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Effect of Individual, Group or ESF Housing in Pregnancy and Individual or Group Housing in Lactation on Sow Behavior

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ABSTRACT : To evaluate the effect of different housing systems on sow behavior, 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). Behavioral observations were carried out on a total of 16 animals per treatment at the following stages: first day of allocation to housing treatment, day of service, 80 days after service, 109 days after service on entry to farrowing accommodation, 24 h before farrowing, day of farrowing, 14, 27 and 28 days after farrowing, at weaning. On each occasion, individual animals were observed for a 24 period with one minute time sampling. There were significant differences ($p<0.001$) between stages of the reproductive cycle for all the behavior patterns in all treatments. On the first day in experimental housing treatments, sows spent more time rooting and dog-sitting. Activity and investigatory behavior decreased as pregnancy progressed. An activity peak was apparent just before farrowing, followed by a high level of inactivity on the day of farrowing. Time spent active, eating and drinking increased as lactation progressed, and greatest activity and locomotion was seen immediately following weaning. There were significant differences between housing treatments ($p<0.01$) for standing, moving, eating, drinking, dog-sitting and lying. During pregnancy SC sows spent more time standing, rooting, drinking and dog sitting, while EC sows spent less time rooting and drinking and more time lying. During lactation, GC sows spent more time standing, moving and eating, less time dog sitting and lateral lying. Nursing frequency was reduced in GC sows ($p<0.001$). The maternal and piglet behaviors were influenced strongly by environment during lactation. However, it was also shown that previous housing history can influence the maternal behavior in the pre-farrowing stage and during early lactation. (**Key Words :** Group, Individual, Housing, ESF, Sow, Behavior)

INTRODUCTION

Behavior, physiology, immunity, body injury score, and performance are five important tools for evaluating animal housing and management. Sow stalls for dry sow and farrowing crates for lactating sows have been used for about the last 40 years in Taiwan. However animal welfare concerns have been also expressed about both types of housing for a long time (Kiley-Worthington, 1977). There are now many papers comparing housing systems for dry sows (Brouns and Edwards, 1992; Broom et al., 1995; Jensen et al., 1995; Turner, 2000; Bates et al., 2003) and lactating sows (Edwards and Fraser, 1997; Wechsler and Weber, 2007), although there has been little work carried out under Asian conditions. Furthermore, most reports consider the production stage in isolation, and few reports have studied the performance of varied combinations of gestating and lactating sow systems. The objective of this study was to compare the behavior of sows in different combinations of gestation and farrowing accommodation which might be adopted by Taiwanese farmers in the future to improve sow welfare.

MATERIALS AND METHODS

One hundred Landrace×Yorkshire (LY) gilts were purchased from the same breeding company on two occasions, i.e. 50 gilts each time, at an age of 160-170 days and with body weights ranging from 90-95 kg. First 40 gilts which reached puberty early were selected. Gilts were initially housed in groups of five in the same building,

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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 first 40 gilts of each batch were allocated to one of four different housing treatments, 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.

The electronic sow feeding (ESF) system was located in a pen built onto a partially slatted concrete floor, 1300cm 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. Sows were weaned at 28 days after farrowing and returned to their original gestation system.

Detailed behavioral observations were carried at the following times in the reproductive cycle: i) on the first day when gilts were allocated to each housing treatment, ii) day of service, iii) 80 days after service, iv) 109 days after

Table 1. Sow behaviors (minutes in 24 h) during different sow physiological stages for all housing treatments (sampled from 64 first-litter LY sows' data for nine 24 h observations with 1 minute interval scanning)

