Swine Reproductive Traits under Different Housing Systems through Pre-puberty to Fifth Parity

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Abstract Twelve F₁ female littermates (Landrace × Large White) were compared for reproductive performances under two different housing systems, individual stall and group pen (three/group), through pre-puberty (>60 kg in body weight) to fifth parity. They were randomly assigned to two groups across litters and fed the same feeding regime. Estrus was checked once a day with the aid of a boar and twice servicing was performed per estrus either by artificial insemination or natural service. Reproductive criteria recorded were age at first estrus, dates of first service, conception and farrowing, body weight at first estrus, at conception and at farrowing, litter size at birth and at weaning, piglet weight at birth and at weaning, percentage of weaned piglets against live born litter size, along with date of returning to estrus after first parity weaning and subsequent parities. Gilts in group pens reached puberty at an average of 24.5 days earlier than gilts in the individual stalls. Average length of the estrous cycle from the first heat to the second heat was significantly shorter ($P < 0.05$) in group pen gilts than the individual stall gilts, 22.2 vs. 26.0 days. Average body weight at first service was significantly higher ($P < 0.05$) in individual stall gilts than in the group pen gilts, 137.2 vs. 123.8 kg. Litter size at birth and at weaning through all parities averaged 9.6 and 8.7, and 11.0 and 9.4 for sows kept in the group pens and in the individual stalls, respectively. Average piglet weight at birth was significantly higher ($P < 0.01$), through all parities, in group pen sows than individual stall sows, 1.55 vs. 1.32 kg. Average piglet weight at weaning was significantly higher ($P < 0.01$) in group pen sows compared to individual stall sows through all parities, 7.43 vs. 6.37 kg. Average percentage of weaned piglets against live born litter size through all parities was significantly higher ($P < 0.05$) in group pen sows than individual stall sows, 96 vs. 88%. Average interval from weaning to mating through all parities was significantly shorter ($P < 0.01$) in sows kept in the group pens compared to sows in the individual stalls, 10.8 vs. 41.0 days. Individual cases of both locomotive defects and abortion were encountered in solitarily confined sows.

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The confinement system used for swine breeding herds has recently been advocated as an impetus to intensify production. With most conventional systems, gilts and sows are penned either individually or in groups¹⁴⁾. Both

of these systems have its own advantages and disadvantages. Individual housing allows discrete supervision and intensive care. It enables the animal to feed at its own pace and this further allows the ration to be regulated

according to the animal's needs. The major drawback of this system is that it has an adverse influence on attainment of puberty as well as libido^{4,9,11,12}. On the contrary, group confinement enhances attainment of puberty and libido^{4,9,11,12}. It provides more room to exercise and wider choice of resting place. However, the biggest disadvantage of group housing is the fighting and intimidation of weaker animals by dominant ones resulting in insufficient intake of food and rest for some. The preceding may cause some animals to abort, with remote possibility of fatalities.

Comparison of the two systems, over a shorter period, is well documented^{4,5,7,9,11,12,16}, however, data on long term study is still vague. The objective of this study was to compare reproductive performances of gilts and sows kept under different housing systems through pre-puberty to reproductive ages.

Materials and Methods

Twelve F₁ gilts (Landrace × Large White), six each from two different litters with an age difference of seven days, were randomly assigned before attainment of puberty (body weight > 60 kg) either to be housed individually in gestation stalls or grouped in pens, three gilts per pen. Estrus was checked once a day before attainment of puberty and after weaning with the aid of a boar. Gilts were artificially inseminated using fertile Duroc boar semen twice during the second cycle. Similarly, primiparous sows were also artificially inseminated twice during the first cycle following weaning, however, multiparous sows were naturally mated twice during the first cycle following weaning. Approximately five days before expected date of farrowing, the pregnant animals were moved to farrowing stalls in a separate farrowing house. After weaning all sows were once again moved to the gestation house.

All animals were confined in the same open house during the experimental period. Indi-

vidually housed animals were kept in gestation stalls (0.7 × 1.8 m) separated by metallic tubes. Grouped animals were housed in two pens (3.4 × 4.9 m), three animals per pen. The pens were attached to a concrete yard (4.8 × 4.9 m) and a dirt lot (5.0 × 4.9 m) outside. Floor of both confinement systems was made of solid concrete with the provision of sawdust bedding.

