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Housing system during pregnancy on behavior, reproductive and health parameters of sows

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SUMMARY

The aim of this study was to determine whether behavior, reproductive and health parameters could differ between sows housed individually throughout gestation (Stall) or group-housed on days 3 to 5 (Pen5) or 38 to 42 (Pen42) after insemination. After insemination, 198 sows of a same commercial farm were randomly allocated to one of three housing treatments, namely Stall, Pen5 and Pen42 systems. There was interaction between the housing system and gestation time on behavior parameters. The prevalence of active sows was higher in the Stall system than in group-housing. Stall system sows displayed marked exploratory behavior than the sows in Pen5 system. Sows in Stall system showed lower prevalence of health disorders such as vulva and body lesions and manure on the body, but higher prevalence of rectal prolapse and constipation than group-housed sows. Sows in Pen42 system showed higher rates of live piglets at birth, total piglets born and shorter gestation period than sows in Stall System. Lower number of mummified fetuses and larger number of stillbirths and stillbirths type 2, were associated to sows in Pen5 system. Sows in Pen5 system presented a reduction in health problems such as rectal prolapse and bursitis and skin inflammation as well as colds, decreased the stress level of the sows that showed greater expression of positive social behavior and decreased stereotypic behaviors, as well as maintained the reproductive parameters similar to those in individual stalls.

Palavras chave adicionais
Bem-estar animal.
Estresse.
Fêmeas suínas.
Gestação coletiva.
Produtividade.

Sistema de alojamento durante a prenhez sobre os parâmetros comportamentais, reprodutivos e sanitários de porcas

RESUMO

O objetivo deste estudo foi determinar se os parâmetros comportamentais, reprodutivos e de saúde podem diferir entre as porcas alojadas individualmente durante a gestação (Individual) ou alojadas em grupos entre os dias 3 a 5 (Grupo5) ou 38 a 42 (Grupo42) após a inseminação. Após a inseminação, 198 porcas de uma mesma granja comercial foram alocadas aleatoriamente em um dos três tratamentos, denominados sistema Individual, Grupo5 e Grupo42. Houve interação entre o sistema de alojamento e o tempo de gestação sobre os parâmetros comportamentais. A prevalência de porcas com comportamento ativo foi maior no sistema Individual do que nos sistemas em grupos. As porcas no sistema Individual apresentaram maior prevalência de comportamento exploratório do que as porcas no sistema Grupo5. As porcas no sistema Individual apresentaram menor prevalência de problemas de saúde, como vulva e lesões corporais e esterco no corpo, e maior prevalência de prolapso retal e constipação do que as porcas nos sistemas de grupos. As porcas no sistema Grupo42 apresentaram maior número de leitões nascidos vivos, total de leitões nascidos e menor período de gestação do que as porcas no sistema Individual. Menor número de fetos mumificados e maior número de natimortos e natimortos tipo 2 foram associados a porcas no sistema Grupo5. As porcas no sistema Grupo5 apresentaram redução de problemas de saúde, como prolapso retal e bursite e inflamação de pele, além de resfriados, e diminuíram o nível de estresse pois apresentaram maior expressão de comportamento social positivo e diminuição de comportamentos estereotipados, além de manterem os parâmetros reprodutivos semelhantes àquelas do sistema Individual.

Information

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INTRODUCTION

Awareness regarding farming issues and animal welfare has grown over recent years. Brazil has been working to improve welfare standards in pork production systems to meet market demands. One of the main animal welfare issues for Brazilian consumers regards industrial pig farming and gestating sows in stalls.

The use of gestation stalls allows an individualized and low-cost feeding management, and minimizes the occurrence of aggressive behaviors, although restricting movements and making it impossible to females to display natural feeding patterns, as well as hinders the expression of social behaviors. Thus, gestation stalls may cause welfare issues, leading to the development of stereotyped behavior, chronic stress, lameness, and

shoulder sores as well as gastric ulcers (Hötzel et al. 2004; Cappai et al. 2013). On the other hand, group-housing sows after breeding hinders individualized feeding and requires supervision that is more effective. Major welfare problems related with sows group-housed are stress and lesions caused by aggressions that occurs soon after mixing the animals (Chapinal et al. 2010).

High prevalence of gastric ulcers has been connected to confinement. A 40% prevalence of gastric ulcers in male pigs and 29.17% in females raised in confined indoor spaces was observed by Rodríguez et al. (2008). Gastric ulcers are associated with chronic stress, the restrictive imposed on sows, and the quality and granulometry of the diet (Almeida et al. 2006; Cappai et al. 2013).

Sows raised in dynamic groups (with input and output of sows), where females after insemination are group-housed throughout the gestation (Marchant-Forde 2009), suffer from stress more frequently if compared to the sows maintained in individual stalls throughout the gestation, due to higher occurrence of agonistic interactions (D'Eath &Turner 2009). This management can also affect the reproductive parameters of sows maintained in group-housed system if the correct mixing time were not observed.

When choosing the correct moment to house the sows in groups, several factors should be taken into account such as the stage of the estrous cycle, the sow´s genetic predisposition to stress, type of stress and the reproductive cycle phase (Einarsson et al. 2008). If mixing of sows is performed during the phase of hormonal changes that induces follicular growth and ovulation or in the implantation phase of embryos (Turner et al. 2009; Einarsson et al. 2008), there may be a higher rate of return to estrous, higher embryo absorption rate and, consequently, reduction in the reproductive rate.

In Brazil, there are few studies that report the effect of group-housing the sows in different gestational stages on behavioral, health and reproductive parameters. Strawford and Gonyou (2008) and Knox et al. (2014) found that aggressive behavior was similar in sows group-housed within 2 to 12 days after breeding or within 35 to 46 days after breeding. However, lower levels of cortisol concentration were reported in females that were early group-housed.

The aim of this study was to determine whether behavioral, health and reproductive parameters measures differed between sows housed individually throughout gestation or group-housed on days 3 to 5 or 38 to 42 after insemination.

MATERIAL AND METHODS

Animal care procedures throughout the study followed protocols approved by the Ethics Committee for Animal Use (CEUA) at the University of Brasília, number 44568/2009.

