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Effect of Individual, Group or ESF Housing in Pregnancy and Individual or Group Housing in Lactation on the Performance of Sows and Their Piglets

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ABSTRACT : To evaluate different housing systems, 80 gilts were randomly allocated at puberty to four treatments: i) sow stall in gestation followed by farrowing crate (SC), ii) group housing with individual feeding in gestation followed by farrowing crate (GC), iii) ESF (Electronic Sow Feeding) system in gestation followed by farrowing crate (EC), and iv) ESF system followed by group farrowing pen (EG). The results showed that stalled sows had a longer interval between puberty and second estrus ($p<0.001$). The sows kept in the ESF system gained more body weight ($p<0.01$) and backfat ($p<0.05$) prior to service, and more backfat during gestation ($p<0.05$), but also had greater backfat losses in the subsequent lactation ($p<0.01$). Sows changing from loose housing to confinement at farrowing had longer gestation length ($p<0.001$). Total litter size did not differ significantly between gestation treatments, but the number of stillborn piglets was significantly higher in the SC treatment ($p<0.01$). After weaning, SC sows had the longest interval for rebreeding ($p<0.001$). Some EG sows came into heat before weaning, giving this treatment the shortest interval. These results indicate that gestation confinement in sow stalls had several detrimental effects on sow performance relative to group housing. (**Key Words** : Individual, Group, ESF, Sow, Piglet)

INTRODUCTION

Sow stalls are still a very popular form of gestation housing in Asia area, although they are being phased out in Europe as a result of concerns about sow welfare (SVC, 1997). Prior to the adoption of gestation stalls by family based farmers in the 1970s, following trends in Europe, most farmers had group-housing systems of various kinds. However, before considering a return to group systems, it is important to know the consequences for sow reproductive performance of different types of system. Bates et al. (2003) found that gestation sows kept in electronic sow feed house had either similar or improved performance compared to sows kept in stall house. The present experiment was therefore designed to compare the stall system with a traditional group-housing system and a more modern development of electronic sow feeding (ESF) during pregnancy. There is particular interest in the possible interactions between different forms of pregnancy and lactation housing, since it has been suggested that sows which have been group-housed in pregnancy may experience greater stress when confined for the first time immediately prior to farrowing, and that this might have adverse consequences for performance (Vestergaard and Hansen, 1984). The study therefore included different combinations of gestation and farrowing accommodation which might be adopted by Taiwanese farmers.

MATERIALS AND METHODS

Eighty Landrace×Yorkshire (LY) gilts were purchased from the same breeding company on two occasions, i.e. 40 gilts each time, at an age of 160-170 days and with body weights ranging from 90-95 kg. Gilts were initially housed in groups of five in the same building, where they were given daily full boar contact for 15 minutes in the early morning and in the late afternoon, using four different boars in turn. When signs of first estrus were seen, the 40 gilts were allocated to one of four different housing treatments.

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and daily boar contact continued. When signs of second estrus were seen, all the gilts were served by using AI. From the gilts which conceived, 8 animals per treatment were designated for detailed experimental study in each batch.

The different housing systems were constructed at the Innovation and Practical Training Center in the National Pingtung University of Science and Technology, Taiwan, ROC. Selected combinations of three different dry sow housing systems and two types of farrowing pen were used for housing treatments. They were i) sow stall in gestation followed by farrowing crate, ii) group housing with individual feeding in gestation followed by farrowing crate, iii) ESF (Electronic Sow Feeding) system in gestation followed by farrowing crate, and iv) ESF system followed by group farrowing pen.

The sow stalls consisted of metal bar frames, built into the concrete floor; 235 cm in length and 60 cm in width with a gate at both ends. An iron feeding trough was 15 cm above the ground and hung on the front gate, with a nipple drinker 45 cm above the ground hanging on the dividing gate. A fast single drop simultaneous feeding system was located above the stall and adjustable feed boxes connected with plastic pipes to the trough for each sow.

