets, respectively. However, the vitality of the piglets and assistance at birth affected the birth intervals. Stillborn piglets had greater distances with 15 min compared to piglets born alive (7 min; p < 0.05). Assistance at birth shortened the length of farrowing significantly (7 min vs. without assistance: 16 min).

Suckling of sows and piglets
The housing system had no significant effect on the suckling behavior of the sows. The duration (GH and SH: 17 min per time period of three hours) and the frequency of sucklings (GH: 3.9 vs. SH: 3.6 per time period of three hours) were nearly similar between sows in the different farrowing systems (p > 0.05). However, the suckling behavior of the GH-gilts and GH-sows tended to be different. On lactation day 5, gilts and sows suckled their piglets with an average frequency of 1.4 per h. These intervals varied between 1.3 to 1.7 sucklings per h until the weaning process of the sows was introduced. On lactation day 18, the gilts had reduced the number of sucklings per hour (0.8 per h) while the sows decreased them first on lactation day 22 (0.7 per h).
In addition, the stability of the teat order in GH was evaluated by counting the number of missing and foreign piglets per 30 s scan during suckling (max. 10 minutes). The suckling was initiated with udder massage (30-90 s) which was followed by milk flow (30 s). Afterwards the piglets continued the udder massage. During the milk flow phase, fewer than one GH-piglet (0.9) was missing, while more piglets missed udder massages before and after milk flow (p < 0.05; Figure 1). The number of foreign GH-piglets during suckling remained constant with 0.3 to 0.4 piglets per 30 s scan (p > 0.05).
Figure 1
Least-square-means of the number of missing and foreign piglets (N=205) per 30 s scan during 10 minutes of suckling in group housing

The number of missing and foreign piglets was under influence of the sows’ location in the GH (pen vs. running area; p < 0.05) and the day of lactation. In the running area the numbers of missing and foreign GH-piglets (2.3 and 0.9 piglets per 30 s scan) was higher compared to the missing and foreign piglets in the pens (1.7 and 0.2 piglets per 30 s scan), respectively. Furthermore, significantly more missing and foreign piglets were observed on lactation day 5 (2.5 and 0.5 piglets per 30 s scan) compared to lactation day 25 (1.7 and 0.3 piglets per 30 s scan).

**Activity of sows and piglets**
The housing system had no effect on the sows’ duration of lying, sitting and standing (Table 3). However, the GH-sows showed significantly enhanced frequencies of using sideways positions and standing while the number of sitting was lower (p < 0.05).
Table 3

Least-square-means (LSM) and standard error (SE) of the activity duration (min) and frequency of three hours at selected lactation days for the sows (N=60) in group (GH) and single housing (SH)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration (min)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GH LSM (±SE)</td>
<td>SH LSM (±SE)</td>
</tr>
<tr>
<td>Lying (belly)</td>
<td>72 (±2.99)</td>
<td>76 (±2.97)</td>
</tr>
<tr>
<td>Lying (side)</td>
<td>57 (±3.65)</td>
<td>55 (±3.61)</td>
</tr>
<tr>
<td>Sitting</td>
<td>9 (±1.16)</td>
<td>11 (±1.15)</td>
</tr>
<tr>
<td>Standing</td>
<td>32 (±2.51)</td>
<td>39 (±2.47)</td>
</tr>
<tr>
<td>Walking</td>
<td>9 (±0.93)</td>
<td>-</td>
</tr>
</tbody>
</table>

*a,b* Values with different superscripts differ significantly (p < 0.05).

Furthermore, the duration time of the GH-sows in the crates differed during the lactation period. The GH-sows preferred the crates until the flexible steps were removed on lactation day 5 (Figure 2). However, the GH-gilts used the running area more early. The duration time of sows in the GH-crates decreased until lactation day 11 (12.1 h). Afterwards the sows spent nearly half of the day in the crate and the other half in the running area. The GH-gilts spent considerably less time in the crate and chose the running area as their preferred location.

![Figure 2](image-url)

Figure 2

Least-square-means of the duration time of gilts and sows in the pen of the group housing during lactation
The behavior of the GH-piglets showed large variation during the day. Active phases included walking and playing in the running area and were often followed by resting periods in the pen. Figure 3 illustrates a typical course of the day of 12-day-old GH-piglets during summer.

![Piglet activity graph](image_url)

**Figure 3**

Piglet activity in the running area of the group housing during the course of lactation day 12 in batch 12

The piglets preferred to rest on their heated nest in the GH-pen. This observation was verified with the least-square-means of the 5 min scans during the whole lactation period. Only 0.1 to 0.4 piglets per 5 min scan were counted for resting in the running area. Especially in winter, the GH-piglets rarely rested in the running area due to the cold temperatures. However, the lactation period had an effect on the intensity of walking and suckling in the running area. After removing the flexible steps on lactation day 5, 3.2 piglets per 5 min scan were walking in the running area. At this time the number of suckling piglets was at a low level (1.4 piglets per 5 min scan) and the sows preferred their crates to suckle the piglets. The most GH-piglets in the running area were counted on lactation day 14 with 14.2 piglets per 5 min scan. Half of the piglets were walking while the other piglets were suckling. At the end of the lactation (day
the number of suckling piglets decreased (2.5 piglets per 5 min scan) while the number of walking piglets remain at the same level with 6 piglets per 5 min scan.

DISCUSSION

Farrowing
Sows in GH and SH were fixed in crates before and during farrowing. This might be the reason why no effects were detected on the activities 12 h a.p. and on the birth intervals between the two housing systems. Oliviero et al. (2008) observed significantly shorter farrowing durations for penned sows (218 min) compared to crated sows (311 min). Therefore, a GH without crating the sows during parturition is necessary to improve the sows’ welfare during nest-building and farrowing.

The results of the present study verified the statement of van Dijk et al. (2005) that stillborn piglets have significantly longer birth intervals compared to piglets born alive. Gu et al. (2011) added that birth intervals exceeding 30 min indicate an enhanced risk of stillbirth. In contrast, Vallet et al. (2010) reported increased stillbirth rates with intervals longer than 1 h. It remains unclear however whether the farrowing duration or the number of dead piglets a.p. was the causative factor for high stillbirth rates (van Dijk et al., 2005). Even so, assistance should be given as soon as the birth interval is longer than 15 to 30 min since a dead piglet can not help partition actively but blockades the birth canal for littermates.

Suckling of sows and piglets
The total suckling duration and frequency was not under the influence of the farrowing system, which concurred with results of Silerova et al. (2006). Likewise, Arellano et al. (1992) compared crated with group-housed sows and detected no influence of the housing design on the proportion of successful sucklings. The reason is probably the attractiveness of the GH-pen, which included individual feeding in the personal crates. The sows could leave their piglets, if they wished. However, the GH-sows spent their resting time with the piglets in the pen during the first five days p.p..

In the present study, the gilts in GH reduced their suckling frequencies earlier than the sows. Additionally, nine of twelve GH-gilts had to be weaned before lactation day 26 because of hurt teats compared to three (of twelve) SH-gilts. Obviously, suckling in the running area (own plus foreign piglets) and the natural weaning process put more strain on the GH-gilts.
compared to GH-sows. It might be a better solution to extend the fixation time after farrowing and reduce the numbers of sucklings in the running area.

The time of the beginning of the weaning process is in accordance with Jensen et al. (1991), who assessed decreasing suckling frequencies of about 1.3 sucklings per hour in week 1 to almost 0 at week 15. Likewise, Silerova et al. (2006) established fewer nursings during the third to fourth week of lactation and Bøe (1994) added that a considerable variation between sows exists. Jensen (1994) suggested that sows are more stressed by older piglets and spend more time away from the litter to terminate nursing at the end of lactation. A piglet-free area would improve the sows’ possibilities to rest without piglets and to terminate nursing in dependence of their fitness. Bøe (1993) investigated such loose-housing systems but determined poorer weight gain for early weaned piglets due to decreased numbers of sucklings between week 2 (20.4 sucklings per day) and week 4 (4.8 sucklings per day).