Data collection

The study was carried out for two years on a commercial farm in Midwest of Brazil (15°47' S and 47°56' W with altitude of 1,000 meters) a region with tropical climate, characterized by two distinct seasons, with rainy summers and dry winters, with average ambient temperatures varying from 13° to 29°C.

After insemination, 66 sows (DB25, commercial genetics) between the second and seventh parity were randomly allocated to one of three treatments (22 each): Stall - sows were maintained in individual stalls throughout the gestation; Pen5 - sows were transferred to the group-housing system within 3 to 5 days after breeding, and Pen42 - sows were maintained in individual stalls until days 38 to 42 after breeding, and then they were transferred to the group-housing system. This was repeated three times, enrolling 198 sows that were evaluated in total throughout the experiment. Semen used for inseminations was from commercial hybrid lines (LM6200 and Landrace). All sows enrolled in this study had previous experience in individual stalls from previous pregnancies at 42 or 67 days of gestation.

The sows in group-housing systems were allocated in dynamic groups (with input and output of sows) with 80 sows each (22 females were used for health and reproductive traits with 58 non-experimental animals per group) until three days before the farrowing when the sows were moved to farrowing crates. The pens used in the group-housing systems were composed of a circulation area built with slatted floors and five sub-areas interconnected to the common area, with compact floors, which allowed the sows to hide. The density was 0.45 sow/m^2. Each pen had an automatic feeding station (EFS) in which individual RFID transponder code was read to identify each single animal, according to individual preset feed rationing. The feed was mixed with water and dispensed in 200gram measures. When the sow left the EFS, the door opened for another sow enter and the balance of feed that remained to be offered for the sow was registered.

A data logger was used to collect the temperature and moisture every 10 minutes during the experiment. The equipment was placed a meter and a half away from the ground. The sows were monitored for behavior, productive parameters and health.

Behavioral parameters

During the gestation period, behavioral assessments (**Table I**) were performed from 8h00 to 11h30 and from 14h30 to 17h40 for three consecutive days, starting at day 3, 24, 42 and 100 of gestation. The behavioral evaluation was performed using the SCAN method (Martim et al. 1993), with a 10 minute interval between observations. In the Stall treatment 22 sows were monitored and in Pen42 and Pen5 treatments all 80 females that were in the pens were observed.

Stereotypic behavior was analyzed separately from lying behavior, since the sows could express stereotypic behaviors while they were standing up, in activity or at rest. In the evaluation of lying behavior, one annuls the presence of the other. For this reason, the sum of the prevalence of the behavior is greater than one hundred percent, which is solved by removing the value of the prevalence of the stereotypic behavior.

Table I. Ethogram used for behavioral evaluation of pregnant sows (Etograma utilizado para avaliação comportamental das porcas prenhes)**.**

Behavior	Description of behavior
Exploratory	Sow exploring the floor, wall, bar or any other structure with the muzzle, mouth or tongue.
Aggressive	Sow with aggressive behavior directed to another sow, pushing, biting, fighting etc.
Social positive	Sow with behavior of smelling, massaging and licking another female without aggression.
Active	Sow sitting or standing (in activity or at rest) without expressing exploratory, agonistic or social positive behaviors, with or without stereotyped behavior.
Stereotypes	Sow presenting repetitive behaviors without adaptive functions, for example: chewing in the vacuum, sucking the tongue, swallowing the air, biting the bars and rolling the tongue.
Lying	Sow lying without expressing exploratory, agonistic, positive or active behavior, with or without stereotyped behavior.

Reproductive parameters

For the assessment of the reproductive parameters, all 80 sows in the treatment were evaluated from the moment of the insemination until farrowing. Females that returned to estrous, aborted and had vulva discharge and hoof problems were identified, monitored and their behavior, reproductive and health data were only collected up to the period where they returned to estrous or aborted. Also, the sows were monitored during farrowing and the following parameters were registered: farrowing duration, farrowing type (normal or dystocic), piglets born alive, mummified piglets, stillbirths (stillbirths type 1 - death during farrowing and stillbirths type 2 - animals that died before farrowing and presented signs of decomposition), piglet sex and individual piglet weight at birth.

Health parameters

Animal health assessment was performed according to the Welfare Quality® protocol (2013), adapted for the purpose of the research, in all sow of the experiment at 3, 24, 42 and 100 days of gestation and at weaning (**Table II**). Each sow was numbered from 1 to 22 on the back and sides of the body with a non-toxic brush and always corresponded to the same female.

Statistical analysis

All data were analyzed by Statistical Analysis System (SAS® Institute, Cary, NC, USA) with the analysis of variance in PROC GENMOD procedure. Normal distribution was tested with the UNIVARIATE procedure and the link function was used depending on the response probability distribution. Means were compared by Tukey-Kramer test with a significance level of 5%. For behavior analysis, housing system, gestation time and housing system x gestation time were considered as independent variables and exploratory, aggressive, social positive, active, stereotypes and lying behaviors types as dependent variable. For health parameters, the collected data were transformed into binomial data, considering 0 for the non-occurrence and 1 for the presence of the analyzed variable, considering the classification scores. For reproductive parameters, two groups of analyses were considered: i) those referring to piglets where piglet sex, insemination month, year, parity order, male lineage, housing system and farrowing type were considered as independent variables and piglet weight at birth as dependent variable; and ii) farrowing duration, days in gestation, number of piglets born alive, stillbirths type 1, stillbirths type 2, mummified and total piglets born as dependent variables. The individual sows were considered in all models as repeated measures. For both health and reproductive parameters, principal component analyses were performed using PROC PRINCOMP procedure of SAS®, and the figures built considering the first two eigenvectors. In a principal component analysis (PCA), the variables studied are used to create new variables that are independent of each other, and the most important ones (which explain the most variance) are plotted. These new variables are combinations of the original variables.

RESULTS

Behavior parameters

Interactions between the housing system and gestation time on exploratory, aggressive, social positive, active, stereotypes and lying behavior parameters were found ($P<0.05$) (**Figure 1**).