The group housing with individual feeding consisted of pens for 5 sows with concrete dividing walls built onto a partially slatted concrete floor, 300 cm in length and 300 cm in width with one gate on the front frame. The concrete trough was 10 cm above the ground and was located on the front frame, with a 45 cm-long metal shoulder division between each position. The trough was 45 cm in length, 30 cm in width, and 15 cm in depth, with a nipple drinker 45 cm above the ground hanging on the front frame. The same simultaneous feeding system was located above the trough, with adjustable feed boxes connected by plastic pipes to the trough for each sow.

Forty gilts were put into the electronic sow feeding (ESF) system which was located in a pen built onto a partially slatted concrete floor, 1,300 cm in length and 700 cm in width. The ESF system consisted of a feeding station with a separation possibility, and a removable training pen. The feeding station was programmed by personal computer, with a movable trough for separation, a two-way dividing gate hanging on the back, a screw auger for measuring dispensed feed and an antenna circuit for detecting the identification number of each sow. Each sow had a transponder collar on the neck that allowed identification of its number by antenna circuit inside the station. There were five training days before sows were mixed into the main group. Five sows were kept in the removable training pen and trained together; there were thirty minutes training for each sow, fifteen minutes in the morning and fifteen minutes in the afternoon. The training pen was taken away after training allowing mixing of sows into the group; therefore, all the sows used the same feeding station, and newcomers were able to keep contact with the group through the dividing gates before mixing. The large pen had ten drinking bowls 25 cm above the ground hanging on the side frame in the dunging area.

The individual farrowing pens consisted of a metal bar crate, built on a metal tri-bar slatted floor, 235 cm in length and 215 cm in width. Each crate had a trough, a nipple drinker, and an extension water pipe at the front and a removable access gate at the rear. There was a metal cooling plate lying in the middle part of the crate with a water cooling system for lactating sows. Two metal warm plates lay parallel to the cooling plate on each side of the pen as a heating system for piglets. There were also two heating lamps hanging 30 cm above the heating plates. A drinking bowl for piglets was 10 cm above the ground and hung on the dividing frame.

The group farrowing pen comprised 5 adjacent farrowing nests on each side, a dunging area in the middle part of the pen, and two passages circling the pen. Each nest consisted of metal bar frames built on the fully metal tri-bar slatted floor, 235 cm in length and 215 cm in width. There were two bars lying parallel within the nest and projecting 28 cm above the floor to prevent the crushing of piglets when the sow lay down. These two bars were fixed at both ends onto the metal frames and projected 60 cm out from the dividing frame, being fixed with another short bar. Each nest had a trough, a nipple drinker, and an extension water pipe at the front, and a door without gate at the rear. There was a metal cooling plate lying in the middle part of each pen with a water cooling system for lactating sows. Two metal warm plates lay parallel to the cooling plates on each side of the pen as a heating system for piglets. There was also a heating lamp hanging 30 cm above the heating plate. A drinking bowl for piglets was 10 cm above the ground hanging on the dividing frame. No pens were bedded. The group farrowing system was operated as an all-in all-out batch system with 10 gilts each time; within the group 8 gilts were experimental and 2 gilts non experimental.

All gilts were fed the diets depending on their physiological stages. There were three phases of feed for the experimental gilts: a finishing diet for the rearing stage, another for the pregnancy stage, and the last one for the lactating stage.

Performance parameters for each gilt were recorded from puberty until rebreeding after the first litter. These included: age at first estrus, age at second estrus (date served), age at first farrowing, days of pregnancy (gestation length), farrowing duration (hours). Body weight and backfat thickness measured ultrasonically at the P_2 position were recorded at puberty, at service, 80 days after mating, 109 days after mating (one day before moving to farrowing house), and 28 days at weaning. Litter details recorded

Table 1. Sow performance for different sow housing treatments (sampled from 64 first-litter LY sows' data, with four treatments of 16 sows in each treatment)