The presented results show that more missing piglets were counted during udder massage compared to the milk flow phase. Similar to the presented results, Andersen et al. (2011) assessed on average one piglet that did not receive milk during the milk flow phase in a litter size of 12 piglets in LSH. The present study determined a constant level of foreign piglets during the whole suckling with the 30 s scans. In contrast, random direct observation showed that more than 0.3 to 0.4 foreign piglets were at the sows’ teats during the udder massage (but not during milk flow). These observations indicate that foreign piglets stay less than 30 s at one sow and search for another place soon afterwards. In accordance to this observation, Jais et al. (2009) established more non-littermates before nursing during stimulate massage (10 %) and observed less cross-suckling during milk ejection (7 to 8 %). However, Maletinska and Spinka (2001) observed 29 % cross-suckling in GH. The authors expressed the litter size to be the main factor of influence. Andersen et al. (2011) amended that 10 to 11 piglets might be the upper limit for sows to take care of. In the present study, the litter size could not be verified as a factor of influence since we standardized the litter size immediately after birth (max.12 piglets) and weaned 11.4 piglets in GH and SH (p > 0.05), respectively.

Activity of sows and piglets

The GH-sows had enhanced freedom of movement due to the common running area but the duration of lying, sitting and standing was not different between GH- and SH-sows. However, the numbers of changing positions lying laterally and standing were significantly higher in GH while sitting was observed more often in SH. These results indicate that sows in GH change between their crate and the running area regularly, but perform similar activities
compared to SH-sows. The sows and piglets in GH used the running area to distinguish the functional areas feeding, resting and defecating. In consequence, no manual cleaning was necessary in GH after removing the flexible steps. Individual differences between GH-sows were detected by the intensity of using the running area. Some sows preferred the “silence” of their crate during the whole time in GH, while other sows spent more than 50% of the day in the common running area. However, there was a difference between GH-gilts, which spent less time in the crate than the GH-sows. The reason is seen in the combination of sows in the groups. The gilts had known each other since they were retained in quarantine in the agriculture research farm. However, the sow groups varied in age from 2nd to the 8th litter, which resulted in a different hierarchy. In GH, it is important to keep sows together with similar conditions and an homogenous age structure to prevent agonistic behavior. The long duration times of sows in the GH-pen immediately after farrowing could also be a result of previous experiences with other farrowing systems.

At the beginning of lactation, the sows and piglets preferred their own pens for suckling. With decreasing age of the piglets, they also shared their resting place with non-littermates and decreased numbers of suckling were counted. Jensen and Redbo (1987) verified that the piglets spent more time outside the nest after lactation day 10 and have more contact with non-littermates. This observation is in accordance with Bünger (2002) and also with Jais et al. (2009), who assessed fewer foreign piglets in the resting place with 6% on day 11 p.p. compared to 24% on day 25 p.p.

CONCLUSION

Group housing of lactating sows had no effect on farrowing, suckling duration and frequency as well of the duration of lying, sitting and standing. Suckling in the common running area resulted in increased numbers of missing and foreign piglets compared to suckling in the GH-crates. Gilts choose the running area as their preferred location. In consequence, gilts were more stressed due to foreign piglets during suckling, which might be the reason for hurt teats and the early weaning of the sows. The running area was used as a place of activity and a defecating zone by sows and piglets. In GH, manual cleaning was not necessary since the piglets had access to the running area.
ACKNOWLEDGEMENT
This work is financially supported by the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Federal Agency for Agriculture and Nutrition (BLE), grant number 2807UM005.

REFERENCES


CHAPTER THREE

Comparison of growth performance and agonistic interaction in weaned piglets of different weight classes from farrowing systems with group or single housing

A.-L. Bohnenkamp\textsuperscript{1a}, I. Traulsen\textsuperscript{1}, C. Meyer\textsuperscript{2}, K. Müller\textsuperscript{2}, J. Krieter\textsuperscript{1}

\textsuperscript{1}Institute of Animal Breeding and Husbandry, Christian-Albrechts-University, Olshausenstraße 40, D-24098 Kiel

\textsuperscript{2}Chamber of Agriculture Schleswig-Holstein, Gutshof 1, D-24327 Blekendorf

\textsuperscript{a}Corresponding author: Anna-Lena Bohnenkamp
E-mail: abohnenkamp@tierzucht.uni-kiel.de

Published in Animal, available on CJO 2012 doi:10.1017/S1751731112001541
ABSTRACT

The present study was designed to analyze the growth performance, behavioral patterns, frequency and intensity of injuries of weaned pigs (weaning age: 26 days) during rearing. The farrowing system (group, single) and the post weaning regrouping weight class (light, medium and heavy) were considered as the main factors.

A total number of 240 weaned pigs of a group farrowing system (GH) and conventional single farrowing system (SH) were observed during a rearing period of six weeks. 120 GH-pigs and 120 SH-pigs were kept in three batches in a total of 20 pens consisting 12 pigs each. The GH- and SH-pigs were divided by weight into three groups: light (5 to ≤ 7 kg), medium (> 7 to ≤ 9 kg) and heavy (> 9 to ≤ 12 kg), with two pigs of six different litters in each pen. Female and castrated pigs were kept together. The pigs were weighed individually at weaning (week 1) and during rearing (in week 2, 3 and 7). The feed conversion ratio (FCR) was calculated on a pen basis between week 1 and week 7. Agonistic behavior was videotaped for about 40 hours after weaning. The duration and number of fights per pen and hour were determined by continuous sampling. Lesions of the integument were scored into four classes (none, minor, medium, severe) and recorded immediately at weaning (LS 1) and 48 hours after weaning (LS 2). The lesion score difference (LSD) described the change in LS 2 minus LS 1. Keeping sows with their piglets in GH or SH had no significant effect on the weaning weights (week 1: GH: 7.8 kg vs. SH: 7.7 kg; week as linear, quadratic regression nested within housing systems) or the weights after rearing (week 7: GH: 29.4 kg vs. SH: 28.6 kg). The body weights were influenced by the weaning weight class (light: 11.7 kg (SEM: 0.30), medium: 14.8 kg (SEM: 0.22) heavy: 17.3 kg (SEM: 0.26); p < 0.05). The FCR of the GH-pigs was 1.64 (SEM: 0.03) and 1.58 (0.03) for SH-pigs (p = 0.1). A reduced agonistic behavior of the GH-pigs was observed with 2.1 fights per pen and hour (SEM: 0.07) versus the SH-pigs with 4.6 fights per pen and hour (SEM: 0.05; p < 0.05). The fight duration of the GH-pigs with 10.3 s per pen and hour (SEM: 1.07) was significantly lower in comparison to the SH-pigs with 18.8 s per pen and hour (SEM: 1.06; p < 0.05). The SH-pigs had significantly (p < 0.05) more new skin lesions at the shoulders than the GH-pigs 48 hours after weaning.

In conclusion, early mixing of unacquainted litters during lactation had no influence on their growth performance during rearing but reduced agonistic behavior and lesion score difference during the first two days after weaning. No significant interaction between the farrowing system and weaning weight class was detected with regard to growth performance and number of fights.
Key Words: agonistic behavior, group housing, growth performance, lesion score, weaning weight class

IMPLICATIONS
A group housing system with electronically controlled crates and conventional single farrowing systems were compared with regard to the growth performance and agonistic behavior of weaned and weight sorted pigs during rearing. This study confirms that mixing piglets during lactation reduces agonistic behavior after weaning and improves animal welfare without significant effect on performance during rearing.

INTRODUCTION
Group housing for gestating sows was predefined as a consequence of the European Union Council Directive 91/630/EEC amended by Council Regulation (EC) No. 806/2003 (2003). This provision targets increased animal welfare by allowing more social interaction and free movement based on natural behavior. In farrowing systems, pens with crates are built to improve piglet survival (Cronin and Smith, 1992) but keeping sows in crates has been increasingly criticized in public discussions. Alternative farrowing systems such as loose housing pens or group housing systems can affect the performance of weaned pigs during rearing. Bünger (2002) assessed higher body weights after rearing for weaned pigs from group housing compared to pigs from loose housing systems. Likewise, Hessel et al. (2006) and Reiners (2009) detected advantages concerning the growth performance of weaned pigs during rearing when single housed litters were mixed ten or twelve days after farrowing. The enhanced performance of mixed pigs said to be caused by a higher voluntary feed intake and reduced agonistic behavior immediately after weaning (Hessel et al., 2006; Pluske, 2006). Furthermore, the weaning weight could affect weight gain during rearing. McConnell et al. (1987) and Bruininx et al. (2001) detected that heavy pigs grew significantly faster than light pigs during the rearing period. McConnell et al. (1987) assessed that small pigs did not make compensatory gains and the growth curves of the light and heavy groups of pigs remained parallel.

