Reproductive traits in gilts housed individually or in groups during the first thirty days of gestation

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Summary

Objectives: To compare pregnancy rate and number of embryos 30 days post mating in gilts group-housed in pens of three and gilts housed individually in gestation stalls. Other potential indicators of swine welfare examined included body weight, backfat thickness, lesions, lameness, display of stereotypies, and serum cortisol concentrations.

Methods: After artificial insemination, Yorkshire × Landrace gilts were placed in gestation stalls (n = 14) or pens of three gilts each (n = 14 pens, 42 gilts) until 30 days post mating. Measures of welfare and performance assessed before mating and days 1, 3, 7, 14, and 28 post mating were compared between treatment groups. Gilts were euthanized and reproductive tracts were examined on day 30.

Results: Group-housed gilts gained more body weight than gilts housed in stalls, but backfat thickness was similar between treatments. The proportion of gilts exhibiting stereotypies on day 28 was not affected by treatment. Lesion scores (0 to 5; 5 = severe) were higher for group-housed gilts and were highest during the first 7 days post mating.

On day 30, lameness scores (0 to 5; 5 = severe) were higher in group-housed gilts, and serum cortisol concentration was higher in stall-housed gilts. Pregnancy rate on day 30 was lower for group-housed gilts. The numbers of ovulations and embryos, embryo weight, and crown-rump length were similar between groups.

Implications: Indicators of welfare were differentially affected by type of gestation housing, and pregnancy rate was higher in gilts housed individually in stalls.

Keywords: swine, gestation, housing, gilt

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Resumen – Parámetros reproductivos en primerizas alojadas individualmente o en grupos durante los primeros treinta días de gestación

Objetivos: Comparar el porcentaje de concepción y el número de embriones 30 días después de la monta en primerizas alojadas en grupo en corrales de tres contra primerizas alojadas individualmente en jaulas de gestación. Los otros indicadores potenciales del bienestar porcino examinados incluyeron peso corporal, espesor de la grasa dorsal, lesiones, cojera, muestra de estereotipos, y concentraciones de cortisol en suero.

Métodos: Después de la inseminación artificial, las primerizas Yorkshire × Landrace se colocaron en jaulas de gestación (n = 14) o corrales de tres primerizas (n = 14 corrales, 42 primerizas) hasta 30 días después de la monta. Las medidas de bienestar y desempeno valoradas antes de la monta y los días 1, 3, 7, 14, y 28 después de la monta se compararon entre grupos de tratamiento. Las primerizas fueron sacrificadas y los parámetros reproductivos se examinaron el día 30.

Resultados: Las primerizas alojadas en grupo ganaron más peso corporal que las primerizas alojadas en jaula, pero el espesor de la grasa dorsal fue similar entre los tratamientos. La proporción de primerizas que exhibían estereotipos en el día 28 no se afectó por el tratamiento. Los puntajes de lesión (0 a 5; 5 = severo) fueron más altos en las primerizas alojadas en grupo y fueron más altos durante los primeros 7 días después de la monta.

En el día 30, los puntajes de cojera (0 a 5; 5 = severo) fueron más altos en las primerizas alojadas en grupo, y la concentración de cortisol en suero fue más alta en primerizas alojadas en jaulas. El índice de concepción en el día 30 fue más bajo para las primerizas alojadas en grupo. El número de ovulaciones, embriones, peso de embrión, y la longitud de la cabeza a la cola fueron similares entre los grupos.

Implicaciones: Los indicadores de bienestar se afectaron de manera diferente por el tipo del alojamiento de gestación, y el índice de concepción fue más alto en primerizas alojadas individualmente en jaulas.

Résumé – Caractères reproducteurs chez des cochettes logées individuellement ou en groupe durant les trente premiers jours de gestation

Objectifs: Comparer la fréquence des gestations et le nombre d'embryons 30 jours post saillie chez des cochettes logées par groupe de trois dans des enclos et des cochettes logées individuellement dans des cages de gestation. D'autres indicateurs potentiels du bien-être des porcs examinés incluaient le poids corporel, l'épaisseur du gras dorsal, les blessures, la présence de boiterie, l'expression de stéréotypes, et les concentrations de cortisol sérique.