Treatment	SC	GC	EC	EG	SED	Sig.
Puberty age (days)	187.6	188.9	184.1	184.9	2.71	ns
Puberty to service length (days)	31.0[a]	26.0[b]	22.6[c]	22.1[c]	0.84	***
Pregnancy length (days)	112.4[b]	113.8[a]	114.7[a]	112.6[b]	0.50	***
Av. body weight at puberty (kg)	93.2	93.5	96.5	96.1	2.06	ns
Body weight gain before service (kg)	24.0[c]	25.6[bc]	29.3[ab]	29.6[a]	1.86	**
Body weight gain in pregnancy (kg)	58.3	59.5	52.6	59.7	3.32	ns
Total body weight loss in lactation (kg)	16.1	19.5	19.2	23.2	2.83	ns
Av. backfat thickness at puberty (mm)	10.7	10.6	10.8	11.1	0.38	ns
Total backfat gain before service (mm)	2.6[b]	2.9[b]	3.6[ab]	4.1[a]	0.55	*
Total backfat gain in pregnancy (mm)	4.9[b]	6.5[ab]	6.8[a]	7.4[a]	0.85	*
Total backfat loss in lactation (mm)	3.9[b]	4.7[ab]	5.9[a]	5.6[a]	0.62	**
Farrowing length (h)	3.62	3.67	3.55	2.27	0.72	ns

Sow housing treatment: (pregnancy to lactation), SC = Sow stall to farrowing crate; GC = Small group with individual trough (5 sows/group/pen) to farrowing crate; EC = ESF (40 sows/feeding station/pen) to farrowing crate; EG = ESF (40 sows/feeding station/pen) to group farrowing pen (10 litters/unit/pen).

SED = Standard error of the difference between two means; Means with the same letter are not significantly different.

Sig.: ns, p>0.05; * p<0.05; ** p<0.01; *** p<0.001.

included the number of piglets of each gender born alive or dead, the number of piglets alive at 14 days old, and the number of piglets weaned.

The GLM procedure of SAS was used to perform statistical analyses (SAS, 2004). Separate analyses were carried out to compare the 4 treatment combinations, or pooled data for the different dry sow housing systems and farrowing systems. Comparison between individual treatments was done by calculating the standard error of difference (SED) and least significant difference (LSD).

RESULTS

There were no significant treatment differences in the age at puberty of the gilts allocated to the different treatments and also no differences in initial body weight and P_2 backfat thickness (Table 1). However, treatments showed a great number of differences in the following stages. Stalled sows had a longer interval between puberty and second estrus (p<0.001), and gained less backfat during pregnancy. The sows kept in the ESF system gained more body weight (p<0.01) and backfat (p<0.05) prior to service. Whilst body weight gain in pregnancy did not differ between treatments, sows in the ESF system gained more backfat during gestation (p<0.05). However, they also had greater backfat losses in the subsequent lactation (p<0.01).

Sows changing from lose housing to confinement at farrowing had longer gestation length (p<0.001). There were no significant housing effects on the farrowing duration. The sows tended to give birth at all hours of the day in both systems, although more sows farrowed during the period 0:00 to 4:00. There was no difference in the farrowing length for sows which gave birth at different periods of the day (Table 2).

There were no treatment effects on the litter sizes at birth, piglets born alive, number of piglets at 14 days old and number of piglets weaned (Table 3). However, the SC mothers had significantly more stillborn piglets than other mothers (p<0.01). When comparing the proportion of piglets which remained, EG, GC and EC mothers had a similar higher percentage of piglets born alive. There was no treatment effect on the percentage of piglets which remained alive at 14 days old and 28 days old.

In accordance with these effects on litter size, there were no treatment effects on the total litter birth weight or the total weight of piglets born alive (Table 3). However,

Table 2. The farrowing length of sows in different time periods of the day (sampled from 64 first-litter LY sows' data, with two systems, of which 48 sows in Crate and 16 sows in Pen)

	0-4	4-8	8-12	12-16	16-20	20-24	Sig.
% of observations	23.4	15.6	12.5	14.1	17.2	17.2	
Farrowing length (h)	3.29	2.93	2.71	4.00	2.84	3.83	ns
SEM	0.545	0.668	0.747	0.704	0.637	0.637	

SEM = Standard error of the mean.

Means with the same letter are not significantly different. Sig.: ns, p>0.05.