All gilts were fed individually during the growing period (60–120 kg in body weight) with finishing mash (TDN 70.0%, DCP 12.5%) as recommended by Japanese Feeding Standard for Swine¹¹. All pregnant animals received individually 2.3 kg/day of gestation mash (TDN 67.0%, DCP 9.5%) twice daily during the first and second gestational periods. This was increased to 2.5 to 3.0 kg/day during the later part of the gestation period, respectively. During lactating periods all sows were given 5.4 kg/day of finishing mash thrice daily. All piglets were fed starter mash after two weeks of age, and were weaned at four weeks of age. All sows were deprived of food for two days after weaning to suppress milk production. Each stall and pen was equipped with one watercup and water was supplied *ad libitum*. The experiment included up to five successive gestational and nursing periods over three years.

Reproductive criteria recorded were age at first estrus, dates of first service, conception and farrowing, body weight at first estrus, at first service, at conception and at farrowing, litter size at birth and at weaning, piglet weight at birth and at weaning, percentage of weaned piglets against live born litter size, along with date of returning to estrus after first parity weaning and subsequent parities.

Percentage data was analyzed statistically by MANN-WHITNEY test¹⁷. Other data were evaluated statistically by analysis of variance for differences between treatments.

Results

Comparison was made of some reproductive traits in gilts under the two different housing systems, group pen (G) and individual stall (S) (Table 1). Average age at puberty for G was 24.5 days earlier than that for S. Average body weight at first service for S was significantly higher ($P<0.05$) than that for G. Average length of the estrous cycle from the first heat to the second heat was significantly shorter ($P<0.05$) in G compared to S.

Reproductive performances of the sows under the two different housing systems, G and S, through the first to fifth parity are shown in Table 2. Average weight gain in dams during

the gestation period tended to be higher in G compared to S throughout the first to fifth parity, although the differences was not statistically significant. Delay of the average breeding age of S was cumulated over the three-year study. In terminal, the average breeding age of the fifth parity for G was almost equivalent to the age of the fourth parity for S. There were no significant differences in litter sizes throughout the first to fifth parity between G and S. The averages of birth and weaning weight for litters through all parities from G were significantly higher ($P<0.01$) than those from S. The average percentage of weaned piglets against the live born litter size through all parities from G was

Table 2. Reproductive performances in sows under two different housing systems, group pen (G) and

Item	1st parity		2nd parity	
	G	S	G	S
No. of sows	6	5 ^a	6	5
Av. weight at breeding (kg) ¹⁾	123.8 ^A (11.1)	139.4 ^B (10.0)	154.0 (3.8)	168.8 (21.4)
Av. weight gain during gestation (kg) ¹⁾	47.2 (13.4)	32.6 (9.1)	38.2 (1.9)	33.3 (16.5)
Av. breeding age (days) ¹⁾	245.8 (15.8)	274.6 (38.0)	423.7 (10.8)	473.8 (78.2)
Av. litter size (total born) ¹⁾	8.0 (2.4)	8.6 (3.7)	9.7 (0.9)	12.4 (1.1)
Av. litter size weaned ¹⁾	7.8 (2.6)	7.0 (4.3)	8.7 (0.0)	11.4 (1.7)
Av. piglet weight at birth (kg) ¹⁾	1.55 ^A (0.03)	1.15 ^B (0.21)	1.63 ^A (0.00)	1.35 ^B (0.15)
Av. piglet weight at weaning (kg) ¹⁾	7.13 (1.75)	6.31 (1.31)	7.92 ^A (0.11)	5.82 ^B (0.91)
Av. percentage of weaned piglets ²⁾	100.0 (0.0)	81.2 (19.4)	94.3 (9.0)	93.6 (10.8)
Av. interval from weaning to mating (days) ¹⁾	19.5 (8.2)	35.4 (28.1)	11.5 (3.5)	34.0 (45.3)

(): Standard deviation

¹⁾: Values in G through the first to fifth parity were calculated from the number of pens ($n=2$). To-

²⁾: Values in G through the first to fifth parity were calculated from the number of sows ($n=5\sim6$).

^a: One gilt was excluded due to a reproductive disorder.

^b: One sow was excluded due to locomotive defects.

^c: One sow aborted during the fourth gestational period.

^d: One sow was excluded due to being a repeat breeder.

^e: One sow did not return to estrus after weaning of the fourth parity.