Under commercial conditions, unacquainted weaned pigs are often mixed and sorted by weaning weight. However, it should be noted that such a management strategy can influence the pigs’ agonistic behavior. Rushen (1987) assessed more frequent and longer fights when
the difference in weight between the pigs was small (< 0.05 kg) than when it was large (< 3.0 kg). Furthermore, D’Eath (2005), Hillmann et al. (2003) and Li and Wang (2011) suggest that the farrowing environment affects the behavior of pigs due to their experience with acquainted littermates in small groups or unacquainted littermates in large groups. Unacquainted weaners from single housing systems have to determine a new hierarchy and thus have an effect on agonistic behavior and weight performance (Li and Johnston, 2009). In various studies, it has been found that aggressive behavior is caused by different housing conditions, but also by various body weights, changes in space or group sizes or the degree of familiarity (Jensen, 1994; Turner et al., 2009; Stukenborg et al., 2011). As a result of agonistic behavior, skin lesions can occur after mixing foreign litters (Pitts et al., 2000; Turner et al., 2006; Puppe et al., 2007).

In the present study, weaned pigs from group and single housing systems were sorted by weight and kept in the rearing area. The aim of the study was a comparison of their growth performance and the duration and frequency of agonistic behavior in connection to the interaction between the farrowing environment and weaning weight class immediately after weaning.

**MATERIAL AND METHODS**

*Animals and housing*

The data were collected on the agriculture research farm *Futterkamp* of the *Chamber of Agriculture of Schleswig-Holstein* between November 2009 and March 2010. The study was carried out with 240 weaned pigs from two different farrowing systems (group housing: GH and single housing: SH) with 120 cross-bred pigs each (Piétrain x (Large White x Landrace)). Six sows (2nd – 8th parity) and their piglets were kept together in the GH. Each GH-sow had an individual single pen with farrowing crate (4.7 m²). The crates had electronically controlled gates (ear tag). GH-sows could move out of the crates over a flexible step into a shared running area (13 m²) except three days ante partum (a.p.) until one day post partum (p.p.). GH-piglets could leave the single pens after the removal of the flexible steps five days after the calculated farrowing date. Sows and their piglets in SH were kept separately from foreign litters in conventional farrowing pens with crate (5.2 m²). Solid feed was given to the piglets from day 10 onwards.
The study consisted of three batches including 120 pigs from GH and SH (batch 1 and 3: 48 pigs/4 pens; batch 2: 24 pigs/2 pens). Data from 30 weaned litters in total were available. In all three batches, the piglets were weaned on day 26 after farrowing (8.30 to 11.00 AM). The pigs were moved to eight identical rearing pens with a size of 1.6 m x 2.8 m (0.37 m² per pig) for 12 pigs each. GH- and SH-pigs were kept separately and sorted into the pens according to their weaning weight. Two heavy (> 9 to ≤ 12 kg), four medium (> 7 to ≤ 9 kg) and two light pigs (5 to ≤ 7 kg) were chosen for the study from each litter. The average weaning weights of the different weight groups were 10.0 kg (SD: 0.67), 8.1 kg (SD: 0.59) and 6.3 kg (SD: 0.55). Piglets within one litter had the same mark on their backs. Female and castrated pigs were reared together in equal shares. Three pigs died during the rearing period, which resulted in a mortality rate of 1.3 %.

The daily feed demand was controlled by the filling level of the feeding trough (sensor scan every 20 minutes between 6.00 AM and 10.00 PM). An empty trough was refilled with a portion of 1.4 kg. The dry feed was mixed with water in a rotation distributor and supplied into the trough as liquid feed. The feeding portions of one day were added up and saved in the database of the agriculture research farm. Two sorts of rearing feed were used in accordance with the German norm (Gesellschaft für Ernährungsphysiologie, 2006). Feed 1 with 14.6 MJ ME/ kg and 18.5 % CP (1.45 % lysine) and was fed from day 1 to 14. Feed 1 and 2 were mixed for about four days. Feed 2 with 13.4 MJ ME/ kg and 17.5 % CP (1.25 % lysine) was fed from day 18 until the end of the rearing period. The pigs had free access to water by using a nipple drinker. Climate cover plates were used for heat insulation in the lying area. The floor was designed with plastic slats. The degree of perforation was 10 % in the lying area (48 % of the pen) and 40 % in the activity area (52 % of the pen). A climate computer regulated ventilation and heating during rearing in dependence of a climate cycle. The climate cycle started with 28 °C in week 1 and dropped continuously to 22 °C in week 7 in accordance with the thermo neutral zone of the pigs. The lights (80 lux) were switched on at 6.00 AM and switched off at 8.00 PM.

**Recorded traits**

The individual body weight (BW) of the pigs was measured at weaning (week 1) and during rearing (in weeks 2, 3 and 7). The daily feed intake per pen was stored electronically in the database of the agriculture research farm. The average feed conversion ratio per pen (FCR) was analyzed on a pen basis over the whole rearing period (weeks 1 to 7). The pigs were videotaped for 40 hours after weaning from Wednesday 4.00 P.M. until Friday 8.00 A.M.
Due to technical problems, videotapes of batch 2 could not be used. In consequence, the agonistic behavior of 192 pigs of batches 1 and 3 was analyzed. One trained observer viewed the videotapes and documented the duration and number of agonistic behavior per pen and hour by continuous sampling. Agonistic behavior in the present study was defined as a physical contact between two pigs with biting, pushing, circling and/or fleeing initiated by one of the pigs (Puppe, 1998; Colson et al., 2006; Li and Johnston, 2009). A fight was defined when it took at least 3 s. An interruption of 8 s between fight sequences of the same pigs was documented as two fights (Puppe, 1998). The end of a fight was established when one pig fled or stopped fighting. The number of fights and the fight duration (FD) per pen and hour were observed to assess agonistic behavior (Li and Johnston, 2009; Stukenborg et al., 2011).

Lesions of the integument were assessed by one observer for the snout, shoulders, ears and flanks separately (McGlone, 1985) at weaning (LS 1) and 48 h after weaning (LS 2). The lesion scores include four categories of injuries: none, minor, medium and severe lesions of the integument, referring to Stukenborg et al. (2011, Table 1).

Table 1

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(None)</td>
</tr>
<tr>
<td>1</td>
<td>(Minor)</td>
</tr>
<tr>
<td>2</td>
<td>(Medium)</td>
</tr>
<tr>
<td>3</td>
<td>(Severe)</td>
</tr>
</tbody>
</table>

*Statistical Analysis*

The statistical analysis of the recorded traits was conducted with the SAS® statistical software package (SAS® Institute Inc., 2008). The model for body weight gain was designed with the fixed effects batch, housing system, sex, weaning weight and week. The batch was subdivided into three classes (1, 2 and 3). The housing system was given the categories group and single housing (GH, SH), sex involved female and castrated pigs, weaning weight had
three classes with average weights of 6 kg, 8 kg and 10 kg per pen. The week (1, 2, 3 and 7) was included as linear, quadratic regression. The fixed effects were tested for significance with the procedure MIXED in SAS® (SAS® Institute Inc., 2008). Fixed effects were added to the model, stepwise, Maximum Likelihood (ML) was used to test the different models. Interactions between the fixed effects had no significant effect and were excluded. Comparison of the different models were performed with the fit statistic Akaike’s information criteria corrected (AICC; Hurvich and Tsai, 1989) and the Baysian information criteria (BIC; Schwarz, 1978). The smallest values of AICC and BIC were preferred (Littell et al., 2006) without making a statement about the underlying significance. The final model for body weight (BW) contained the fixed effects batch, housing system, weaning weight and week as linear, quadratic regression nested within housing systems and the random effect of the pig. The error covariance was modeled due to the fact that repeated measurements within the growing period were assumed to contain autocorrelated repeated measures. The covariance of the residual term was modeled with the spatial (exponential) structure (sp(exp); Littell et al., 2006). The significance of differences in the least square means was adjusted with the Bonferroni-correction.