Table 3. The litter performance for different sow housing systems (sampled from 64 first-litter LY sows' data, with four treatments of 16 sows in each treatment)

	SC	GC	EC	EG	SED	Sig.
Litter weight (g)	16,018	16,817	15,477	14,995	952.5	ns
Live litter weight at birth (g)	13,918	15,938	14,228	14,591	820.9	ns
Stillbirth weight (g)	2,099^{a}	879^{b}	1,048^{b}	404^{b}	511.9	*
Live litter weight at day 14 (g)	35,707^{b}	40,301^{a}	36,080^{b}	30,553^{c}	1,571.0	***
Live litter weight at day 28 (g)	68,204^{bc}	76,804^{a}	73,633^{ab}	61,906^{c}	3,778.8	**
Litter size (piglets)	11.6	10.9	10.6	10.8	0.59	ns
Number of live piglets at birth	10.1	10.4	9.9	10.5	0.49	ns
Number of stillbirths	1.56^{a}	0.50^{b}	0.69^{b}	0.25^{b}	0.38	**
Number of live piglets at day 14	9.7	10.2	9.4	9.6	0.45	ns
Number of live piglets at day 28	9.6	10.2	9.4	9.6	0.44	ns
Live piglets at birth/litter size (%)	88.3^{b}	95.4^{a}	93.6^{ab}	97.8^{a}	2.92	*
Dead piglets at birth/litter size (%)	11.7^{a}	4.6^{b}	6.4^{ab}	2.2^{b}	2.92	*
Live piglets at day 14/litter size (%)	85.2	93.1	89.6	90.2	3.34	ns
Live piglets at day 28/litter size (%)	84.2	93.1	89	90.1	3.30	ns

Sow housing treatment: (pregnancy to lactation), SC = Sow stall to farrowing crate; GC = Small group with individual trough (5 sows/group/pen) to farrowing crate; EC = ESF (40 sows/feeding station/pen) to farrowing crate; EG = ESF (40 sows/feeding station/pen) to group farrowing pen (10 litters/unit/pen).

SED = Standard error of the difference between two means. Means with the same letter are not significantly different.

Sig.: ns, $p>0.05$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

SC sows had a heavier weight of stillborn piglets. Litter weight at 14 ($p<0.001$) and 28 ($p<0.01$) days of age differed significantly between treatments, with GC and EC sows tending to have the heaviest litters while EG sows had the lowest weight of piglets. After weaning, SC sows had the longest interval for rebreeding ($p<0.001$; Table 4). Some EG sows came into heat before weaning, giving this treatment the shortest interval.

DISCUSSION

There were no significant differences in the puberty age, initial body weight and P_2 backfat thickness. This indicates unbiased allocation and would be expected since animals were genetically similar and had been maintained under standard conditions until this time. EC and EG gilts had the similar shortest length of time from puberty to service, while this period was longest in crated gilts. These differences may be explained as a result of different due to stimulation in a group housing system (Spoolder et al., 1997), or the stress of being confined for the first time in the SC animals. It has been shown that stress hormones can adversely affect the reproductive endocrine system (Arey and Edwards, 1998). SC gilts had lower weight gain between puberty and service, which again might be attributed to stress since cortisol can decrease protein synthesis (Terlouw et al., 1991). In the following stages, all the gilts gained similar body weight but SC gilts had a lower backfat gain. These differences may be because of the different thermal environment experienced by the animals. Individually housed pigs cannot huddle, and therefore have an increased Lower Critical Temperature (Geuyen et al., 1984). If the environmental temperature was below this value, feed would be diverted from deposition of body reserves to thermoregulation.

GC and EC gilts had a similar longer length for

Table 4. The weaning to heat interval for different sow housing treatments (sampled from 64 first-litter LY sows' data, with four treatments of 16 sows in each treatment)

Treatment	SC (SEM)	GC (SEM)	EC (SEM)	EG (SEM)	Sig.
Wean to heat interval	11.75^{a}	7.50^{ab}	5.36^{b}	-3.6^{c}	***
(days)	(1.765)	(1.634)	(1.634)	(1.579)	
Number observed in estrus	12	14	14	15	
(per 16 sows)	(75.0%)	(87.5%)	(87.5%)	(93.7%)	

Sow housing treatment: (pregnancy to lactation), SC = Sow stall to farrowing crate; GC = Small group with individual trough (5 sows/group/pen) to farrowing crate; EC = ESF (40 sows/feeding station/pen) to farrowing crate; EG = ESF (40 sows/feeding station/pen) to group farrowing pen (10 litters/unit/pen).