Méthodes: Après insémination artificielle, des cochettes Yorkshire × Landrace ont été logées dans des cages de gestation (n = 14) ou dans des enclos de trois cochettes chaque (n = 14 enclos, 42 cochettes) jusqu'à 30 jours post saillie. Les mesures de bien-être et de performance évaluées avant l'accouplement et aux jours 1, 3, 7, 14, et 28 post saillie ont été comparées entre les groupes de traitement. Au jour 30, les cochettes ont été euthanasiées et les tractus reproducteurs examinés.

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Résultats: Les cochettes logées en groupe ont pris plus de poids que les cochettes logées dans des cages, mais l'épaisseur du gras dorsal était similaire entre les deux groupes. La proportion de cochettes montrant des stéréotypes au jour 28 n'était pas affectée par le traitement. Les pointages de lésion (0 à 5; 5 = sévère) étaient plus élevés pour les cochettes logées en groupe et étaient plus élevés durant les 7 premiers jours suivant la saillie.

Au jour 30, les pointages de boiterie (0 à 5; 5 = sévère) étaient plus élevés chez les cochettes logées en groupe, et la concentration de cortisol sérique était plus élevée chez les cochettes logées dans des cages. Le taux de gestation au jour 30 était plus bas chez les cochettes logées en groupe. Le nombre d'ovulations et d'embryons, le poids des embryons, et la longueur couronne-croupe étaient similaires entre les groupes.

Implications: Les indicateurs de bien-être ont été affectés différemment par le type de logement lors de la gestation, et le taux de gestation était plus élevé chez les cochettes logées individuellement dans des cages.

From the perspective of the swine producer, housing gestating swine in individual stalls offers a number of advantages compared with traditional group-housing systems. For example, caretaking is simpler and signs of morbidity, such as feed refusal or discharge from the vulva, are more easily detected. As a consequence, individual housing of pregnant females in stalls is a common practice in the swine industry. Indeed, Barnett et al[1] estimated that at least 60% to 70% of US sows and gilts are housed in stalls throughout gestation.

The use of gestation stalls, however, is currently one of the most contentious welfare issues facing pork producers. Typical gestation stalls physically limit sows to standing, sitting, and lying, and this restricted freedom of movement has been robustly criticized by many animal rights and welfare activists. On the basis of an exhaustive review of the scientific literature, however, McGlone et al[2] concluded that stalls or well-managed pens generally (but not in all cases) produced similar states of welfare for pregnant females in terms of physiology, behavior, performance, and health.

Because the use of gestation stalls is a highly controversial issue, limiting this type of housing to a defined period of time that is considerably less than the entire length of gestation could conceivably become mandated, as it has in some jurisdictions. In swine, potential litter size is limited by a high rate of embryonic mortality, with the greatest percentage of losses generally occurring during the first 30 days of gestation.[3] It is therefore logical to initially focus on the first 30 days post mating when attempting to define the periods of gestation when housing swine in stalls may influence reproductive performance. Thus, the main objective of this experiment was to determine the effect of housing type (gestation stall or group pen) on pregnancy rate and number of embryos in gilts assessed 30 days after mating. During the course of the investigation, we also examined various potential indicators of welfare, including body weight, backfat thickness, lesions, lameness scores, display of stereotypies, and serum cortisol concentrations.

Materials and methods

Animals and housing

The experiment was conducted during the months of October, November, and December at the Swine Research Facility located at the Tidewater Agricultural Research and Extension Center in Suffolk, Virginia. All animal procedures were approved by the Institutional Animal Care Committee of Virginia Polytechnic Institute and State University.

Gestation pens (3.1 m × 1.7 m; 5.27 m^2 floor space) with partially slatted concrete flooring were located in a mechanically ventilated building. Gestation stalls (0.6 m × 2.0 m; 1.2 m^2 floor space) with partially slatted concrete flooring were contained in an adjacent curtain-sided building. Both buildings were serviced by propane heaters. Gestation pens and stalls were equipped with vertical-bar partitions and nipple waterers. For the building containing the gestation pens, mean high temperature was 22.4°C (range 18.9°C to 25.6°C) and mean low temperature was 17.6°C (range 14.4°C to 20.0°C). For the barn containing the gestation stalls, mean high temperature was 19.8°C (range 15.6°C to 23.3°C) and mean low temperature was 15.8°C (range 13.3°C to 17.8°C).