Throughout the gestation period, sows in the Stall system had a higher prevalence of exploratory behavior than the sows in Pen5 system. After mixing sows in the Pen42 system, which occurred at day 42 of gestation, a decrease in the prevalence of exploratory behavior (**Figure 1**) was observed. On day 3 of gestation, the prevalence of aggressive behavior of sows in Pen5 system was higher than in the other periods, whereas on day 24, 42 and 100 of gestation no differences in the prevalence of aggressive behavior were found. The prevalence of aggressive behavior on day 3 and 24 of gestation was similar for sows in Pen42 and Stall systems, but on day 42 and 100 of gestation the prevalence of aggressive behavior of sows in Pen42 was higher than for sows in Stall and Pen5 systems. The threat behaviors were not evaluated in this study, if these behaviors had been considered the results may have been altered, increasing the amount of aggressive behavior, especially in sows in the Stall system. Sow maintained group-housed since the beginning of the gestational period (Pen5) had higher prevalence of social positive interactions than sows in Pen42 and Stall systems. The prevalence of active sows was higher in Stall system than in group-housed systems (Pen5 and Pen42). Sows in Pen42 system were more active that sows in Pen5 system at day 3 and 24 of gestation, after that the prevalence of active behavior was similar between both group-housed systems (**Figure 1**).

Reproductive parameters

Sows maintained in the Pen5 system presented longer gestation period (117.10 *vs*. 116.5 and 116.15 days), longer duration of farrowing (7h03 *vs.* 6h23, 6h30), a greater number of stillbirths (1.04 *vs*. 0.45 and 0.74%) and stillbirths type 2 (0.29 *vs*. 0.06 and 0.05%) as well as higher percentage of non-pregnant sows (4.55 *vs*. 0 and 0%) than those in Stall and Pen42 systems (**Table III**).

The birth weight of the piglets and the farrowing rate was not affected by the housing system, with average values of 1,462.96 grams and 99.93% (**Table III**). Sows in Pen42 system had higher number of piglets born alive (15.40 *vs.* 13.70 and 13.50 animals), total piglets born (16.18 *vs*. 15.00 and 13.98 animals) and a lower percentage of stillbirths (0.74 *vs*. 1.04 and 0.45%) although presented higher hoof problems (4.55 *vs.* 0 and 0%) than sows in the Pen5 and Stall systems (**Table III**). Sows in Stall system had higher percentage of mummified piglets (1.57 *vs.* 0.79 and 0.72%), and a lower number of total piglets born (13.98 *vs.* 16.18 and 15.00 animals) than the sows in the Pen42 and Pen5 systems (**Table III**).

The first two autovectors explained 48% of the variation (**Figure 2**) in the reproductive parameters of sows maintained in different housing system during gestation. The first autovector (33%) showed that longer gestation period tends to lead to an increase in the number of stillbirths, stillbirths type 2, mummified and longer duration of farrowing.

The second autovector (15%) showed that higher parity order sows tend to have a longer duration of farrowing and as a consequence, a higher number of stillbirths and stillbirths type 2. Larger percentages of mummified piglets tend to influence the number of piglets born alive (**Figure 2**)

Health parameters

Housing system did not affect health parameters such as of body condition score, shoulder lesions, local infections and labored breathing (**Table IV**). Group-housed sows (Pen5 and Pen42) presented higher percentage of vulva lesions classified as score 2 (6.03, 4.65

Table II. Health parameters based on the Welfare Quality® protocol (Parâmetros de saúde baseados no protocolo Welfare Quality®)**.**

Characteristics evaluated	Classification score		
	0	1	2
Body condition score	A firm pressure with the palm of the hand is able to feel the ribs and bone of the hip of the sow. But the sow is not obese.	The ribs and bones of the hip are easily felt without any pressure with the palm of the hand, or the sow is apparently obese and it is not possible to feel any bone, even pressing with the tips of the fingers.	Sow very skinny and the rib and hip bones are prominent.
Shoulder lesions	No shoulder lesion	Evidence of an old or healed wound, or cured wound or redness without penetration into the skin.	Open wound
Vulva lesions	No damage to the vulva, or small lesions (<2cm), scar visible on the tissue.	Injury visible but in process of healing (scar or crust formed), or formed vulva	Any injuries that are bleeding
Rectal prolapse	No evidence	-	Evidence.
Body lesions	All regions of the body with A score (no visible injuries or up to 4 visible lesions).	Any region of the body with a B score (5 to 10 visible lesions) or a region of the body with a C score (11 to 15 lesions)	Two or more regions of the body with a C score or a region with more than 15 lesions.
Skin conditions	No evidence of discoloration or inflammation	Up to 10% of skin is inflamed or discolored/stained.	More than 10% of the skin is inflamed or discolored/stained.
Local infections	Not visible abscesses or swelling	Some visible swelling. But no evidence of inflammation, or a small abscess.	More than one small abscess, any open or pus abscess, a large closed abscess (5 cm in diameter)
Bursitis	No evidence of bursitis.	One or several small bursitis of 1.5 to 2.0 cm in diameter or a large bursitis of 3 to 5 cm in diameter	Several large bursitis or one extremely large, greater than 7 cm or an eroded bursitis.
Lameness	Animal without lameness or with slight lameness, but supporting all the members on the ground	Animal with severe claudication, with difficulty to support the affected member on the ground	Animal does not support the affected member on the ground or is unable to walk
Manure on the body	Up to 10% of the body surface is soiled.	10 to 30% of body surface is soiled.	More then 30% of the body surface is soiled.
Constipation	No evidence of solid feces	-	Evidence of solid feces
Laboured breathing	No evidence of laboured breathing	-	Evidence of laboured breathing