^{A,B}: Values with different superscripts within the same row for the same parity are significantly different

^{C,D}: Values with different superscripts within the same row for the same parity are significantly different

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Table 1. Comparison of reproductive traits in gilts under two different housing systems, group pen (G) and individual stall (S)

Item	G	S
No. of gilts	6	6
Age at first estrus (days)	223.7 ± 16.0 ^a	248.2 ± 30.7
Body weight at first estrus (kg)	114.7 ± 10.8	127.7 ± 16.2
Age at first service (days)	245.8 ± 15.8	274.2 ± 32.2
Body weight at first service (kg)	123.8 ± 11.1 ^A	137.2 ± 9.9 ^B
Estrous cycle from first heat to second heat (days)	22.2 ± 0.2 ^A	26.0 ± 3.2 ^B

^a : Average value with standard deviation. Values in G were calculated from the number of pens (n=2).

^{A,B} : Values with different superscripts within the same row are significantly different (P<0.05).

individual stall (S), through the first to fifth parity

3rd parity		4th parity		5th parity		Total	
G	S	G	S	G	S	G	S
6	4 ^b	6	4 ^c	5 ^d	3 ^e	29	21
168.0 (1.4)	179.6 (15.7)	177.5 (8.2)	183.5 (27.2)	191.6 (15.0)	215.3 (29.8)		
35.0 (1.8)	15.7 (26.5)	41.0 (9.0)	40.5 (16.0)	43.8 (5.3)	37.0 (16.6)	41.0 (7.3)	31.7 (17.7)
578.8 (15.8)	634.5 (64.7)	732.3 ^c (15.6)	885.0 ^d (85.3)	890.6 ^c (4.4)	1053.7 ^d (32.5)		
8.3 (2.8)	11.5 (3.1)	9.7 (2.4)	12.8 (5.7)	12.3 (2.4)	10.0 (6.2)	9.6 (2.3)	11.0 (4.1)
7.2 (3.1)	10.3 (3.3)	8.3 (1.4)	9.5 (3.1)	11.5 (2.1)	8.7 (5.5)	8.7 (2.2)	9.4 (3.6)
1.55 (0.01)	1.34 (0.17)	1.55 ^A (0.09)	1.17 ^B (0.28)	1.47 (0.05)	1.75 (0.51)	1.55 ^C (0.06)	1.32 ^D (0.31)
8.04 (0.29)	6.13 (0.93)	7.58 (1.33)	6.09 (0.45)	6.50 (0.70)	8.06 (2.47)	7.43 ^C (0.97)	6.37 ^D (1.34)
93.5 (10.2)	88.4 (7.8)	92.7 (9.0)	83.9 (12.8)	97.6 (5.3)	96.7 (5.8)	95.6 ^A (7.7)	88.2 ^B (13.0)
9.7 ^A (0.5)	95.0 ^B (88.9)	6.3 (0.5)	9.0 (5.3)	6.8 (1.8)	19.7 (14.2)	10.8 ^C (5.9)	41.0 ^D (52.7)

tal values in G were calculated from the total number of pens (n=10).

Total value in G was calculated from the total number of sows (n=29).

(P<0.05).

(P<0.01).

significantly higher ($P < 0.05$) compared to S. The average interval from weaning to mating through all parities was significantly shorter ($P < 0.01$) in G compared to S.

Discussion

In this study, onset of puberty was delayed in gilts housed in individual stalls compared to those in group pens. This finding accords with some earlier reports^{9,11,12}. The first estrous cycle of gilts in individual stalls was also longer than that of gilts in group pens. ENGLAND and SPURR⁴¹ reported that coupling was frequently difficult in individually housed gilts either due to a complete absence or irregular expression of overt estrous signs or an unwillingness to mate. Further, it has been suggested that stress interferes with the normal sexual development and onset of estrus⁹. In this study, delayed puberty in individually stalled gilts was presumably caused by limited exercise in the small stalls, plus added effect of psychological stress arising from individual confinement. In contrast, RAMPACEK *et al.*¹⁵ was of the opinion that confined-induced delayed puberty in gilts was not primarily caused by stress.

In the present study, the average interval from weaning to mating tended to be shorter in sows housed in group pens compared to sows in individual stalls throughout first to fifth parity. Previous studies also reported a similar trend of reduced weaning-to-mating interval in group-housed as opposed to individually-housed sows^{7,16}, although their data was not clear-cut. On the contrary, FAHMY and DUFOUR⁵¹ noted that the weaning-estrus interval was shorter for sows housed individually than those housed in groups.

BARNETT *et al.*²¹ found that individually housed gilts, compared to grouped gilts, tended to suffer from chronic stress. Furthermore, chronic stress has also been found to affect the pituitary-ovarian axis in the gilt⁸ and the sow¹⁰. In the present study, grouped sows

could freely select a comfortable place to rest within the pen, whereas, sows housed in individual stalls were often forced to lie on their own feces and urine even under extreme weather conditions. Moreover, there was no opportunity for individual sows in stalls to huddle, in contrast to grouped sows. Considering these factors, chronic stress in individually stalled sows seems to contribute to the longer period to return to estrus after weaning.