Behavior items	Pregnancy			Pre-farrowing		Lactation			Post-weaning	SED	Sig.
	1	2	3	4	5	6	7	8	9		
Standing	70^{b}	56^{c}	54^{c}	32^{e}	45^{cd}	19^{f}	37^{de}	42^{de}	106^{a}	5.98	***
Rooting	61^{a}	44^{b}	20^{d}	12^{def}	8^{ef}	5^{f}	4^{f}	14^{de}	36^{e}	4.30	***
Moving	28^{b}	18^{e}	23^{bc}	9^{de}	8^{e}	5^{e}	18^{cd}	26^{bc}	49^{a}	4.37	***
Eating	36^{c}	32^{c}	35^{c}	53^{a}	50^{ab}	31^{c}	53^{a}	55^{a}	44^{b}	3.01	***
Drinking	26^{bc}	21^{d}	16^{e}	16^{e}	26^{bcd}	8^{f}	29^{b}	38^{a}	23^{cd}	2.15	***
Dog-sit	60^{a}	13^{d}	21^{cd}	35^{b}	22^{cd}	9^{d}	27^{bc}	26^{bc}	33^{bc}	6.52	***
Lying	$1,158^{c}$	$1,254^{b}$	$1,269^{ab}$	$1,283^{a}$	$1,282^{a}$	969^{e}	$1,064^{d}$	$1,052^{d}$	$1,150^{e}$	14.06	***
Nursing	-	-	-	-	-	394	207	187	-	-	-

Sow physiological stages: Pregnancy: 1 = 1st day in each sow housing treatment; 2 = day of service; 3 = 80 days after service; Pre-farrowing: 4 = 109 days after service; 5 = 24 hours before farrowing; Lactation: 6 = day of farrowing; 7 = 14 days after farrowing; 8 = 27 days after farrowing; Post-weaning: 9 = return to previous dry sow house.
SED = Standard error of the difference between two means. Means with the same letter are not significantly different.
Sig.: *** $p<0.001$.

service, immediately after transfer to farrowing crates, v) 24 hours before farrowing, vi) day of farrowing, vii) 14 days after farrowing, viii) 27 days after farrowing and ix) 28 days after farrowing, immediately after weaning. On each of these days, behavioral data were collected on individual animals for a 24 h period. The observation period for stages 5 and 6 started at 112 days after service and ended at 24 h after farrowing, with the records from the period of 24 h before and after farrowing subsequently being used. All other observations began at 9:00 in the morning and lasted for 24 h. One-minute interval scanning was used for recording the general behavior, with observers alternating every 4 to 6 h. The following categories of general behavior were used: standing, sternal lying, lateral lying, eating, drinking, moving, rooting, dog-sitting, and nursing. The following additional behavioral data were also recorded at farrowing: farrowing duration (hour), birth order, and birth intervals of piglets.

Data were analyzed using the GLM procedure of SAS (SAS, 2004). The model included housing system and physiological stage. 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 nine observation periods for each sow, of which three were in pregnancy (stage 1, 2 and 3), two in the pre-farrowing stage (stage 4 and 5), three in lactation (stage 6, 7 and 8) and one in the post-weaning stage (stage 9).

Table 1 shows the means of the time spent in each behavior in each of these 24 h periods to compare the differences between physiological stages. There were significant differences between stages for all the behavior patterns through means of all treatments. On the first day in experimental housing treatments, sows spent more time rooting and dog-sitting. Activity (standing, rooting, eating, drinking, and dog-sit behavior) and investigatory behavior decreased as pregnancy progressed. An activity peak was apparent just before farrowing, followed by a high level of inactivity on the day of farrowing. Time spent active, eating and drinking increased as lactation progressed, and greatest activity and locomotion was seen immediately following weaning.

When comparing the behavior of dry sows in different housing systems during pregnancy (Table 2), there were significant differences in all the behavior patterns. Stalled sows spent more time standing, drinking and dog sitting. Group housed sows in either system spent more time in locomotion, while ESF sows spent less time rooting and drinking and more time lying

Table 3 shows the behaviors of sows in different farrowing systems during the pre-farrowing period; 109 days after service (the first day in the farrowing house) and 24 h before farrowing. Sows kept in a crate were less active, spent a longer time dog-sitting and less time eating and drinking.