Prior to the experiment, spontaneously cycling gilts (Yorkshire × Landrace; n = 62) were housed in pairs in the gestation pens. Gilts were floor-fed a diet based on corn and soybean meal (2 kg per gilt per day) that met or exceeded recommended nutrient requirements.[4]

Study design

Estrous cycles in gilts were synchronized as previously described.[5] Feed containing altrenogest, an orally active progestin (Matrix; Intervet Inc, Millsboro, Delaware), was provided at a rate of 15 mg per day for 18 days. Duration of treatment was longer than specified on the label (14 days), but is consistent with previous experiments conducted in our laboratory. Twenty-four hours after withdrawal of progestin, gilts received an intramuscular injection of 400 IU pregnant mare serum gonadotropin and 200 IU human chorionic gonadotropin (P.G. 600; Intervet Inc).

Beginning the day after P.G. 600 treatment, gilts were checked for estrus twice daily (7:00 AM and 7:00 PM) in the presence of a mature boar. Fifty-six gilts (90.3%) displayed estrus within 6 days after administration of P.G. 600, with an injection-to-estrus interval of 4.5 ± 0.7 days. These gilts were used for the experiment.

Gilts were mated via artificial insemination 12 and 24 hours after first detection of standing estrus. Semen from six Duroc boars housed at a commercial stud (Swine Genetics International, Cambridge, Iowa) was collected, pooled, and extended to create insemination doses that each contained approximately 5×10^9 sperm cells. Semen was stored at 18°C and used within 4 days after collection.

Gilts were blocked in groups of four (14 total blocks) according to the time at which standing estrus was first observed. Within a block, one gilt was randomly assigned to be housed in a gestation stall (n = 14) and the three remaining gilts were assigned to a gestation pen (n = 14 pens containing three gilts each). In no case did a gestation pen contain two gilts that had been previously housed together.

Gilts were moved to their assigned gestation housing immediately after the second mating and stayed there until day 30 post mating. During this period, gilts were fed the gestation diet at 2 kg per gilt per day. Gilts were weighed and last-rib backfat thickness was determined ultrasonically (Sonograder; Renco Corporation, Minneapolis, Minnesota) on the day prior to progestin withdrawal and at day 30 post mating.

On the day of mating (before moving to gestation housing) and days 1, 3, 7, 14, and 28 post mating, gilts were evaluated for lesions.[6,7] On day 28 post mating, gilts were evaluated for stereotypies as previously described.[8] On day 30 post mating, lameness was scored using the system described by Main et al[9] (Table 1). Gilts were neither evaluated for stereotypies nor scored for lameness before treatments were assigned. On day 30, gilts were restrained with a

metal snare for collection of blood samples via jugular venipuncture and euthanized (captive-bolt pistol followed by exsanguination), and reproductive tracts were collected.

Lesion scoring

Lesions were scored for six body regions: head, face, and ears; neck and shoulders; middle body (excluding udder); udder (ventral middle body); rump, tail, anus, and vulva; and legs and feet, using modifications of a scoring system previously described.[6,7] The following scale was used to score lesions: 0 = no blemishes or lesions; 1 = some reddening or mild abrasion or mild callus; 2 = < 10 scratches or areas of major redness; 3 = < 5 cuts or small wounds; 4 = ≥ 10 scratches, a moderate wound, some swelling, or all three; 5 = ≥ 5 cuts or small wounds, a severe wound, or severe swelling.

Evaluation for stereotypies

Gilts were continuously observed for 1 hour starting from the beginning of the morning feed distribution. To facilitate this process, gilts were marked with colored spray paint to distinguish them. The observer walked quietly along the pens or stalls and noted at 2-minute intervals the occurrence of stereotypies. Stereotypies were defined as repeated movements, oral activities without obvious finality, rooting, and nosing occurring on successive observations at 2-minute intervals. Stereotypies observed included floor licking, bar biting, bar licking, vacuum chewing, yawning, and tongue movements.