The analysis of feed conversion ratio (FCR) was based on 20 observations in total. Due to this fact the model was reduced to the fixed effects housing system and weaning weight. The analysis of the agonistic patterns used the pen as the observation unit since the pigs had no individual marks on their backs. Fight duration per pen and hour (FD) was not normally distributed. In consequence, an approximated normal distribution was obtained after log-transformation. The number of fights per pen and hour (NF) was measured as count data. A linear model with poisson distribution, log link function and overdispersion was fitted to these data using the procedure GENMOD (Minkenberg, 2009). Back transformations of values were performed when the least-square-means were presented. The final models for the NF and FD contained the fixed effects batch, housing system, weaning weight and hour (1, …, 40). The model of FD was added with the interaction between housing system and weaning weight class. The lesion scores were evaluated as the difference (LSD) between LS 2 and LS 1. No changes in the lesion scores were documented with LSD = 0. A negative lesion score difference (LSD < 0) represented fewer skin lesions 48 h after weaning in relation to weaning, while LSD > 0 represented more new skin lesions 48 h after weaning compared to weaning. The Wilcoxon rank-sum test in the procedure NPAR1WAY (SAS® Institute Inc., 2008), was used to identify significant differences in the intensity of new skin lesion at the snouts and at
the shoulders of weaned pigs, which were reared in group and single farrowing systems. The lesion score difference was not obviously influenced by the weaning weight class.

RESULTS

Growth performance and feed conversation ratio

The effect of the batch was significant and resulted in reduced growth performance in Batch 2 (Batch 1: 15.1 kg (SEM: 0.23), Batch 2: 14.1 kg (SEM: 0.32), Batch 3: 14.6 kg (SEM: 0.23)). The body weights of weaned GH- and SH-pigs during the rearing period did not differ significantly (Figure 1, Table 2). The results of the linear, quadratic regression of the weaning weights of GH- and SH-pigs was similar (GH: 7.8 kg vs. SH: 7.7 kg). During the whole rearing period, the increasing curves of the body weights for GH- and SH-pigs strayed without obvious differences. In week 7, GH-pigs weighed 29.4 kg and SH-pigs had a body weight of 28.6 kg (p > 0.05).

Figure 1
Least square means of the linear, quadratic growth development of weaned pigs from group or single housing system (GH, SH) during rearing
The effect of the weaning weight classes (6 kg, 8 kg and 10 kg) was significant (Table 2). Heavy pigs had the highest body weight during rearing with 17.3 kg (SEM: 0.26) in comparison to light pigs with 11.7 kg (SEM: 0.03) and medium pigs with 14.8 kg (SEM: 0.22). The interaction between the housing system and weaning weight class did not affect the body weight during rearing. The feed conversion ratio per pen tended (p = 0.097) to be higher for the GH-pigs in relation to the SH-pigs (Table 2). A significant influence for FCR was detected between pigs with weaning weights of 6 kg and 10 kg. Pigs with weaning weights of 8 kg were not different from light and heavy pigs, respectively.

Table 2
Least square means (LSM) and standard error of the means (SEM) of body weights (BW), feed conversion ratio (FCR), number of fights (NF) and fight duration (FD) per pen and hour of weaned pigs during rearing depended on housing conditions (group housing (GH), single housing (SH)) and weaning weight classes (light, medium and heavy)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Class</th>
<th>BW (kg)</th>
<th>FCR (kg)</th>
<th>NF</th>
<th>FD (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LSM¹) (±SEM)</td>
<td>LSM (±SEM)</td>
<td>LSM²) (±SEM)</td>
<td>LSM²) (±SEM)</td>
</tr>
<tr>
<td>Housing system</td>
<td>GH</td>
<td>14.7 (±0.21)</td>
<td>1.64 (±0.03)</td>
<td>2.1ᵃ (±0.07)</td>
<td>10.3ᵃ (±1.07)</td>
</tr>
<tr>
<td></td>
<td>SH</td>
<td>14.5 (±0.21)</td>
<td>1.58 (±0.03)</td>
<td>4.6ᵇ (±0.05)</td>
<td>18.8ᵇ (±1.06)</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>6 kg</td>
<td>11.7ᵃ (±0.30)</td>
<td>1.68ᵃ (±0.03)</td>
<td>2.9ᵃ (±0.08)</td>
<td>12.9ᵃ (±1.07)</td>
</tr>
<tr>
<td></td>
<td>8 kg</td>
<td>14.8ᵇ (±0.22)</td>
<td>1.62ᵇ (±0.03)</td>
<td>3.5ᵇ (±0.06)</td>
<td>15.1ᵇ (±1.06)</td>
</tr>
<tr>
<td></td>
<td>10 kg</td>
<td>17.3ᶜ (±0.26)</td>
<td>1.54ᵇ (±0.04)</td>
<td>3.1ᵃᵇ (±0.07)</td>
<td>13.8ᵃ (±1.07)</td>
</tr>
</tbody>
</table>

¹ᵃ,ᵇ,ᶜ Values with different letters differ significantly (p < 0.05)
² Different letters of back-transformed values refer to log-transformed values
**Fight duration and number of fights**

Agonistic behavior depended on the time of day. The least-square-means of NF for the observation period showed a bimodal circadian of the day (Figure 2). This trend started at the day of weaning and continued until the end of the observation period. Activity times with more than 9 fights per pen and hour were recognized in the morning and in the afternoon. Periods with less than 3 fights per pen and hour occurred during the evening and night.

![Graph showing the number of fights per pen and hour](image)

**Figure 2**

Least square means and standard error of the means of the number of fights per pen and hour in the observed 40 hours after weaning for pigs from group and single housing system

The batch did not affect the agonistic behavior, whereas the farrowing system did have an influence on the fight duration and the number of fights. The GH-pigs fought significantly (p < 0.05) less with 2.1 fights per pen and hour (SEM: 0.07) compared to the SH-pigs with 4.6 fights per pen and hour (SEM: 0.05; Table 2). Light pigs fought significantly less compared to medium pigs, while heavy pigs were not different with p > 0.05, respectively. Furthermore, a FD was recorded at 10.3 s per pen and hour (SEM: 1.07) for the GH-pigs and was significantly (p < 0.05) shorter than for the SH-pigs with an FD lasting 18.8 s per pen and hour (SEM: 1.06). The weaning weight class influenced the fight duration per pen and hour and medium pigs fought for a significantly longer period in comparison to light and heavy pigs.
**Lesion score difference**

In total, 71.4 % of the snouts of the GH-pigs and 76.6 % of the SH-pigs were assessed with no changes (Figure 3). Healing of the snout injuries (LSD classes -2 and -1) was observed with 26 % for the GH-pigs and 17.7 % for the SH-pigs. New lesions at the snout occurred marginally (GH: 2.5 % and SH: 5.7 %). The LSD of the snouts of the GH- and SH-pigs was not significantly different (p > 0.05). The developments of scratches at ears and flanks between GH- and SH-pigs were comparable with the LSD classes of the shoulders. However, the greatest number of lesions occurred at the shoulders. After weaning, the shoulders of the GH-pigs had significantly lower values (p < 0.05) for the LSD compared to the shoulders of SH-pigs. The pigs in GH had more observations for healing shoulders lesions with LSD classes -2 and -1 (14.3 % vs. 0 % SH-pigs; Figure 3). No changes of the integument were recognized for 68.9 % of the GH-pigs vs. 45.4 % of the SH-pigs. In consequence, the amount of observations for LSD in class 1 was lower for the GH-pigs (16.8 %) compared to the SH-pigs (34.5 %). The worst lesions at the shoulders were documented only for the SH-pigs with 14.3 % in LSD class 2 and 5.9 % in class 3.