SEM = Standard error of the mean. Means with the same letter are not significantly different. *** $p<0.001$.

pregnancy but SC and EG gilts had a similar shorter length. These effects can be explained by the housing system changes combined with different space allowances between pregnancy and farrowing accommodation. Cortisol and adrenaline produced in response to stress can antagonize the effects of oxytocin, which is involved in the induction of farrowing (Randall, 1972a, b; Svendsen et al., 1986; Lawrence et al., 1994). However, it is interesting that the farrowing length was not affected by the housing treatments. Other authors have suggested that sows confined during pregnancy have longer farrowings (Baxter and Petherick, 1980; Vestergaard and Hansen, 1984; Lawrence et al., 1994; Fraser and Broom, 1997).

In the lactation stage, all the sows had a similar body weight loss. The feed intakes of the sows depended on litter size and there was no significant difference in the litter size between treatments in lactation. Sows from the ESF system mobilized more backfat during lactation. There is a tendency for sows which are fatter at farrowing, as were gilts from the ESF system, to lose more fat during lactation (Spoolder et al., 1997).

When the sows returned to their previous housing treatments at weaning, SC sows were observed to have the longest interval for rebreeding followed by EC and EG sows, with GC sows intermediate. The same trend was seen in expression of estrus; 93.7% of EG sows were seen in heat after weaning followed by EC (87.5%), GC (87.5%) and SC (75%) sows. Once again, this may reflect the benefits of group housing in stimulating estrus and/or the negative effects of confinement stress on function of the reproductive axes.

When considering the effects of farrowing system on sow performance, the differences in mean body weight before farrowing can be explained by the residual effects of pregnancy housing treatments. Sows farrowed in a group pen lost more body weight and backfat in lactation. Since they did not rear a greater piglet weight, and therefore presumably did not have higher milk yield, this suggests either a greater energy demand for activity in the larger area, or a lower feed intake. Since these animals all came from ESF housing, and were heavier and fatter at farrowing, it may be that the known effects of body condition at farrowing on change in lactation can explain the result (Spoolder et al., 1997). Overall, the sows which farrowed in pens tended to have a shorter duration of farrowing ($p<0.05$). Comparison of individual treatment combinations indicated that this was an effect of current housing and not a residual effect of pregnancy housing. It has been shown that sows which farrow in crates have higher plasma cortisol levels than sows which farrow in pens (Lawrence et al., 1994), and this may explain their longer farrowing duration.

There were no treatment effects on the means of the born litter weight and born live litter weight. However, SC sows tended to have more stillborn pigs. This seemed to relate more to the effects of pregnancy confinement, with stalled sows having a greater proportion of stillborn piglets than group housed sows which farrowed in a similar crate system, and producing piglets which took longer to stand and to suckle. Sows which farrowed in group housing had a shorter duration of farrowing, were more active and had lower suckling frequency, associated with reduced weaning weight of piglets. They also showed a high incidence of lactational estrus, and thus a shorter farrowing to reconception time. The piglets of the group farrowed sows ate more creep feed, and drank more water than from the sows in farrowing crates, indicating reduced milk supply (Weng, 2000).

In conclusion, sows confined in stalls during pregnancy tended to perform less well than group housed sows, suggesting that group-housing is a viable commercial alternative under modern subtropical conditions. The movement away from confinement towards loose-housing at farrowing would also be beneficial to the sow. However, the sows kept in an ESF system during pregnancy and farrowed in a group farrowing pen (EG) nursed their litters less often, and initiated fewer successful nursing. Their litters also initiated fewer successful nursing and ate creep feed more often. The EG sows were also observed to show lactational estrus, which occurred as early as 17 days after farrowing, i.e. 11 days before managed weaning at 28 days old. These results imply that the EG mothers start to wean their litters themselves earlier than other mothers, and this is detrimental for both welfare and performance of the piglets. Further research and development work on such systems is therefore necessary before they can be recommended for commercial adoption.

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