Reproductive data collection

Pregnancy status, number of corpora lutea (ie, ovulation rate), total number of embryos, number of viable embryos, embryo length and weight, and percent embryo survival were determined. Embryos were considered nonviable if crown-rump length was more than two standard deviations less than the mean for that particular litter.[5,10] Embryo survival was determined by dividing the number of viable embryos by the number of corpora lutea.

Blood samples and radioimmunoassay

Blood samples were allowed to clot overnight at 4°C and serum was harvested after centrifugation. Samples were stored at -20°C. Serum concentrations of cortisol were determined using radioimmunoassay as previously described.[11] The intra-assay coefficient of variation was 3.5% and assay sensitivity was 2.0 ng per mL.

Data analysis

Data were analyzed by analysis of variance for a randomized block design using the GLM procedure of SAS version 8.2 (SAS Institute Inc, Cary, North Carolina). The model included block and housing (ie, gestation stalls or gestation pens) as possible sources of variation. Stall (n = 14) or pen (n =14) was considered the experimental unit. Thus, each pen value represented a mean of three gilts. While it is acknowledged that pen type was confounded with building, care was taken to insure that the internal environment and general management of both buildings were similar. Mean differences were considered statistically significant at $P < .05$. Tendencies for statistical significance were considered at $P < .10$.

Table 1: System used to score lameness in gilts (Main et al[9]) housed during the first 30 days post mating in gestation stalls (n = 14) or pens (n = 14 pens: three gilts per pen)

Score	Characteristics
0	Even strides, caudal body sways slightly while walking, gilt able to accelerate and change direction rapidly
1	Abnormal stride length, movements no longer fluent, gilt appears stiff, gilt still able to accelerate and change direction
2	Shortened stride, lameness detected, swagger of caudal body while walking, no hindrance in gilt agility
3	Shortened stride, gilt displays minimum weight-bearing on affected limb, swagger of caudal body while walking, gilt will not trot and gallop
4	Gilt does not place affected limb on floor while moving
5	Refuses to move

Results

Group-housed gilts gained more body weight than stall-housed gilts; however, the change in last-rib backfat thickness was not affected by treatment (Table 2). Mean body weights of pregnant gilts were numerically higher (171.5 kg) than those of nonpregnant gilts (165.3 kg).

Lesion scores for various regions of the body for group-housed gilts and gilts housed in gestation stalls are provided in Table 3. Group-housed gilts displayed more severe injuries in each body region except legs and feet on post-mating days 1, 3, 7, 14, and 28. Lesion scores were generally highest early in the 30-day post-mating period. Lameness scores determined at day 30 post mating tended to be higher in group-housed gilts than in stall-housed gilts (Table 2). No gilts died or were removed for health reasons during the experiment.

The percentage of gilts displaying stereotypies day 28 post mating did not differ due to treatment (Table 4). The percentages of gilts displaying various stereotypies were generally similar for group-housed and stall-housed gilts; however, there was a tendency for more group-housed gilts than stall-housed gilts to display vacuum chewing (Table 4).

Reproductive and endocrine characteristics of stall-housed gilts and group-housed gilts are provided in Table 5. Pregnancy rate was greater in stall-housed gilts than in group-housed gilts. The number of corpora lutea, total embryos, number of viable embryos, embryonic survival, and embryo weight and crown-rump length did not differ between treatments. Serum cortisol concentrations tended to be greater in stall-housed gilts than in group-housed gilts (Table 5).

Discussion

Despite similar daily feed allowances, group-housed gilts gained more weight during the experimental period than did stall-housed gilts. In contrast, last-rib backfat thickness did not differ between groups. The greater weight gain in group-housed gilts cannot be attributed to the proportion of nonpregnant gilts in this group (approximately 15%), as mean body weights for pregnant gilts were numerically higher (171.5 kg) than for nonpregnant gilts (165.3 kg). A higher growth rate exhibited by the group-housed group might have been associated with the lack of opportunity for stall-housed gilts to huddle when barn temperature was relatively low. Huddling decreases lower critical temperature, environmental heat demand, and total thermoregulatory heat and feed requirements.[12] However, lesion and lameness scores suggested that the group-housed gilts may have expended more energy in fighting

than gilts housed in gestation stalls.