![Figure 3](image-url)

Percentage of lesion score difference (lesion score 48 h after weaning minus lesion score at weaning) at the snout and shoulders between weaning and 48 h after weaning of pigs from group and single farrowing system (GH, SH)
DISCUSSION

_Growth performance and feed conversation ratio_

In the present study, piglets were mixed 5 days p.p. and had no significant differences from unmixed piglets concerning their body weights at weaning or after the rearing period. The time of mixing the piglets could be one influencing factor. Lactating sows and their piglets in a semi-natural environment return to the sounder on average 10 days p.p. (Jensen and Redbo, 1987). However, Rantzer et al. (1997) compared GH-pigs which were firstly mixed on day 7 p.p. with SH-pigs which were not mixed during lactation and rearing. These GH-pigs had a lower growth rate (p < 0.05) with 152 g per day in relation to the SH-pigs with 181 g per day after four weeks of rearing. In contrast, Hessel et al. (2006), Kutzer et al. (2009) and Reiners (2009) mixed SH-piglets from three different litters together from day 10 or 12 p.p.. Hessel et al. (2006) and Reiners (2009) detected that mixed SH-piglets had a significantly increased weight gain (p < 0.05) of 1 kg during a rearing period of five weeks compared to those initially mixed at weaning. In addition, Kutzer et al. (2009) included a group housing system in their study and detected significantly higher body weights for GH-pigs (23.8 kg) after a rearing period of five weeks compared to SH-pigs (21.0 kg) and mixed SH-pigs (21.8 kg). Furthermore, Rantzer et al. (1997), Hessel et al. (2006) and Kutzer et al. (2009) did not assess different weaning weights (p > 0.05) of GH-, mixed SH- and SH-pigs. Therefore, mixing piglets during lactation may have no effect on weaning weights but affect the weight performance during rearing. Mixing piglets on day 5 p.p. had no significant effect on their weight performance during rearing while other studies suggest that mixing between day 10 to 12 p.p. increases weight gain during rearing.

Body weights and feed conversation ratio during rearing in the present study also depended on the weaning weights (light, medium, heavy). Bruininx et al. (2001) assessed a significantly higher daily weight gain of 345 g for heavy pigs (weaning weight: 9.3 kg) in comparison to 298 g for light pigs (weaning weight: 6.7 kg) between the 14th and the 35th day in the rearing pen. Likewise McConnell et al. (1987) suggested that the daily gain of light pigs (3.6 kg) with 136 g vs. heavy pigs (6.4 kg) with 233 g differed significantly (p < 0.05) during 28 days of rearing. In conclusion, the GH and SH-pigs in the present study had similar body weights at weaning and after rearing, but their weaning weight affected their body weight during rearing.
**Fight duration and number of fights**

A bimodal circadian rhythm was observed for the NF and confirmed the statement of Stukenborg et al. (2011). However, in contrast to Stukenborg et al. (2011), different peaks during the activity time in the morning were detected in our study. The reason could be seen in the feeding pause between 10.00 PM and 6.00 AM, while pigs in the study of Stukenborg et al. (2011) were fed ad libitum all day long. Thus it seems that feed should not be limited to reduce conflicts over the resources of pigs. In the present study, the group farrowing system reduced the number of fights per pen and hour (NF) and shortened fight durations (FD) of the pigs immediately after weaning. Mixing pigs during lactation reduced fighting after weaning because new hierarchies did not need to be established (Friend et al., 1983; Pitts et al., 2000; Weary et al., 2002). Likewise, Hessel et al. (2006) and Reiners (2009) determined lower rates of agonistic behavior after weaning between SH-pigs commingled 48 hours before weaning, compared to SH-pigs mixed at weaning (p < 0.05). Simultaneously imposing stressors such as a new environment, separation from the dam, changes in diet and mixing non-littermates accentuated the distress response at weaning (Hessel et al., 2006; Pluske, 2006). These stress factors were disentangled for the GH-pigs in the present study since agonistic behavior between unacquainted GH-pigs had already occurred during lactation.

Furthermore, Li and Wang (2011) reported on similar results with 1.5 fight per hour for GH-pigs versus 3.8 fights per hour for SH-pigs (fight duration: GH: 4.5 s versus SH: 18.3 s). In contrast to the present study Li and Wang (2011) mixed familiar and unfamiliar GH- or SH-pigs from different groups into pens with 9 pigs each at an age of 8 weeks. The authors concluded that pigs originated from GH were less aggressive and more tolerant to unfamiliar pigs compared to pigs from SH due to the pig’s experience of a large social group during lactation.

In this study, weaning weights also seemed to influence agonistic behavior. A fewer number of fights per hour in pens with light pigs and the longest fight durations per hour in pens with medium pigs were detected. Li and Johnston (2009) however observed that different body weights at weaning did not affect behavior in familiar groups but increased aggression-induced injuries in unfamiliar groups. Finally, mixing unacquainted litters during lactation is effective in decreasing agonistic behavior and skin lesions immediately after weaning. The interaction between the farrowing environment and the weaning weight category did not affect the growth performance and the numbers of fights.
**Lesion score difference**

In general, the intensity of skin lesions is said to depend on the body area, and the front of the body is the most stressed region in all age groups (McGlone, 1985; D’Eath, 2005; Stukenborg et al., 2011). This could be confirmed by the results of the present study. More skin lesions were observed on the shoulders of the GH-pigs before weaning in comparison to the SH-pigs. In contrast, the GH-pigs had fewer new scratches after weaning. These results are in accordance with the findings of NF and FD. GH-pigs fought less compared to SH-pigs which resulted in fewer skin lesions after weaning. Rantzer et al. (1997) and Parratt et al. (2006) verified less of agonistic patterns in the pens with GH-pigs. Andersen et al. (2004) added that unacquainted pigs in groups of six and 12 pigs fought significantly less compared to pigs in groups of 24. It would be interesting to discover whether SH-pigs in groups of 24 (or more) also had a significantly greater fight activity compared to GH-pigs. The lesion score difference could be used as a less expensive and time-saving parameter to determine the intensity of agonistic behavior of weaned pigs compared to the effort of videotapes.

**CONCLUSION**

The present finding suggests that mixing piglets in a group housing system (5 days p.p.) has no influence on growth performance at weaning or after rearing compared to piglets from single pens with crates, however body weight is significantly affected by weaning weights (light, medium, heavy). The interaction between weaning weight classes and the farrowing environment had no influence on the weight performance or the number of fights. Keeping lactating sows and their piglets in groups can be said to improve the animal welfare of weaned pigs due to the reduced number of fights and shorter fight durations which result in fewer skin lesions during the first two days after weaning.

**ACKNOWLEDGEMENT**

This work was financially supported by the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) through the Federal Agency for Agriculture and Nutrition (BLE), grant number 2807UM005.
REFERENCES

Andersen I L, Nævdal E, Bakken M and Bøe K E 2004. Aggression and group size in domesticated pigs, sus scrofa: 'when the winner takes it all and the loser is standing small'. Animal Behaviour 68, 965-975.


Gesellschaft für Ernährungsphysiologie 2006. Empfehlungen zur Energie- und Nährstoffversorgung von Schweinen 2006. DLG-Verlag, Frankfurt am Main, Germany.


CHAPTER FOUR

Gruppenhaltung mit Einzelbuchtsteuerung für laktierende Sauen:
3. Auswirkungen auf Arbeitszeit und Platzbedarf
Group housing for lactating sows with electronically controlled crates
3. Effect on labor and space requirement

ANNA-LENA BOHLENKAMP$^1$, C. MEYER$^2$, KARIN MÜLLER$^2$, J. KRIETER$^1$

$^1$ Institute für Tierzucht und Tierhaltung, Christian-Albrechts-Universität, Olshausenstraße 40, 24098 Kiel, E-Mail: abohnenkamp@tierzucht.uni-kiel.de

$^2$ Landwirtschaftskammer Schleswig-Holstein, Gutshof, 24327 Blekendorf, E-Mail: cmeyer@lksh.de
ZUSAMMENFASSUNG


Die GH hat mit 1,6 m² ein größeres Platzangebot pro Sau im Vergleich zur EH und ermöglichte den Sauen und Ferkeln eine bessere Strukturierung der verschiedenen Funktionsbereiche (Futter, Koten, Liegen). Zuzüglich zur Gruppenhaltung mussten Reservebuchten für Jungsauen, Sauen mit schlechter Mobilität und für vorzeitig abgesetzte Würfe vorgehalten werden. GH-Sauen wurden während der Geburt und während der Servicearbeiten an den Ferkeln kurzzeitig im Ferkelschutzkorb fixiert. Diese Maßnahme gewährleistete die Arbeitssicherheit, schränkte aber das Nestbauverhalten der Sauen ein.