Table 4 shows the behaviors of sows in different farrowing systems during the lactation period; day of farrowing, 14 days after farrowing and 27 days after farrowing. Sows in crates spent a more time eating, dog-sitting and lateral lying than those in group housing. A longer duration of the first nursing after farrowing was found overall in the group farrowing pen (52 v 34 minutes, SED 3.7, $p<0.001$). This was the period from the first sucking of the last piglet to the first end of nursing. When either the mother changed the posture or 80% piglets left

Table 2. Sow behaviors (minutes in 24 h) for different dry sow housing systems in pregnancy (sampled from 64 first-litter LY sows' data of which 16 sows in stalls, 16 sows in groups and 32 sows in ESF, for three 24 h observations with 1 minute interval scanning)

Behavior items	Stall (SEM)	Group (SEM)	ESF (SEM)	Sig.
Number of sow	16	16	32	
Standing (minutes/24 h)	77^{a} (4.97)	52^{b} (4.97)	56^{b} (3.52)	***
Rooting (minutes/24 h)	46^{b} (5.65)	63^{a} (5.65)	29^{c} (3.99)	***
Moving (minutes/24 h)	9^{b} (2.24)	27^{a} (2.24)	28^{a} (1.58)	***
Eating (minutes/24 h)	39^{a} (2.58)	37^{ab} (2.58)	31^{b} (1.82)	*
Drinking (minutes/24 h)	34^{a} (1.82)	26^{b} (1.82)	13^{c} (1.29)	***
Dog-sit (minutes/24 h)	91^{a} (6.53)	13^{b} (6.53)	11^{b} (4.62)	***
Lying (minutes/24 h)	$1,145^{c}$ (12.45)	$1,222^{b}$ (12.45)	$1,271^{a}$ (8.81)	***

SEM = Standard error of the mean.
Means with the same letter are not significantly different. Sig.: * $p<0.05$; *** $p<0.001$.

Table 3. Sow behaviors (minutes in 24 h) for different farrowing systems in the pre-farrowing stage (sampled from 64 first-litter LY sows' data of which 48 sows in crates and 16 sows in pens, for two 24 h observations with 1 minute interval scanning)

Behavior items	Crate (SEM)	Pen (SEM)	SED	Sig.
Number of sows	48	16		
Standing (minutes/24 h)	36 (2.48)	46 (4.29)	5.0	*
Rooting (minutes/24 h)	10 (1.18)	9 (2.04)	2.4	ns
Moving (minutes/24 h)	4 (1.58)	23 (2.73)	3.2	***
Eating (minutes/24 h)	47 (1.81)	62 (3.14)	3.6	***
Drinking (minutes/24 h)	20 (1.02)	24 (1.76)	2.0	*
Dog-sit (minutes/24 h)	31 (1.93)	20 (3.35)	3.9	**
Sternal lying (minutes/24 h)	325 (13.13)	301 (22.74)	26.3	ns
Lateral lying (minutes/24 h)	967 (16.26)	954 (28.17)	32.5	ns
Lying (minutes/24 h)	1,292 (5.78)	1,255 (10.02)	11.6	**

SEM = Standard error of the mean. SED = Standard error of the difference between two means.
Means with the same letter are not significantly different. Sig.: ns, $p>0.05$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

Table 4. Sow behaviors (minutes in 24 h) for different farrowing systems in the lactation stage (sampled from 64 first-litter LY sows' data of which 48 litters in crates and 16 litters in pens, for three 24 h observations with 1 minute interval scanning)

Behavior items	Crate (SEM)	Pen (SEM)	SED	Sig.
Number of sows	48	16		
Standing (minutes/24 h)	29 (1.76)	44 (3.04)	3.5	***
Rooting (minutes/24 h)	5 (0.83)	15 (1.44)	1.7	***
Moving (minutes/24 h)	4 (1.95)	55 (3.38)	3.9	***
Eating (minutes/24 h)	48 (1.57)	40 (2.73)	3.1	**
Drinking (minutes/24 h)	25 (1.44)	27 (2.50)	2.9	ns
Dog-sit (minutes/24 h)	23 (1.84)	13 (3.19)	3.7	**
Sternal lying (minutes/24 h)	242 (9.54)	220 (16.53)	19.1	ns
Lateral lying (minutes/24 h)	808 (9.33)	746 (16.17)	18.7	***
Nursing (minutes/24 h)	256 (8.76)	280 (15.16)	17.5	ns
Nursing frequency (occasions/24 h)	33.0 (0.41)	21.4 (0.71)	0.82	***