Harris et al[7] reported that gilts housed in pens of four had 20% greater weight gains during gestation than did gilts housed in individual stalls, but this difference was not statistically significant. In that experiment, backfat thickness did not differ between groups. In an experiment conducted over several parities, Broom et al[13] reported that by the fourth parity, body weights were lower for stall-housed sows than for group-housed sows. Reduced exercise while housed in stalls may have resulted in lower muscle mass and bone strength in these sows over successive parities.[14]

Group-housed sows may display aggression toward pen-mates and exhibit a number of vices such as vulva biting.[15] Indeed, an advantage often cited by advocates of gestation stalls is that this method of housing prevents fighting between sows and minimizes potential injuries. The results of the current experiment support this concept. Group-housed gilts had more severe injuries throughout the body than did stall-housed gilts. At the end of the study, a higher incidence of lameness was also observed in group-housed gilts. Similarly, Harris et al[7] reported that throughout pregnancy, group-housed females had more scratches, cuts, and wounds on their heads, faces, and bodies than did sows housed in gestation stalls. At day 91 of gestation, the feet and legs of group-housed gilts were also in poorer condition compared with those of stall-housed gilts. The majority of gilts in that study (63%) walked normally, and although mean lameness scores were numerically higher for group-housed gilts (0.64) than for stall-housed gilts (0.29), this difference was not statistically significant.[7]

Vieuille-Thomas et al[8] reported the results of an experiment conducted under commercial conditions during which stereotypies were compared for pregnant sows individually housed in stalls or group-housed. The proportion of sows developing stereotypies was lower in group-housed sows (66.2%) than in stall-housed sows (92.6 %). In contrast, in this study, there was no difference between group-housed and stall-housed gilts in development of stereotypies. In agreement with our findings, a meta-analysis of 35 studies revealed that sows in stalls or groups show similar oral, nasal, and facial (ONF) behaviors and that ONF behaviors and stereotypic bar biting are not measures that can be used to differentiate welfare in sows housed in stalls or pens.[2]

Despite the limitations of this technique, assessment of blood cortisol concentration

Table 2: Body weight (BW), backfat thickness, and lameness score in gilts housed during the first 30 days post mating in gestation stalls (n = 14) or pens of three gilts each (n = 14 pens)*

Variable	Pens	Stalls	SE	*P*¶
Initial BW (kg)†	159.5	159.6	0.9	.95
Final BW (kg)†	170.6	166.3	1.1	< .01
Change in BW (kg)†	11.0	6.7	0.8	< .01
Initial backfat (mm)‡	14.9	15.4	0.7	.61
Final backfat (mm)‡	14.5	14.9	0.5	.59
Change in backfat (mm)‡	-0.3	-0.4	0.5	.80
Lameness score§	0.57	0.21	0.13	.06

* Estrus was synchronized by oral administration of altrenogest (Matrix; Intervet Inc, Millsboro, Delaware), 15 mg per day for 18 days, then intramuscular injection of a mixture of pregnant mare serum gonadotropin (400 IU) and human chorionic gonadotropin (200 IU) (P.G. 600; Intervet Inc, Millsboro, Delaware) 24 hours after withdrawal of altrenogest. Gilts that demonstrated estrus within 6 days were artificially inseminated.

† Mean body weights were calculated the day prior to altrenogest withdrawal (initial BW) and approximately 37 days later on day 30 post mating (final BW).

‡ Ultrasonically determined at the last rib on the same days as BW and reported as least squares means.

§ Determined on day 30 post mating (scale shown in Table 1) and reported as least squares means.

¶ Determined using analysis of variance for a randomized block design.