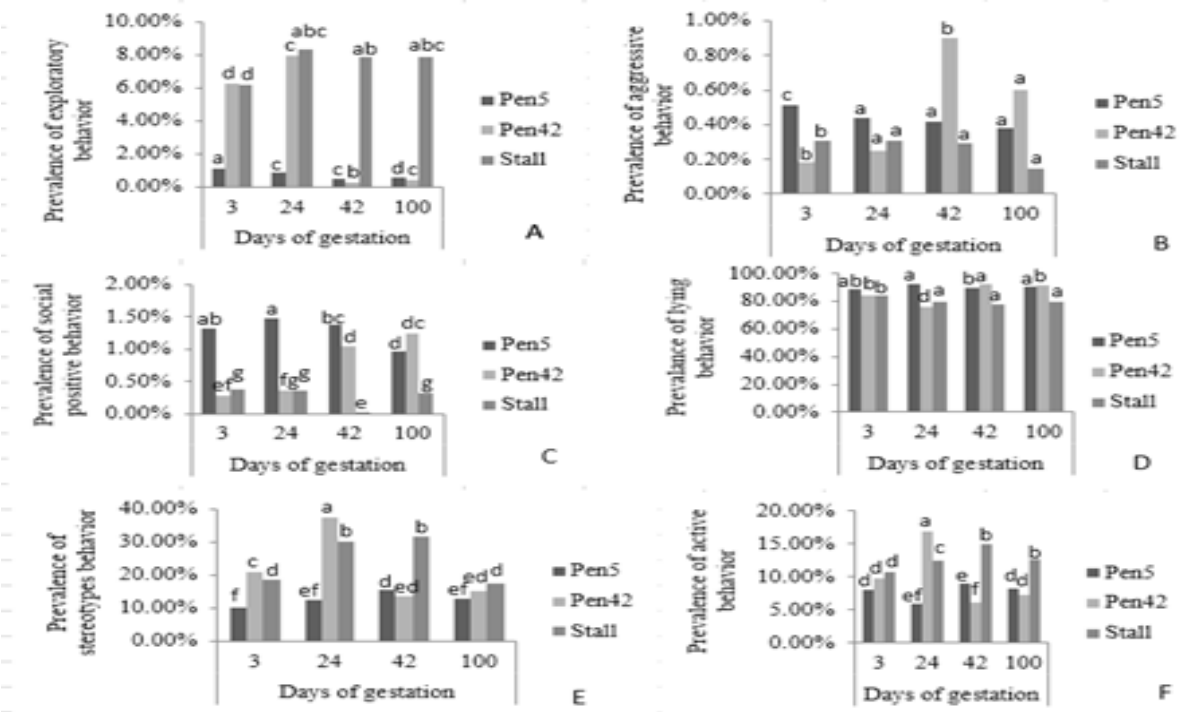

Figure 1. Interaction between the housing system and gestation time on prevalence of exploratory (A), aggressive (B), social positive (C), lying (D), stereotypes (E), and active (F) behaviors of sows (Interação entre o sistema de alojamento e o tempo de gestação na prevalência dos comportamentos exploratório (A), agressivo (B), social positivo (C), deitado (D), estereotipado (E), e ativo (F) de porcas).

vs. 0.83%) than those in Stall system. Sows in Stall system showed a higher prevalence of rectal prolapse classified as score 2 (0.83 *vs.* 0 and 0%) than sows in Pen5 and Pen42 systems (**Table IV**).

Sows in Pen5 system had the highest percentages of body lesions classified as score 1 (27.12 *vs.* 19.19 and 9.39%) and 2 (16.44 *vs*. 11.92 and 3.87%) compared with the sows in Stall and Pen42 systems. Sows in Pen42 system had more percentage of red and irritated skin classified as score 2 (29.94 *vs.* 27.62 and 21.37%) compared with the sows in Stall and Pen5 systems (**Table IV**).

The prevalence of bursitis classified as score 2 were higher for sows in the Pen42 and Stall systems than those in Pen5 system (29.94, 27.62 *vs.* 21.37%). Sows in Pen42 system presented greater severity in the degrees of lameness (classification score 2) than sows in Stall and Pen5 systems (1.10 *vs.* 0.28 and 0.27%) (**Table IV**).

Sows in Pen5 system had higher prevalence of manure on the body classified as scores 1 (27.40 *vs.* 14.53, 4.14%) and 2 (6.30 *vs.* 4.14 and 0.00%) than sows in Pen42 and Pen5 systems. Higher prevalence of constipation classified as score 2 (19.89 *vs*. 10.23 and 0.27%) was observed in sows in Stall system compared to

Table III. Reproductive parameters of sows according to the housing system during gestation (Parâmetros reprodutivos de porcas de acordo com o sistema de alojamento durante a gestação).

Reproductive parameter	Housing system		
	Stall	Pen42	Pen5
Piglets born alive	13.50^{b}	15.40^{a}	13.70^{b}
Stillbirths, %	0.45^{b}	0.74^{c}	1.04^{a}
Stillbirths type 2, %	0.06^{b}	0.05^{b}	0.29^{a}
Total piglets born	13.98^{c}	16.18^{a}	15.00^{b}
Mummified, %	1.57^{a}	0.79^{b}	0.72^{b}
Duration of farrowing, h	6h23min^{ab}	6h30min^{b}	7h03min^{a}
Gestation period, d	116.5^{ab}	116.15^{c}	117.10^{a}
Birth weight, g	1,493.00	1,461.10	1,434.80
Hoof problems, %	0.00^{b}	4.55^{a}	0.00^{b}
Non-pregnant, %	0.00^{b}	0.00^{b}	4.55^{a}
Farrowing rate, %	99.96	99.92	99.93

Stall: individual stalls; Pen42: group-housed within 38 to 42 days after breeding; Pen5: group-housed within 3 to 5 days after breeding; Means with different letters in the same row differ statistically by Tukey test (P<0.05).

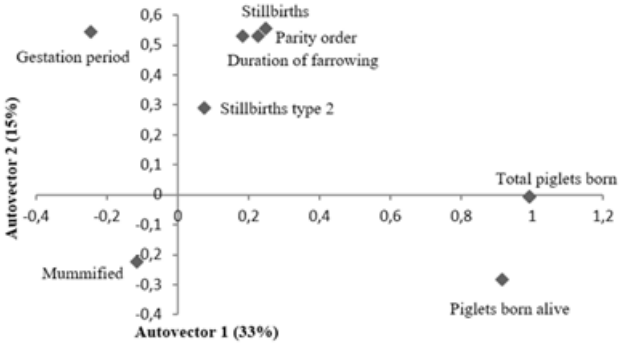

Figure 2. First two autovectors for reproductive parameters of sows maintained in different housing system during gestation (Primeiros dois autovetores para os parâmetros reprodutivos de porcas mantidas em diferentes sistemas de alojamento durante a gestação).