SEM = Standard error of the mean. SED = Standard error of the difference between two means.
Means with the same letter are not significantly different. Sig.: ns, $p>0.05$; ** $p<0.01$; *** $p<0.001$.

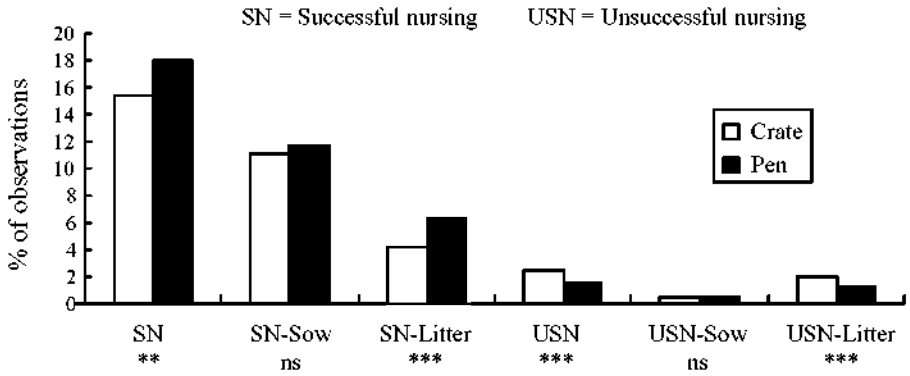

Figure 1. The percentage of time spent in nursing in 24 h for different farrowing systems in lactation.

the udder. However, crate housed sows subsequently nursed their litter more frequently, although total nursing time (when piglets were active at the udder) did not differ.

A greater time spent in successful nursing was found in the group farrowing pen ($p<0.01$), as a result of a difference in the piglet initiated nursing (Figure 1). However, a higher frequency of successful nursing was found in farrowing crates ($p<0.001$), for both mother- and piglet-initiated bouts (Figure 2). The frequencies of, and time spent in, unsuccessful nursing were also higher in farrowing crates, as a result of differences in piglet initiated nursing.

When looking at the possible interactions between pregnancy and lactation housing, it can be seen in Table 5 that, when moved into farrowing crates, previously group-housed sows spent more time dog sitting and sternal lying, and less time standing and lateral lying than previously stalled sows. The duration of first nursing was shorter for sows which had previously been housed in stalls than in sows which had been group housed in pregnancy.

Table 6 shows the behaviors of sows immediately after their return to the original dry sow housing at weaning. Overall, stalled sows stood ($p<0.001$), dog-sat ($p<0.001$) and drank ($p<0.001$) more often than sows returned to groups, which spent more time in locomotion ($p<0.001$), rooting ($p<0.001$) and lying ($p<0.001$). Investigation of the different treatment combinations (EC and EG) indicated that no difference resulted from the previous lactation housing system.

DISCUSSION

All the observed behaviors changed significantly with different physiological stages. This may be because the sows were seeking for their litters after deprivation (Weary and Fraser, 1995). They also have to reestablish their social order, therefore, they spent a longer time in active behavior. For the rooting behavior, (Lammers and Lange, 1986) suggest the rooting behavior is one sign of nesting behavior in a farrowing crate. It is supposed to have a higher frequency just before farrowing; Jensen (1988) reported that nest building behaviors were observed 10 h before farrowing in free-ranging domestic sows. However, it was actually observed here to have a lower frequency before farrowing; this may be because of the barren environment or because the primiparous sows have less nest building behavior in the modern commercial environment. The sows spent more time drinking before farrowing, which may be a sign of thwarted nesting behavior. The most concerning behavior "dog-sitting" changed dramatically when the sows changed their accommodation, suggestion that they had