Schlüsselwörter: Abferkelbereich, Arbeitsbelastung, Gruppenhaltung, Platzbedarf

SUMMARY
The aim of the present study was the evaluation of labor and space requirement of a group housing system for lactating sows with electronically controlled crates. The group housing (GH) was compared with the conventional single housing (SH) with crates. In total 36 sows were kept in GH and SH in three batches. The labor requirement for services at birth, castration and vaccination was similar in GH and SH. The intensity of work during the vaccination of GH-piglets was enhanced due to extra doors, which were necessary to catch the
piglets in the running area. Sows and piglets used the common running area as a defecating zone and no manual cleaning of the GH was necessary after removing the flexible steps (day 5 p.p.). Furthermore, care of piglets with diarrhea had to be carried out for all litters in GH. The management of the GH placed greater demand on the stockperson due to the daily control of large groups (N=70 piglets) and the electronically controlled crates.

The GH provided 1.6 m² more space per sows compared to the SH and resulted in a better structuring of the different areas in GH (feeding, defecating, lying). Extra single pens have to be kept available for gilts, sows with decreased mobility and early weaned litters. GH-sows were fixed during parturition and could be fixed during servicing of the piglets. These circumstances ensured labor safety but restricted the nest-building behavior of the sows.

**Keywords:** farrowing system, work loading, group housing, space requirement

---

**EINLEITUNG**

Die Entwicklung alternativer Abferkelsysteme mit erhöhtem Bewegungsangebot und Steigerung der Sozialkontakte zwischen Sauen und Ferkeln führte zu diversen Varianten verschiedener Bewegungsbuchten und Gruppenhaltungssystemen (Bates et al., 2003; Bøe, 1993; Bünger, 2002; Pajor et al., 2002). Diese unterscheiden sich in erster Linie durch die Buchtenform, Fixierungsmöglichkeit während der Geburt, Fütterungstechnik, Ferkelschutzeinrichtung und dem Platzangebot pro Sau. Unter Praxisbedingung werden insbesondere Abferkelsysteme ohne Ferkelschutzkorb hinsichtlich erhöhter Ferkelverluste und reduzierte Arbeitssicherheit diskutiert (Edwards, 2008; Baxter et al., 2011). Weiterhin ist bei einigen alternativen Haltungstechniken mit einem erheblichen Anstieg der routinemäßigen Arbeitszeiten zu rechnen, wenn Sauen während der Fütterung in Fressständen fixiert werden müssen bzw. wenn das Einfangen der Ferkel in erweiterten Freilaufbereichen erfolgen soll (Bates et al., 2003; Bøe, 1993; Kutzer, 2009).

MATERIAL UND METHODEN

**Versuchsaufbau**


Die Buchtengrundfläche der EH beträgt 5,2 m² pro Sau (2 m x 2,60 m) und in der GH 6,8 m² pro Sau. Hierbei unterteilt sich die GH in sechs Einzelbuchten mit 4,7 m² (1,80 m x 2,60 m) und einen 13 m² (5,40 m x 2,40 m) großen Freilaufbereich zwischen den Einzelbuchten (Abbildung 1). Sauen in der GH können ihren Aufenthaltsort frei zwischen ihrer zugeordneten Einzelbucht (Transponder) und dem gemeinsamen Freilauf wählen. Drei Tage vor der Geburt bis einen Tag danach wurden die GH-Sauen in ihren Ferkelschutzkörben fixiert. Die Sauen konnten über eine bewegliche Türschwelle (25 cm) in den Freilauf, während die Ferkel in den Buchten blieben. An Tag 5 post partum (p.p.) wurde die Türschwelle entfernt und alle Sauen und Ferkel konnten den Freilauf benutzen.

Abbildung 1

Stallübersicht der Gruppenhaltung mit elektronischer Buchtensteuerung für laktierende Sauen (GELAS)

*Overview of the group housing with electronically controlled crates for lactating sows (GELAS)*
**Erfasste Merkmale**


**ERGEBNISSE UND DISKUSSION**

**Arbeitszeit**

Im Mittel wurden für die Erstversorgung der GH-Ferkel 52 s Arbeitszeit pro Ferkel benötigt während es in der EH 45 s pro Ferkel waren (Tabelle 1). Der zeitliche Unterschied erklärt sich durch die bauartlich bedingten längeren Arbeitswege zwischen Einzelbucht und Servicewagen. Kastrieren dauerte in der GH mit 80 s pro Ferkel länger im Vergleich zur EH mit 68 s pro Ferkel. Ferkelschutzkörbe in der GH konnten rückseitig nicht umrundet werden und das Einfangen der Tiere dauerte pro Ferkel 8 s länger.

In der GH kann der Ferkelschutzkorb im Vergleich zur EH rückseitig nicht umrundet werden. Ein Einfangen der GH-Ferkel während der ersten fünf Lebenstage ist deswegen mit wiederholtem Überwinden von Buchtentrennwänden durch das Rein- und Raustreten aus der Bucht verbunden.

Keine unterschiedlichen Arbeitszeiten wurden bei der Mykoplasmenimpfung festgestellt. Der eigentliche Impfvorgang konnte in der GH sogar schneller durchgeführt werden (11 s pro Ferkel), jedoch entstand beim Fixieren der Ferkel im Freilauf zusätzlichem Kraftaufwand.

Tabelle 1
Mittelwert (Mean) und Standardabweichung (SD) für die Arbeitszeit von Erstversorgung, Kastrieren, Impfen und Zusatztüren in der Gruppen- (GH) und Einzelhaltung (EH)

<table>
<thead>
<tr>
<th></th>
<th>GH (s pro Ferkel)</th>
<th>EH (s pro Ferkel)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Erstversorgung</td>
<td>52 (± 5,63)</td>
<td>45 (± 12,37)</td>
</tr>
<tr>
<td>Kastrieren</td>
<td>80 (± 11,31)</td>
<td>68 (± 1,24)</td>
</tr>
<tr>
<td>Mycoplasmenimpfung</td>
<td>17 (± 4,38)</td>
<td>17 (± 5,35)</td>
</tr>
<tr>
<td>Circoimpfung</td>
<td>14 (± 0,65)</td>
<td>15 (± 1,52)</td>
</tr>
</tbody>
</table>

**Platzbedarf**

Die Ergebnisse der vorliegenden Untersuchung zeigen, dass eine GH mit einem Platzangebot von 6,8 m² pro Sau grundsätzlich möglich ist. Das erhöhte Platzangebot in der GH ist auf den Freilaufbereich (13 m²) zwischen den Buchten zurück zu führen. Während in der EH eine Gangbreite von 0,80 m zum Arbeiten ausreicht, benötigt der Freilaufbereich eine Breite von mindestens 2,40 m (Bøe et al., 2011), damit sich eine Sau ungehindert umdrehen kann, wenn andere Sauen im Freilauf liegen. Das Platzangebot ist ein wesentlicher Einflussfaktor auf die Investitionskosten. Mit 1,6 m² mehr Fläche (Freilauf) sind etwa 500-600 € höheren Baukosten anzurechnen (Meyer, 2012). In Untersuchungen von Bates et al. (2003), Bøe (1994), Bünger (2002), Kutzer (2009) und Marchant et al. (2001) wurden Gruppenhaltungssysteme mit 8-14 m² pro Sau getestet, so dass das Platzangebot der vorgestellten GH als niedrig zu bewerten ist.

**Arbeitsschutz**


**LITERATUR**


GENERAL DISCUSSION

The aim of the present study was the evaluation of a group housing system for lactating sows with electronically controlled crates and running area compared to conventional single housing with crate. Under investigation were litter performance and behavioral traits during farrowing, lactation and rearing as well as the labor and space requirement.