Table 3: Lesion scores (least squares means) for gilts housed during the first 30 days post mating in gestation stalls (n = 14) or pens of three gilts each (n = 14 pens)*

Day	Pens	Stalls	SE	*P*†
Head, face, and ears				
0	0.26	0.14	0.09	.37
1	2.41	1.21	0.16	< .01
3	2.45	1.29	0.16	< .01
7	2.05	1.00	0.15	< .01
14	1.62	0.86	0.13	< .01
28	1.12	0.86	0.12	.14
Neck and shoulders				
0	0.07	0.05	0.06	.77
1	2.21	0.57	0.16	< .01
3	2.55	0.29	0.20	< .01
7	2.21	0.29	0.17	< .01
14	1.55	0.07	0.12	< .01
28	0.88	0.00	0.12	< .01
Middle body (excluding udder)				
0	0.07	0.07	0.04	.99
1	1.62	0.21	0.13	< .01
3	1.59	0.79	0.27	.05
7	1.45	0.93	0.29	.22
14	0.76	0.21	0.14	< .01
28	0.45	0.07	0.10	.02

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Udder (ventral middle body)				
0	0.02	0.07	0.05	.54
1	0.64	0.07	0.10	< .01
3	0.52	0.21	0.14	.14
7	0.29	0.07	0.08	.07
14	0.19	0.00	0.05	< .01
28	0.26	0.07	0.09	.15
Rump, tail, anus, and vulva				
0	0.05	0.14	0.08	.38
1	1.38	0.21	0.17	< .01
3	1.60	0.50	0.18	< .01
7	1.45	0.64	0.21	< .01
14	1.14	0.29	0.14	< .01
28	0.43	0.14	0.12	.12
Legs and feet				
0	0.07	0.07	0.06	.99
1	1.05	0.57	0.20	.12
3	1.29	0.64	0.18	.02
7	0.62	0.79	0.18	.52
14	0.40	0.50	0.12	.58
28	0.69	0.43	0.11	.10

* Gilts were evaluated for lesions using modifications of a scoring system previously described by Arey[6] and Harris et al.[7] Lesions were characterized using the following scale: 0 = no blemishes or lesions; 1 = some reddening or mild abrasion or mild callus; 2 = < 10 scratches or major redness; 3 = < 5 cuts or small wounds; 4 = ≥ 10 scratches, a moderate wound, some swelling, or all three; 5 = ≥ 5 cuts or small wounds, a severe wound, or severe swelling.

† Determined using analysis of variance for a randomized block design.

has often been used as an indicator of stress in farm animals.[2] Indeed, an acute stress response is an easily demonstrated increase in cortisol release. The effects of potential chronic stressors on cortisol concentrations are more difficult to ascertain, as cortisol levels may increase only modestly and may be influenced by naturally occurring diurnal variation and the method by which blood samples are obtained. A thorough assessment of the effects of a housing system on circulating cortisol levels would necessitate a time series of cortisol measurements. Nevertheless, in this study, serum cortisol, determined in single samples collected on day 30 post mating, was higher in stall-housed than in group-housed gilts. In concert with these findings, Barnett et al[16] reported that sows housed in stalls had moderately higher cortisol concentrations than group-housed sows, and this difference was statistically significant. In contrast, Broom et al[13] reported similar concentrations of cortisol for stall-housed and group-housed sows. Chronic stress increases responsiveness of the adrenal gland to an adrenocorticotropin (ACTH) challenge. However, Von Borell et al[17] reported no difference in the cortisol response to an injection of ACTH for gilts housed individually in gestation stalls or group-housed in a pen serviced by electronic feeders.

Existing data concerning the effect on reproductive performance of housing sows in stalls during early gestation are equivocal. In this study, pregnancy rate on day 30 of gestation was higher for stall-housed than group-housed gilts. Consistent with this finding are the results of an Australian study[1] during which sows were either housed in stalls for 5 weeks post mating and in groups for the reminder of gestation, or housed in groups throughout gestation. The sows housed in stalls during early gestation had significantly more pigs born alive. In contrast, Schmidt et al[18] reported 15% lower pregnancy rates at day 35 post mating for multiparous sows housed in relatively small gestation stalls (0.49 m × 1.71 m) than in group-housed sows.

Swine are characterized as having a high rate of embryonic death loss, with the greatest percentage of mortalities (20% to 30%) occurring during the first 30 days of gestation.[3] A variety of nutritional and environmental factors can cause early embryonic death loss. In this study, total number of embryos, number of viable embryos, embryo weight, and embryo crown-rump length were similar for stall-housed and group-housed gilts. Across treatments, embryo survival (number of viable embryos divided by the number of corpora lutea) was relatively low (55%). This finding is consistent with that of a previous study[5] in which estrus was synchronized in gilts by feeding 15 mg altrenogest for 18 days (ie, longer than the 14 days specified on the label) and administering P.G. 600 24 hours after withdrawal of the progestin.