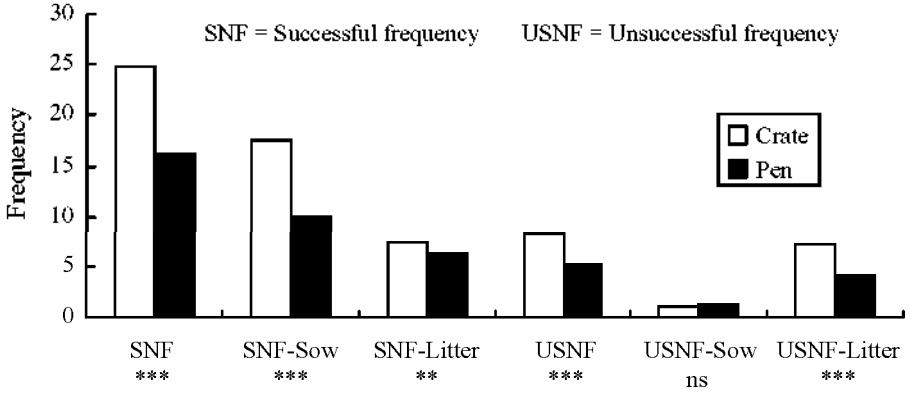

Figure 2. The nursing frequency (occasions) in 24 h for different farrowing systems in lactation.

Table 5. Sow behaviors (minutes in 24 h) for different sow housing treatments in the pre-farrowing stage (sampled from 64 first-litter LY sows' data for two 24 h observations with 1 minute interval scanning) and the duration of nursing immediately after farrowing

Behavior items	SC	GC	EC	EG	SED	Sig.
Standing (minutes/24 h)	45[a]	20[b]	43[a]	46[a]	5.6	***
Rooting (minutes/24 h)	8	8	13	9	2.9	ns
Moving (minutes/24 h)	2[c]	1[c]	10[b]	23[a]	3.8	***
Eating (minutes/24 h)	45[b]	48[b]	49[b]	62[a]	4.5	***
Drinking (minutes/24 h)	20[ab]	16[b]	24[a]	24[a]	2.4	**
Dog-sit (minutes/24 h)	17[c]	30[b]	47[a]	20[c]	3.9	***
Sternal lying (minutes/24 h)	174[d]	336[b]	433[a]	301[c]	21.7	***
Lateral lying (minutes/24 h)	1,129[a]	951[b]	821[c]	954[b]	29.0	***
Lying (minutes/24 h)	1,303[a]	1,318[a]	1,254[b]	1,255[b]	12.9	***
First nursing duration (minutes)	21[c]	36[b]	46[a]	52[a]	3.30	***

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, $p>0.05$; ** $p<0.01$; *** $p<0.001$.

difficulty in adjusting themselves to the environment differences of their new accommodation.

In the pregnancy stage, EC and EG sows were kept in the same accommodation condition, and so the data could be pooled during comparison. There is more restriction for stalled sows. They stood more often and moved less often. They also spent a slightly longer time eating, drank the most often and dog-sat more often. This is indicative of poor welfare conditions. Fraser and Broom (1997) who pointed out that, in stalled sows, dog-sitting for a long time and "play with nipple" behaviors were indicators of poor welfare. The longer time recorded for drinking by SC sows may have just been playing with the nipple on some occasions. This behavior has been reported previously as a stereotypy of confined sows (Terlouw et al., 1991).

Sows kept in the Group or ESF system had more space for moving. However, the small group system offered less total space but a more stable social environment. Behavioral differences between the two systems were relatively few. Sows kept in the ESF system spent the shortest time for drinking and a slightly shorter time eating. This can be explained because the feeding station had a pressure controlled water injector, and the water was given together with the feed during the feeding in a ratio of 1.5-2 to 1. Pigs eat wet feed more quickly than dry diet (Pettigrew et al., 1984; O'Grady et al., 1985). ESF sows spent less time rooting and more time lying, possibly reflecting greater satiation as a result of the higher volume of liquid feed consumed.