Reproductive traits, body condition and daily feed intake

The GH did not affect reproductivity traits significantly compared to the SH. The total numbers of piglet losses were at a similar level in GH and SH. However, the percentage of crushed piglets was higher in GH compared to SH. Piglets were vulnerable to crushing especially until the third day of life (Marchant et al., 2001; Stabenow and Manteuffel, 2002) and the farrowing crate was able to prevent piglet losses due to crushing (Blackshaw et al., 1994; Lay et al., 2002; Edwards, 2008; Baxter et al., 2012). In consequence, the reason for more crushed piglets in GH was seen in the narrow size of the pens compared to SH.

In total, GH-sows weaned the same numbers of piglets but with lighter weaning weights, consumed more feed and lost more body condition during lactation. In this regard, one influencing factor might be the time of removing the flexible steps. Bates et al. (2003) mixed piglets 7 days p.p. and also detected lower litter weaning weight for GH-sows (55.5 kg per litter) compared to SH-sows (58.4 kg per litter). The authors explained that the weight difference with the decreased milk consumption of the GH-piglets was due to fewer nursings. Klaver et al. (1981) and Algers and Jensen (1990) added that piglets with low milk intake spent more energy reserves by initiating the milk flow which resulted in a lower daily weight gain during lactation. However, Bünger (2002), Hessel et al. (2006), Kutzer (2009) and Rantzer et al. (1997) investigated GH, LSH and SH with mixed litters between days 7 to 12 p.p. and revealed no disadvantages with regard to the litters growth performance due to an established teat-order.

The enhanced daily feed intake of GH-sows was caused by the feeding system. Regardless of the feeding system, GH-sows had an increased daily feed intake, lost more body condition during lactation and weaned their litters with lower weights at the same time. These results indicate that GH-sows needed more energy during lactation. A less restricted feeding curve might be a better feeding strategy for GH-sows and could improve the weaning weights of the GH-piglets. The sows mobilized their body reserves (Algers and Uvnäs-Koberg, 2007) and
enhanced their feed intake (Eissen et al., 2000) to increase the energy demand during lactation.

According to these results, the time of mixing piglets during lactation, the stability of the teat-order, the enhanced activity of GH-piglets and the feeding strategy of the sows seemed to be the major causes for the total milk intake and weight differences between GH- and SH-piglets.

**Behavioral parameters: farrowing, suckling and activity**

The suckling frequency and duration was similar in both housing systems and verified the statements of Silerova et al. (2006) and Arellano et al. (1992). However, suckling in the GH resulted in more disturbances during udder massage. More missing and foreign GH-piglets were especially observed in the running area, whereas fewer than 1 piglet was absent during milk flow. Andersen et al. (2011) added that the number of missing piglets depended on the litter size and detected 1.7 to 1.9 missing piglets in litter sizes greater than 12. A low level of foreign piglets was observed during milk flow and the numbers of runts were not significantly different in SH and GH. In contrast, Jais et al. (2009) established 7 to 10 % cross-suckling, whereas Maletinska and Spinka (2001) observed 29 %. This difference might be a result of balancing the litter size to a maximum of 12 piglets. Andersen et al. (2011) suggested that 10 to 11 piglets could be the upper limit for a sow, since teat competition rose with greater litter sizes.

The durations of lying, sitting and standing of sows in GH and SH did not differ. GH-sows changed their location between crate and running area regularly and had enhanced frequency of lying and standing, whereas sitting was observed more often in SH.

GH-sows preferred their crates as long as the piglets remained in the GH-pens. Gilts spent more time in the running area compared to the sows between day 1 p.p. and day 5 p.p.. One explanation could be the experience of the sows with previous farrowing systems or the hierarchy within the group. Most of the GH-gilts which chose the running area as their preferred location had already reduced their suckling frequency by lactation day 18 (GH-sows: lactation day 22) and had to be weaned before lactation day 26 due to hurt teats. Lower weaning weights of GH-piglets (Chapter 1), early weaned GH-gilts and disturbances during suckling in the running area lead to the conclusion that a longer fixation in the GH-crates could improve the teat order and therefore optimize the weaning weights of GH-piglets.
**Growth performance and agonistic interaction during rearing**

The results of the third chapter implicate that mixing piglets in a group housing system (5 days p.p.) has no influence on growth performance of GH- and SH-piglets at weaning and after rearing. However, the body weight at the end of rearing is significantly affected by weaning weight (light, medium, heavy).

Similar weaning weights of GH- and SH-piglets in the third chapter did not agree with the significant lower weaning weights of GH-piglets in the first chapter. The reason for these different results was seen in the sample size. In Chapter One, 103 sows (parity 2: 27%, 3 and 4: 36%, 5 to 8: 39%) were included in the statistical analysis. In contrast, the data of Chapter Three is based on 36 sows with a different age structure (parity 2: 50%, 3 and 4: 25%, 5 to 8: 25%). These results are in line with Eissen et al. (2000), who reported increased milk production from the first to the second parity. The milk production reached a maximum in the second parity and slowly decreased after the fourth parity (Eissen et al., 2000).

The agonistic behavior of GH-piglets during lactation resulted in more skin lesions before weaning in comparison to the SH-pigs. In contrast, the GH-pigs had fewer new scratches at the shoulders after weaning. These results are in accordance with fewer numbers of fights and shorter fight durations immediately after weaning in the pens with GH-piglets. Mixing pigs during lactation reduced fighting after weaning because no new hierarchies needed to be established (Friend et al., 1983; Pitts et al., 2000; Weary et al., 2002; Hessel et al. (2006); Reiners (2009). Li and Wang (2011) added that GH-pigs were more tolerant to unfamiliar pigs due to their experience of a large social group during lactation.

**Labor and space requirement**

The labor requirement for services at birth, castration and vaccination was similar in GH and SH. The intensity of work during the vaccination of GH-piglets was enhanced due to extra doors, which were necessary to catch the piglets in the running area. Sows and piglets used the common running area as a defecating zone and no manual cleaning of the GH was necessary after removing the flexible steps. Furthermore, care of piglets with diarrhea has to be carried out for all litters in GH and extra single pens have to be kept available for gilts, sows with decreased mobility and early weaned litters.

In consequence, the total amount of labor requirement depends on the litter size, health of the piglets and on the skills of the stockperson to manage the GH.

The GH needed 1.6 m² more space compared to the SH and resulted in a better structuring of the different areas in GH (feeding, defecating, lying). GH-sows were fixed during parturition.
and could be fixed during servicing of the piglets. These circumstances ensured labor safety but restricted the nest-building behavior of the sows (Baxter et al., 2011).

REFERENCES


GENERAL SUMMARY

The aim of this thesis focused on the consequences of a group housing system with single pens and electronically controlled crates on the performance and behavioral parameters of sows and piglets during lactation and after weaning. It also determined the effects on labor and space requirement.

The study took place in the agriculture research farm Futterkamp of the Chamber of Agriculture of Schleswig-Holstein from March 2009 until August 2010. In total, 144 crossbred-sows in 12 batches were kept in single housing (SH, 2 m x 2.60 m) with conventional farrowing crates and in a group housing system (GH) with single pens (1.80 m x 2.60 m). The GH-pens had electronically controlled crates with an additional running area (13 m²) between the pens. The sows left the gestation stage 1 week before the calculated farrowing date. GH-sows were fixed in their crates during farrowing from day 3 ante partum (a.p.) until day 1 post partum (p.p.). GH-piglets could use the common running area since lactation day 5 and were weaned on average after 26 days. Furthermore, 120 pigs from GH and SH were observed during rearing from week 1 (weaning) until week 7 in identical rearing pens in 3 batches. GH- and SH-pigs were kept in separate pens, but were sorted according to their weaning weight (light, medium, heavy). The behavioral parameters during farrowing, lactation and rearing were recorded by video (HeiTel Digital Video GmbH, Kiel, Germany).