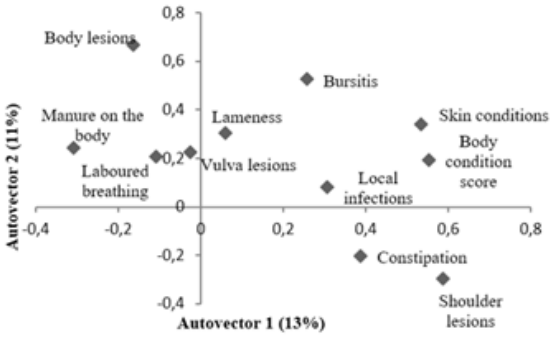

Figure 3. First two autovectors for health parameters of sows maintained in different housing system during gestation (Primeiros dois autovetores para os parâmetros de saúde de porcas mantidas em diferentes sistemas de alojamento durante a gestação).

sows in group-housed systems (Pen42 and Pen5) (**Table IV**).

The first two autovectors explained 24% of the variation (**Figure 3**) in the health parameters of sows maintained in different housing system during gestation. The first autovector (13%) showed that sows with better body condition score tend to have better skin conditions, less body and vulva lesions, less manure on the body and constipation. Even so, they tend to present more bursitis, local infections, labored breathing and lameness (11%) (**Figure 3**).

DISCUSSION

Behavior and health parameters

The higher prevalence of active behavior presented by sows in Stall system can be explained by the greater discomfort they perceived due to the restricted location. Baptista et al. (2011) emphasized that sows in Stall system remain standing and with stereotypes behavior during the period of activity agreeing with the results observed in this study. However, Stall system have been shown to be effective in reducing the prevalence of aggressive behavior and reducing the level 2 body lesions.

Before being group-housed, sows in Pen42 system (day 24 of gestation) presented higher percentage of active behavior than the sows of the other housing systems during gestation, but after being group-housed presented prevalence of active behavior similar to sows in Pen5 system, although there was increased aggressive behavior, in agreement with Chapinal et al. (2010). These authors found that group-housed sows increased their resting period and decreased stereotypes behavior.

The reestablishment of hierarchy in sows group-housed was the main factor responsible for the high prevalence of aggressive behavior found in sows in Pen5 and Pen42 systems, reflecting in the higher percentage of vulva lesions and corporal wounds (skin conditions) classified as score 2 of sows observed in these housing systems in agreement with Strawford et al. (2008). These authors observed that the aggressive behavior in the first four hours after mixing the sows was similar in sows group-housed soon after insemination or after 37 to 46 days. The higher prevalence of wounds could be related to the fact that the scar recover could be impaired, due to frequent fighting episodes between the sows, biting the same body parts and regions, such as the neck and the anterior part of the animal. Several authors have found a greater number of lesions in sows maintained in group-housed system, but this was not enough to reduce the reproductive parameters (Knox et al. 2014; Cunha 2015; Hemsworth et al. 2015).

The prevalence of aggressive behavior expressed in the Stall system could have been even higher if threatening behaviors was considered. This is because, in this study, only the physical and aggressive contact of the sows that went beyond the bars of the pen with their heads to bite the leg, snout, neck and other areas of the female's body beside was considered. Many times, when such fights occurred, other fights were triggered with females close to the female being attacked, generating a ripple effect or only this sow released a grunt or threatening look.

The lower prevalence of positive social behavior in the Stall system is due to the greater difficulty that the sow had in touching the sow beside her. However, it was observed that they perform this activity by placing their snouts between the bars of the pen and licking their neighbor, however, the discomfort of the position makes this behavior last for less time than the females that are group-housed.

The lower prevalence of stereotypes behavior of sows in Pen5 system can be attributed to the possibility of these sows to express a higher range of social positive behavior compared to the other housing systems. According to Manteca (2013), some behavioral needs, such as exploration and seeking for food, locomotion and nesting before farrowing (Bergeron et al. 2008) are essential for the maintenance of the welfare of the pigs, and when unattended they alter production and cause mental illness. However, when animals could

Table IV. Health parameters of sows according to the housing system during gestation (Parâmetros de saúde de porcas de acordo com o sistema de alojamento durante a gestação).

Health parameter (%)	Classification Score	Housing system		
		Stall	Pen42	Pen5
Body Condition Score	0	64.36	65.99	67.40
	1	30.94	29.65	30.14
	2	4.70	4.36	2.47
Shoulder lesions	0	50.00	48.25	55.89
	1	46.96	48.55	42.77
	2	3.04	3.20	1.37
Vulva lesions	0	88.67	84.30	86.30
	1	10.50	11.05	7.67
	2	0.83^{b}	4.65^{a}	6.03^{a}
Rectal prolapse	0	99.17	100.00	100.00
	2	0.83^{a}	0.00^{b}	0.00^{b}
Body lesions	0	86.74^{a}	68.90^{b}	56.44^{c}
	1	9.39^{c}	19.19^{b}	27.12^{a}
	2	3.87^{c}	11.92^{b}	16.44^{a}
Skin conditions	0	33.15^{a}	19.77^{b}	39.18^{a}
	1	48.90	56.40	48.22
	2	17.96^{b}	23.84^{a}	12.60^{b}
Local infections	0	62.71	63.08	69.86
	1	21.55	22.97	18.08
	2	15.75	13.95	12.05
Bursitis	0	31.77^{b}	36.05^{ab}	39.73^{a}
	1	40.61	34.01	38.90
	2	27.62^{a}	29.94^{a}	21.37^{b}
Lameness	0	98.62^{a}	91.86^{b}	94.25^{b}
	1	1.16^{b}	6.98^{a}	5.48^{a}
	2	0.28^{b}	1.10^{a}	0.27^{b}
Manure on the body	0	95.86^{a}	81.10^{b}	66.30^{c}
	1	4.14^{c}	14.53^{b}	27.40^{a}
	2	0.00^{c}	4.14^{b}	6.30^{a}
Constipation	0	80.11^{c}	89.77^{b}	99.73^{a}
	2	19.89^{a}	10.23^{b}	0.27^{c}
Laboured breathing	0	99.72	99.71	99.45
	2	0.28	0.29	0.55

Stall: individual stalls; Pen42: group-housed within 38 to 42 days after breeding; Pen5: group-housed within 3 to 5 days after breeding; Means with different letters in the same row differ statistically by Tukey test (P<0.05).

express those behaviors, the prevalence of stereotyped behaviors would be low or zero.