In this study, various indicators of welfare were differentially affected by type of gestation housing, and pregnancy rate at day 30 was maximal in gilts housed individually in stalls. Future experiments are warranted to assess farrowing rates in gilts housed in stalls for the first 30 days post mating and in group pens for the remainder of gestation. Adverse effects of group housing on pregnancy rate and measures of welfare (eg, injury and lameness scores) might be at least partially remediated by mixing individuals well before mating.

Barnett et al[1] suggested that the homeostasis approach is perhaps the best method for assessing overall animal welfare. This approach for comparing housing or husbandry systems identifies risks to welfare on the basis of changes in behavior and physiology and, corresponding to these changes, decreases in fitness, with fitness defined as the ability to grow, reproduce, and survive. If one applies the homeostasis approach to this study, it might be concluded that overall welfare was similar for gilts housed in gestation stalls and group pens. One measure of fitness favored group pens (ie, greater body weight during the experimental period), while another measure of fitness (ie, pregnancy rate) favored gestation stalls, and survival was equal between treatments.

Implications

- Under the conditions of this study, various indicators of welfare may be differentially affected by type of gestation housing (stalls or group pens).
- Pregnancy rate at day 30 may be

Table 4: Display of stereotypies (least squares means) on day 28 post mating in gilts housed in gestation stalls (n = 14) or pens of three gilts each (n = 14 pens)*

	Pens	Stalls	SE	*P*‡
Gilts displaying stereotypies (%) †	81.0	92.9	7.2	.26
For gilts displaying stereotypies, type of stereotypy displayed (%)				
Floor licking	57.1	59.7	7.9	.81
Bar biting	28.6	38.8	12.5	.55
Bar licking	2.4	7.5	6.1	.54
Vacuum chewing	17.9	1.2	6.2	.07
Yawning	2.4	-0.2	1.8	.33
Tongue movements	3.6	-0.3	2.8	.33

* Stereotypies characterized using the procedure of Vieuille-Thomas et al.[8] Gilts were continuously observed for 1 hour starting from the beginning of the morning feed distribution. Gilts were marked with colored spray paint to distinguish them. The observer walked quietly along the pens or stalls and at 2-minute intervals noted the occurrence of stereotypies. Stereotypies were defined as repeated movements, oral activities without obvious finality, rooting, and nosing, present on successive observations at 2-minute intervals.

† For each pen, the number of gilts that displayed stereotypies was recorded and the percentage of gilts displaying stereotypies was determined.

‡ Determined using analysis of variance for a randomized block design.

Table 5: Reproductive characteristics* and serum cortisol concentration† (least squares means) on day 30 post mating in gilts housed in gestation stalls (n = 14) or in pens of three gilts each (n = 14 pens)

Variable	Pens	Stalls	SE	*P*‡
Pregnancy rate (%)	85.7	100.0	3.2	< .01
No. of pregnant gilts	36	14	NA	NA
No. of open gilts	6	0	NA	NA
No. of corpora lutea	25.9	28.1	2.3	.51
Total embryos	13.8	15.5	1.8	.51
No. of viable embryos	13.3	14.5	1.7	.60
Embryonic survival (%)	56.1	54.2	5.4	.80
Embryo weight (g)	1.59	1.58	0.07	.89
Embryo crown-rump length (mm)	27.2	27.1	0.5	.92
Serum cortisol (ng/mL)	57.1	79.4	7.8	.06

* Gilts were euthanized and reproductive tracts were removed for examination on day 30 post mating.

† Determined by radioimmunoassay.[11]

‡ Determined using analysis of variance (ANOVA) for a randomized block design.

NA = not applicable, ie, these variables were not included in the ANOVA.

higher in gilts housed individually in stalls than in gilts housed in pens of three when gilts are mixed immediately after mating.

- Adverse effects of group housing on pregnancy rate and measures of welfare (eg, injury and lameness scores) might be at least partially remediated by mixing of individuals well before mating.

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