The GH did not affect reproductivity traits significantly compared to the SH. The numbers of piglet losses were almost similar in both systems with 2.2 piglets per litter in GH and 2.4 piglets per litter in SH. In total, GH-sows weaned the same numbers of piglets (11.4 piglets per litter) but with lighter weaning weights (GH: 7.6 kg vs. SH: 8.1 kg; p < 0.05), consumed more feed (GH: 6.4 kg per day vs. SH: 6.2 kg per day; p < 0.05) and lost more body condition during lactation (BCS at weaning in GH: 2.2 vs. SH: 2.4; p < 0.05).

GH-sows were able to choose their location optionally between their personal crate and the common running area. The running area was used as an active place and defecating zone by both sows and piglets. However, suckling in the common running area resulted in an increased number of missing and foreign piglets compared to suckling in the crates. Nevertheless, fewer than 1 piglet was missing during the milk flow phase. Foreign piglets remained at the udder only for short visits during suckling. Most of the GH-gilts, which chose the running area as their preferred location, had already reduced their suckling frequency by lactation day 18 (GH-sows: lactation day 22) and had to be weaned before lactation day 26 due to hurt teats.
The growth performance of GH- and SH-pigs was not influenced by the farrowing system during rearing (week 7: GH: 29.4 kg vs. SH: 28.6 kg), but by the weaning weight class (light: 11.7 kg, medium: 14.8 kg, heavy: 17.3 kg; p < 0.05). Mixing non-littermates during lactation improved animal welfare immediately after weaning due to a reduced number of fights (GH: 2.1 vs. SH: 4.6 fights per pen and hour; p < 0.05) and shorter fight durations (GH: 10.3 s vs. SH: 18.8 s per fight; p < 0.05). In consequence, significant fewer new skin lesions were observed for GH-pigs 48 h after weaning.

The labor requirement for services at birth, castration and vaccination was similar in GH and SH.
ZUSAMMENFASSUNG

Die Ziele dieser Untersuchungen richten sich auf die Auswirkungen einer Gruppenhaltung mit elektronischer Buchtensteuerung für ferkelführende Sauen hinsichtlich ihrer Leistung und Verhaltensparameter. Weiterhin wurden die benötigte Arbeitszeit und der Platzbedarf festgestellt.

Die Untersuchung wurde zwischen März 2009 bis August 2010 am Lehr- und Versuchszentrum Futterkamp der Landwirtschaftskammer Schleswig-Holstein durchgeführt. Insgesamt wurden in 12 Durchgängen 144 Kreuzungssauen in die Einzelhaltung (EH, 2 m x 2,60 m) mit konventionellen Ferkelschutzkörben und in eine Gruppenhaltung (GH) mit Einzelbuchen (1,80 m x 2,60 m), elektronischer Buchtensteuerung und gemeinsamen Freilauf (13 m²) aufgestallt. Die Sauen verließen den Wartestall eine Woche vor dem kalkulierten Abferkeltermin. GH-Sauen wurden nur während des Abferkelns zwischen Tag 3 ante partum (a.p.) bis Tag 1 post partum (p.p.) in ihren Ferkelschutzkörben fixiert. Die GH-Ferkel konnten den gemeinsamen Freilauf ab Laktationstag 5 mitbenutzen und wurden nach durchschnittlich 26 Tagen abgesetzt. Zusätzlich wurden in drei Durchgängen 120 Ferkel aus der GH und EH während der Ferkelaufzucht von Woche 1 (Absetzen) bis Woche 7 in identischen Buchten beobachtet. GH- und EH-Ferkel wurden getrennt aufgestallt und nach Absetzgewicht (leicht, mittel, schwer) in die Buchten sortiert. Die Verhaltensparameter während des Abferkelns, der Laktation und der Ferkelaufzucht wurden mit Videokameras aufgezeichnet (HeiTel Digital Video GmbH, Kiel, Germany).

Die GH hatte keinen statistisch nachweisbaren Einfluss auf die Reproduktionskennzahlen im Vergleich zur Einzelhaltung. Die Anzahl Ferkelverluste war vergleichbar mit 2,2 Ferkeln pro Wurf in der GH und 2,4 Ferkeln pro Wurf in der EH. GH-Sauen setzten die gleiche Anzahl Ferkel (11,4 Ferkel pro Wurf) ab, aber mit geringeren Absetzgewichten (GH: 7,6 kg vs. EH: 8,1 kg; p < 0,05), verbrauchten mehr Futter (6,4 kg pro Tag vs. EH: 6,2 kg pro Tag; p < 0,05) und verloren mehr Körpermasse während der Laktation (BCS beim Absetzen: GH: 2,2 vs. EH: 2,4; p < 0,05).


Während der Ferkelaufzucht wurde die Wachstumsleistung von GH- und EH-Ferkeln nicht durch das Abferkelssystem (Woche 7: GH: 29,4 kg vs. EH: 28,6 kg) beeinflusst, aber durch die Gewichtsklasse beim Absetzen beeinflusst (leicht: 11,7 kg, mittel: 14,8 kg, schwer: 17,3 kg; p < 0,05). Das Mischen wurffremder Ferkel verbesserte während der Laktation das Tierwohl unmittelbar nach dem Absetzen durch eine reduzierte Anzahl Kämpfe (GH: 2,1 vs. EH: 4,6 Kämpfe pro Bucht und Stunde; p < 0,05) und eine kürzere Dauer der Kämpfe (GH: 10,3 s vs. EH: 18,8 s pro Kampf; p < 0,05). Folglich waren 48 Stunden nach dem Absetzen weniger neue Hautverletzungen bei GH-Ferkeln zu beobachten.

Die benötigte Arbeitszeit für Servicearbeiten an den Ferkeln war für die Erstversorgung nach der Geburt, beim Kastrieren und Impfen in der GH und EH vergleichbar. Dagegen ist die Arbeitsbelastung in der GH durch die benötigten Zusatztüren zum Einfangen der Ferkel im Freilauf höher einzustufen.
DANKSAGUNG

An dieser Stelle möchte ich all den Personen danken, die am Gelingen und am Erfolg dieser Arbeit beteiligt waren.

Mein aufrichtiger Dank gilt Herrn Prof. Dr. Joachim Krieter, für die Überlassung des Themas, die gewährleisteten Freiräume, die Unterstützung bei der wissenschaftlichen Betreuung sowie die Möglichkeit, meine Ergebnisse auf Tagungen im In- und Ausland zu präsentieren.

Die Förderung des Vorhabens erfolgte aus Mitteln des Bundesministeriums für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV) über die Bundesanstalt für Landwirtschaft und Ernährung (BLE; FKZ 2807UM005), denen ich an dieser Stelle meinen Dank aussprechen möchte.


Für die Unterstützung bei der Datenaufbereitung und Auswertung danke ich Frau Dr. Imke Traulsen für ihre Geduld und Hilfestellung. Bei all meinen Kollegen des Instituts für Tierzucht und Tierhaltung möchte ich mich für das hervorragende Arbeitsklima, die gute Zusammenarbeit, die netten Klörrunden, Ausflüge und Kochabende bedanken. Ihr seid spitze!!! Ebenfalls danke ich meiner Freundin Anne Sophie, die mit ständiger Bereitschaft zum Korrekturlesen und Diskutieren immer für mich da ist.

LEBENSLAUF

Name: Anna-Lena Bohnenkamp
Geburtsdatum: 22. Mai 1983
Geburtsort: Hamburg
Familienstand: ledig
Staatsangehörigkeit: deutsch

Schulische Ausbildung:
1989-1993 Grundschule Heidberg, Norderstedt
1993-2002 Coppernicus Gymnasium, Norderstedt
Abschluss: Allgemeine Hochschulreife

Berufliche Ausbildung:
2002-2004 Gärtnerei Jenkel, Wilstedt
Abschluss: Gärtner, Fachrichtung Zierpflanze

Studium:
Abschluss: Bachelor of Science (2008)
Abschluss: Master of Science (2009)

Berufliche Tätigkeit:
seit März 2009 Wissenschaftliche Mitarbeiterin am Institut für Tierzucht und Tierhaltung der Christian-Albrechts-Universität zu Kiel bei Herrn Prof. Dr. Krieter

Zusatzausbildung:
April-September 2012 Ausbildung zum professionellen Trainer an der Andreas Hermes Akademie in Bonn bei Herrn Dr. Holger Sobanski