All sows enrolled in this study had previous experience in individual stalls. The permanence of stereotyped behavior in group-housed females demonstrated the persistence of this habit and the influence of individual stall in the female behavior. If they did not have this previous experience, stereotypes prevalence may reduce, since the prevalence of stereotypes behavior was reduced from 38% (day 21 of gestation) to 11% (day 42 of gestation) in females in Pen42 system and 10.5% (throughout the gestation period) in females in Pen5 system.

Sows in group-housed systems were dirtier than sows in Stall system. This parameter was measured indirectly with the evaluation of the degree of manure on the body and is an indicator of facility hygiene and stress. Swine are animals that, when there is sufficient space, separate rest areas from place where they shed feces and urine. Usually, they do not roll over their

feces, unless some factor reinforces this behavior, such as space dispute or the need for moist to decrease body temperature. Dominant females do not let the subordinates reach the area chosen to defecate, and heat stress will cause the sows to search for cooler spaces to lie down and eliminate the heat from their body. The degree of manure on the body of sows was associated with higher prevalence of vulva and body lesions, clear indicators of subordinate sows.

Bursitis is associated with the fact that sows lie down on hard surfaces (Scott et al. 2006; Gillman et al. 2008; Kilbride et al. 2008). Such lesions of the legs could be observed also in other animal species, such as in poultry and rabbits (Cappai et al. 2018; Wolf et al. 2020). Sows that acquired bursitis in the early stages of pregnancy tend to worsen its severity, which reflects the chronic nature of these lesions in the locomotor system (Díaz & Boyle 2014). This may explain the fact that sows of Stall and Pen42 systems had more bursitis than sows maintained in Pen5 system.

Lack of physical exercise leads to a higher prevalence of constipation (Sullivan & Wong 1992) explaining the fact that 19.89% of sows in Stall system present this problem against only 0.27% sows in Pen5 system. Females managed in individual stall tend to drink less water than sows group-housed due to physical exercise, which reinforces the onset of constipation. The high prevalence of constipation was also associated with higher prevalence of rectal prolapse observed in sows in Stall system, but this occurrence happened postpartum, when the sows have a greater contractility of the pelvic musculature in general.

Reproductive parameters

The higher percentage of mummified fetuses in Stall system may be related to the higher stress experienced by these sows, due to the deprivation of movements in addition to undiagnosed subclinical infections. Fetal mummification is associated with infectious diseases, order of farrowing, litter size, uterine capacity, environmental temperature and mycotoxins (Mengeling et al. 2000; Schneider et al. 2015). Swines are really sensitive to contaminated feed with mycotoxins which cause severe reproduction disturbances mimicking estrogenic-dependent syndromes, like in other non-ruminant animals, such as horses (Aboling et al. 2016).

The high prolificacy of the sows is the main factor involved in fetal loss by stillbirth. In breeding females, genetic progression to high prolificacy has generated high fetal demands for nutrients and space, which are not fully satisfied. This is confirmed by the high number of piglets with difficulties to successfully adapt to neonatal life (Colson et al. 2012). The reduced birth weight decreases the probability of survival by the end of the nursery phase. Also, low birth weight has been associated with risk of health problems at finishing stage, as well, generated a reduced carcass value at slaughter (Fix et al. 2010). The DB25 genetics, used in this study, have high prolificacy due to their genetic improvement, so inadequate nutrition in the final third of gestation may be responsible for the increase in the number of stillbirth piglets.

Another risk factor is the duration of farrowing. To reduce the risk of stillbirth, farrowing progress in high parity sows and in sows that may give birth to large litters should be monitored (Borges et al. 2005). The longer farrowing duration of sows in Pen5 system may have increased the number of stillbirths and stillbirths type 2. Another factor that needs to be better evaluated is the moment in which the sows were transferred to the maternity stalls. Sows handled during hot periods may have a greater number of stillbirth piglets, and this situation is aggravated when the transference occurs from one to three days before farrowing.

The higher percentage of non-pregnant sows in the maternity stalls in Pen5 system (3 of 66 sows) demonstrated that this system requires greater attention, training, and commitment from the staff. Non-pregnant sows in maternity stalls increases the non-productive days of sows, decreases productivity parameters of the farm and leads to financial losses. To minimize these effects, farms may adopt technologies that will aid in the early diagnosis of pregnancy, such as the ultrasound at day 25-28 of gestation or the use of an isolated male stall, with motion detector located between two group-housed pens to help in the detection of females returning to estrus. These technologies were not adopted in this study, which favored the increase of human failures in the detection of return to estrus and pregnancy diagnosis.

The use of group-housed systems is considered a risk factor for hoof problems (Anil et al. 2005; Harris et al. 2006; Chapinal et al. 2010). This is due to the impact of restricted mobility on the development of muscle and bone strength (Marchant & Broom 1994), as well as on claudication (Karlen et al. 2007), from the period that the females were in individual stalls. The quality of the floor and facilities also has a great influence in the increase of the hoof problems, being greater the prevalence and intensity of locomotion problems in grooved concrete floors than in compact ones (Spoolder et al. 2009; Kilbride et al. 2010; Pluym 2013). Another important factor is the concrete quality that will prevent the floor from breaking or becoming uneven. The higher percentage of hoof problems of sows in Pen42 system, may be due to the grooved floors and often slippery due to feces accumulation. The ammonia released from animal feces reduces the strength and elasticity of the hoof wall, as well as of other anatomical district of the pad in other animal species (Gregory 2004; Higuchi et al. 2009; Cappai et al. 2018; Wolf et al. 2020), which promotes the degradation of keratin by bacterial enzymes and may cause injury of the foot due to the facilitated penetration of bacteria responsible for painful inflammation (Van Amstel 2011).The lower prevalence of hoof problems of sows in Pen5 systems when compared to sows in Pen42 system, reaffirms the importance of maintain sows after breeding in group-housed pens allowing a better development of muscle and bone strength.