EC sows dog-sitting more often in the pre-farrowing stage. They also spent the longest time in sternal lying and the shortest time in lateral lying. These differences suggest the EC sows may be under stress from the abrupt change in space and increased restraint. Previous work has shown that a change from loose housing to confinement at farrowing may be more stressful than confinement throughout pregnancy and lactation (Vestergaard and Hansen, 1984). SC, GC and EC sows were from different dry sow housing

Table 6. Sow behaviors (minutes in 24 h) for different sow housing treatments in the post-weaning stage (sampled from 64 first-litter LY sows' data for one 24 h observation with 1 minute interval scanning) (n = 16)

Behavior items	SC	GC	EC	EG	SED	Sig.
Standing (minutes/24 h)	188[a]	115[b]	60[c]	61[c]	14.0	***
Rooting (minutes/24 h)	19[b]	29[b]	46[a]	48[a]	6.3	***
Moving (minutes/24 h)	17[c]	77[a]	47[b]	53[b]	8.7	***
Eating (minutes/24 h)	40	48	45	43	4.4	ns
Drinking (minutes/24 h)	30[a]	20[b]	19[b]	22[b]	3.0	**
Dog-sit (minutes/24 h)	91[a]	32[b]	4[c]	4[c]	8.6	***
Lying (minutes/24 h)	1,054[c]	1,119[b]	1,218[a]	1,209[a]	19.6	***

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, $p>0.05$; ** $p<0.01$; *** $p<0.001$.

conditions, but farrowed in crates.

There were fewer residual effects of pregnancy housing after farrowing, but EC sows still showed more dog-sitting than SC and GC sows. This suggests they had still not fully adapted to the changed space allowance. No difference in overall nursing parameters as a result of previous pregnancy housing were recorded. Sows which farrowed in pens tended to have a longer duration of the first nursing. However, EC and EG mothers had the similar longest duration followed by GC and SC mothers. This suggests that this parameter was more dependent on previous housing history than the immediate lactation housing, with sows which were less confined in pregnancy showing better initial nursing behavior or having more viable piglets.

When comparing the behavior changes with lactation stages, standing, rooting, moving, eating, drinking and dog-sitting increased over time. The sternal lying was also increase with lactation stages, while nursing time and frequency were decreased. In particular, the successful nursing length and frequency were decreased with lactation stages. These may be signs of weaning, for they follow the typical pattern reported under semi-natural conditions (Jensen, 1986, 1988).

When EC and EG mothers returned to the ESF system, they had the similar highest time spent lying and the similar lowest time spent standing and dog-sitting. They also spent a similar longer time for rooting. This suggests that immediate effects of housing system at this stage were more important than any residual effects of lactation housing.

When SC mothers returned to sow stalls, they had the highest time spent standing and dog-sitting followed by GC, EG and EC mothers. They also spent a longer time for drinking. Thus the behavioral differences observed during the first pregnancy were quickly reestablished. It has been reported that the effects of confinement on behavior are cumulative, with older sows showing much more pronounced behavioral abnormalities (Terlouw et al., 1991; Spoolder et al., 1997).

CONCLUSIONS

In conclusion, behavioral results indicate that stalls are a less suitable housing system for sow welfare during pregnancy. The maternal and piglet behaviors were influenced strongly by environment during lactation. However, it was also shown that the previous housing history can influence the maternal behavior in the pre-farrowing stage and during early lactation. Therefore, any decision concerning the housing in pregnancy may have to take the combination of farrowing systems available into account. Although it was not possible to test all combinations of housing during pregnancy, farrowing and lactation, the results suggest that the preferred current system would house dry sows in groups but continue to farrow in crates until better loose housing systems are developed for lactation.

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