Average piglet weight at birth and at weaning in grouped sows was higher than in individually housed sows through first to fourth parity in this study. ENGLAND and SPURR⁴¹ reported that the average birth weight per pig was significantly higher in group-housed sows than in individually confined sows, but in their study no significant difference was observed in litters from gilts housed under the two confinement systems. MEACHAM and MASINCUPP¹² found a beneficial effect on birth and weaning weight of piglets when the sow or gilt was kept outside during gestation. In the present study, the average weight gain in dams during gestation periods tended to be higher in grouped sows than in individually housed sows throughout first to fifth parity. Thus, improved body weight of piglets in this study could be attributable to superior body conditions of the dams during gestation and also to better milk production in grouped sows.

Average percentage of weaned piglets against live born litter size in this study was higher in grouped sows than in individually housed sows throughout first to fifth parity. BILLE *et al.*³¹ reported that asphyxia during parturition may influence the viability of live-born piglets and that perinatal losses in litters from sows tied up or kept in small boxes was significantly higher than in litters from sows housed in pens during pregnancy. The higher percentage of weaned piglets from grouped sows than in individually stalled sows in this study could be attributable to heavier birth weights.

In the present study, individual cases of both

locomotive defects and abortion were encountered in solitarily confined sows. HALE *et al.*⁶⁾ found a higher percentage of locomotive defects in gilts confined to a restricted area with minimum room for exercise. Locomotive defects in this study could be attributable to uncomfortable residence in individual stalls, resulting in leg weakness during the growing-finishing period. The cause of abortion in this study was not determined. However, MUIRHEAD¹³⁾ had earlier reported that confined sows are dirtier than loose sows and are often forced to lie on their own feces and urine, which can lead to urogenital tract infections and serious losses in reproductive performances.

In summary, the reproductive performances of grouped sows was superior than that of individually stalled sows over the three-year duration of this study. Therefore, stall housing can not be eliminated as a possible deterrent to swine productivity through pre-puberty to reproductive ages. However, our study did not clearly define the psychological effects of individual confinement along with physical distress due to space restriction and their consequence on swine productivity. Further carefully controlled comparative experiments are needed before definite conclusions can be drawn on the best housing system for optimum productivity.

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性成熟前から5産次まで異なる飼養方式を 継続した雌豚の繁殖成績

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同腹の繁殖雌豚を2種の飼養方式で3年間飼育し、発情と産子成績を比較した。12頭のランドレース×大ヨークシャーの雑種雌豚を育成期(平均体重>60 kg)から5回の妊娠・分娩期を通じてストールで単飼または豚房内で3頭ずつ群飼した。各区に同腹豚を無作為に配置し、育成期から発情を毎日調べ、性成熟後2回目の発情および離乳後の初回発情に人工授精または自然交配を行なった。供試豚はすべて、同一の繁殖ステージには同一の飼料を個別給与した。初回発情時の日齢および体重、受胎時の日齢および体重、分娩時の日齢および分娩後の体重、産子数および離乳頭数、子豚の出生時体重および離乳時体重、離乳時の子豚の育成率および離乳後の発情再帰日数について初産から5産まで調べた。平均初回発情日齢は、群飼豚がストール飼育豚よりも24.5日早かった。初回発情から2回目の発情までの平均発情周期は、群飼豚(22.2日)がストール飼育豚(26.0日)よりも有意に短かった($P<0.05$)。初回交配時の平均体重は、ストール飼育豚(137.2 kg)が群飼豚(123.8 kg)よりも有意に重かった($P<0.05$)。平均産子数と離乳頭数は、群飼豚でそれぞれ9.6頭および8.7頭、ストール飼育豚でそれぞれ11.0頭および9.4頭であった。群飼豚の子豚の出生時の平均体重(1.55 kg)はストール飼育豚のそれ(1.32 kg)よりも有意に重かった($P<0.01$)。群飼豚の子豚の離乳時の平均体重(7.43 kg)はストール飼育豚のそれ(6.37 kg)よりも有意に重かった($P<0.01$)。群飼豚の子豚の離乳時の平均育成率(96%)はストール飼育豚のそれ(88%)よりも有意に高かった($P<0.05$)。群飼豚の離乳後の平均発情再帰日数(10.8日)はストール飼育豚のそれ(41.0日)よりも有意に短かった($P<0.01$)。ストール飼育豚では運動器障害と流産の発生が認められた。

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