CONCLUSIONS

Sows can be group-housed within 3-5 days after insemination without increasing the number of piglets

born alive, mummified fetus, hoof problems, rectal prolapse, skin lesions, bursitis, lameness and constipation as well as provide less stereotypes and more social positive behaviors. Therefore, the complete removal of individual stalls brings benefits to the welfare of the animals, being a good indication for the sow management. The group-housed within 3 to 5 days after breeding system has shown to be as effective as individual stalls but more monitoring and knowledge of animal behavior is needed to achieve better results.

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BIBLIOGRAPHY

Aboling, S, Droetleff, AM, Cappai, MG & Kamphues, J 2016, 'Contamination with ergot bodies (Claviceps purpurea sensu latu) of two horse pastures in northern Germany', *Mycotoxin Research*, vol. 32, no. 4, pp. 207-219.

Almeida, MN, Vearick, G, Lippke, RT, Lagemann, FL, Correa, AMR & Barcellos, DESN 2006, ´Úlceras gástricas em suínos´, *A Hora Veterinária,* vol. 26, pp. 62-66.

Anil, L, Anil, SS, Deen, J, Baidoo, SK & Wheaton, JE 2005, ´Evaluation of well-being, productivity and longevity of pregnant sows housed in groups in pens with an electronic sow feeder or separately in gestation stalls´, *American Journal of Veterinary Research*, vol. 66, no. 9, pp. 1630-1638.

Baptista, IAA, Bertani, GR & Barbosa, CN 2011, ´Indicadores de bem-estar em suínos´, *Ciência Rural*, vol. 41, no. 10, pp. 1823-1830.

Bergeron, R, Meunier-Salaun, C & Robert, S 2008, ´The welfare of pregnant and lactating sows´, in: Faucitano, L & Schaefer, A. (eds.), *Welfare of pigs from birth to slaughter*, Wageningen Academic Publishers, Versailles.

Borges, VF, Bernardi, ML, Bortolozzo, FP & Wentz, I 2005, ´Risk factors for stillbirth and foetal mummification in four Brazilian swine herds´, *Preventive Veterinary Medicine*, vol. 70, no. 3-4, pp. 165-176.

Cappai, MG, Picciau, M & Pinna, W 2013, 'Ulcerogenic risk assessment of diets for pigs in relation to gastric lesion prevalence', *BMC Veterinary Research*, vol. 9, pp. 36-42.

Cappai, MG, Abd El Wahab, A, Arru, G, Muzzeddu, M & Pinna W 2018, 'Prevalence of foot disorders in captive sardinian partridges (*Alectoris barbara barbara* Bonnaterre, 1790) as useful indicators of fitness to natural environment', *Journal of Animal Physiology and Animal Nutrition*, vol. 102, no. 2, pp. 864-869.

Chapinal, N, Ruiz de la Torre, JL, Cerisuelo, A, Gasa, J, Baucells, MD, Coma, J, Vidal, A & Manteca, X 2010, ´Evaluation of welfare and productivity in pregnant sows kept in stalls or in 2 different group housing systems´, *Journal of Veterinary Behavior*, vol. 5, pp. 82-93.

Colson, V, Martin, E, Orgeur, P & Prunier, A 2012, ´Influence of housing and social changes on growth, behaviour and cortisol in piglets at weaning´, *Physiology & Behavior*, vol. 107, no. 1, pp. 59-64.

Cunha, ECP, Menezes, TA, Bernardi, ML, Mellagi, APG, Ulguim, RR, Wentz, I & Bortolozzo, FP 2018, ´Reproductive performance, offspring characteristics, and injury scores according to the housing system of gestating gilts´, *Livestock Science*, vol. 210, pp. 59-67.

D'Eath, RB, Roehe, R, Turner, SP, Ison, SH, Farish, M, Jack, MC & Lawrence, AB 2009, ´Genetics of animal temperament: aggressive behaviour at mixing is genetically associated with the response to handling in pigs´, *Animal*, vol. 3, no. 11, pp. 1544-1554.

Díaz, JAC & Boyle, LA 2014, ´Effect of rubber slat mats on the behaviour and welfare of group housed pregnant sows´, *Applied Animal Behaviour Science*, vol. 151, pp. 13-23.

Einarsson, S, Brandt, H & Rodriguez-Martinez, A 2008, ´Conference Lecture: Influence of stress on estrus, gametes and early embryo development in the sow´, *Theriogenology*, vol. 70, no. 8, pp. 1197-1201.

Fix, JS, Cassady, JP, Holl, JW, Herring, WO, Culbertson, MS & See, MT 2010, ´Effect of piglet birth weight on survival and quality of commercial market swine´, *Livestock Science*, vol. 132, no. 1, pp. 98-106.

Gillman, CE, Kilbride, AL, Ossent, P & Green, LE 2008, ´A cross-sectional study of the prevalence and associated risk factors for bursitis in weaner, grower and finisher pigs from 93 commercial farms in England´, *Preventive Veterinary Medicine*, vol. 83, no. 3-4, pp. 308-322.

Gregory, NG 2004, ´Swelling of cattle heel horn by urine´, *Australian Veterinary Journal*, vol. 82, no. 3, pp. 161-163.

Harris, MJ, Pajor, EA, Sorrells, AD, Eicher, SD, Richert, BT & Marchant-Forde, JN 2006, ´Effect of stall or small group gestation housing on the production, health and behavior of gilts´, *Livestock Science*, vol. 102, no. 1-2, pp. 171-179.

Hemsworth, PH, Mellor, DJ, Cronin, GM & Tilbrook, AJ 2015, ´Scientific assessment of animal welfare´, *New Zealand Veterinary Journal*, vol. 63, pp. 24-30.

Higuchi, H, Kurumado, H, Mori, M, Degawa A, Fujisawa, H, Kuwano, A & Nagahata, H 2009, ´Effects of ammonia and hydrogen sulfide on physical and biochemical properties of the claw horn of Holstein cows´, *Canadian Journal of Veterinary Research*, vol. 73, no. 1, pp. 15-20.

Hötzel, MJ, Machado Filho, LCP, Wolf, FM & Dalla Costa, O 2004, ´Behaviour of sows and piglets reared in intensive outdoor or indoor systems´, *Applied Animal Behavior Science*, vol. 86, no. 1, pp. 27-39.

Karlen,GAM, Hemsworth, PH, Gonyou, HW, Fabrega, E, Strom, AD & Smits, RJ 2007, ´The welfare of gestating sows in conventional stalls and large groups on deep litter´, *Applied Animal Behavior Science,* vol. 105, no. 1-3, pp. 87-101.

Kilbride, AL, Gillman, CE & Green, LE 2010, ´A cross-sectional study of prevalence and risk factors for foot lesions and abnormal posture in lactating sows on commercial farms in England´, *Animal Welfare,* vol. 19, no. 4, pp. 473-480.

Kilbride, AL, Gillman, CE, Ossent, P & Green, LE 2008, ´A cross-sectional study of the prevalence and associated risk factors for capped hock and the associations with bursitis in weaner, grower and finisher pigs from 93 commercial farms in England´, *Preventive Veterinary Medicine*, vol. 83, no. 3-4, pp. 272-284.

Knox, R, Salak-Johnson, J, Hopgood, M, Greiner, L & Connor, J 2014, ´Effect of day of mixing gestating sows on measures of reproductive performance and animal welfare´, *Journal of Animal Science*, vol. 92, no. 4, pp. 1698-1707.

Manteca, X, Silva, CA, Bridi, AM & Dias, CP 2013, ´Bem-estar animal: conceitos e formas práticas de avaliação dos sistemas de produção de suíno´, *Semina: Ciências Agrárias*, vol. 34, no. 6, pp. 4213-4230.

Marchant, JN & Broom, DM 1994, ´Effects of housing system on movement and leg strength in sows´, *Applied Animal Behavior Science,* vol. 41, no. 3-4, pp. 275-276.

Marchant-Forde, JN, Lay Jr. DC, Mc Mumm, KA, Cheng, HW, Pajor, EA & Marchant-Forde, RM 2009, ´Postnatal piglet husbandry pratices and well-being: The effects of alternative techniques delivered separately´, *Journal of Animal Science*, vol. 87, no. 4, pp. 1479-1492.

Martin, P, Bateson, PPG & Bateson, P 1993, *´Measuring behaviour: an introductory guide´*, University Press, Cambridge.

Mengeling, WL, Lager, KM & Vowald, AC 2000, ´The effect of porcine parvovirus and respiratory syndrome virus on porcine reproductive performance´, *Animal Reproduction Science,* vol. 60-61, pp. 199- 210.

Pluym, L, Nuffel, AV & Maes, D 2013, ´Treatment and prevention of lameness with special emphasis on claw disorders in group-housed sows´, *Livestock Science*, vol. 156, no. 1-3, pp. 36-43.

Rodríguez, BJ, Taborda, DA, Valencia, F, Franco, O & Ortiz, LC 2008, ´Frecuencia de lesiones gástricas halladas post mortem en cerdos en la ciudad de Medellín (Colombia)´, *Revista Colombiana de Ciencias Pecuarias*, vol. 21, no. 2, pp. 219-227.

Schneider, JF, Miles, JR, Brown-Brandl, TM, Nienaber, JA, Rohrer, GA & Vallet, JL 2015, ´Genomewide association analysis for average birth

interval and stillbirth in swine´, *Journal of Animal Science*, vol. 93, no. 2, pp. 529-540.

Scott, K, Chennells, DJ, Campbell, FM, Hunt, B, Armstrong, D, Taylor, L, Gill, BP & Edwards, SA 2006, ´The welfare of finishing pigs in two contrasting housing systems: fully-slatted versus straw-bedded accommodation´, *Livestock Science*, vol. 103, no. 6, pp.104-115.

Spoolder, HAM, Geudeke, MJ, Van Der Peet-Schwering, CMC & Soede, NM 2009, ´Group housing of sows in early pregnancy: A review of success and risk factors´, *Livestock Science*, vol. 125, no. 1, pp. 1-14.

Strawford, ML, Li, YZ & Gonyou, HW 2008, ´The effect of management strategies and parity on the behaviour and physiology of gestating sows housed in an electronic sow feeding system´, *Canadian Journal of Animal Science*, vol. 88, no. 4, pp. 559-567.

Sullivan, SN & Wong, C 1992, ´Runners diarrhea. Different patterns and associated factors´, *Journal of Clinical Gastroenterology*, vol. 14, no. 2, pp. 101-104.

Turner, SP, Roehe, R, D'Eath, RB, Ison, SH, Farish, M, Jack, MC, Lundeheim, N, Rydhmer, L & Lawrence, AB 2009, ´Genetic validation of skin injuries in pigs as an indicator of post-mixing aggressiveness and the relationship with aggression under stable social conditions´, *Journal of Animal Science*, vol. 87, no. 10, pp. 3076-3082.

Van Amstel S 2011, *Questions and answers around sow claw trimming*, viewed 13 March 2019, https://www.pigprogress.net/Health-Diseases/Health/2012/1/Questions-and-answers-around-sow-claw-trimming-PP008228W/.

Welfare Quality 2012, *´Welfare Quality® assessment protocol for pigs: sows and piglets, growing and finishing pigs´*, Welfare Quality® Consortium, Netherlands.

Wolf, P, Speers, R & Cappai, MG 2020, 'Influence of different types of bedding material on the prevalence of pododermatitis in rabbits', *Research in Veterinary Science*, vol. 129, pp. 1-5.