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A comparison of the behaviour and performance of sows and piglets in crates and oval pens

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Abstract

A comparison was made of sow lying behaviour, piglet aggregation behaviour and performance in crates (no. = 10) and oval pens (no. = 8). Twenty-four hour time-lapse video tapes were made and a farrowing day defined for each sow by noting the 24-h period during which the sow gave birth (09:00 to 09:00 h). Each sow and litter, balanced for parity and time of year, was analysed from 12:00 to 20:00 h during the 24 h immediately following this day. The following analyses were conducted: (1) the number and type of lying behaviour; (2) each litter was scanned every 10 min and at each lying event the number of piglets within 0·3 m of the sow noted; two indices were then calculated, based on the mean of the 10-min scans and the mean for the lying events, for each sow expressed as a proportion of the total litter size. Any dead piglets were removed and cause of mortality established by post-mortem examination. Production data showed that there was no significant difference between litter size at birth and at weaning but overall level of mortality was higher in the pen compared with the crate due to crushing. The majority of crushing events occurred in the first 3 days after farrowing (crate 75%; oval pen 64%). The total number of lying events and related posture changes did not differ between systems; only 'roll-over' events (movement from lateral on one side to the other within 10 s) were higher in the oval pen. There was no difference in the proportion of aggregating piglets at the 10-min scans or the lying events. Increased crushing mortality in the pen does not appear to be due to the aggregation behaviour of piglets but to the increased number of sow roll-over behaviours.

Keywords: *animal welfare, behaviour, farrowing pens, piglets, sows.*

Introduction

Farrowing crates are widely used in commercial practice but restrict sow movement and have received an increasing amount of criticism in recent years due to the perception that such restriction must impair welfare (e.g. Cronin *et al.*, 1991; Lawrence *et al.*, 1994; Arey, 1997; Edwards and Fraser, 1997). Various alternative systems have therefore been developed which are less restrictive for the sow and allow varying degrees of freedom of movement (for recent reviews see Arey, 1997; Edwards and Fraser, 1997). These systems may be divided into group-farrowing systems where sows share a communal area and allow sows to build an individual nest (e.g. van Putten and van de Burgwal, 1990; Baxter, 1991; Houwers *et al.*, 1992; Gotz and Troxler, 1993; Rudd *et al.*, 1993; Arey, 1995; Rantzer *et al.*, 1995; Cronin *et al.*, 1996; Wechsler, 1996) and pen-systems which confine the sows individually (without a common communal area) but allow some restricted freedom of movement (e.g. turn-around crates McGlone and Blecha, 1987; Ottawa crates Fraser *et al.*, 1988; ellipsoid crates Lou and Hurnik, 1994; slope-floor pens Collins *et al.*, 1987; McGlone and Morrow-Tesch, 1990; and farrowing boxes Schmid, 1991). Any replacement to the farrowing crate must provide good welfare for sows, piglets and stock persons and be economically viable.

Various problems have been encountered with both pen and group systems as they may be difficult to manage (e.g. Arey, 1997) or result in high piglet mortality due to crushing (e.g. freedom farrowing: Danske Slagterier, 1993). However there have been some small-scale successes (e.g. Ottawa crates: Fraser *et al.*, 1988; ellipsoid crate: Lou and Hurnik, 1994) but any benefits to the sow must be balanced against the costs to stock persons and piglets (Arey, 1997). Since group-systems introduce added difficulties due to the possibility of social aggression they may not be suitable in all cases particularly where the mixing of unfamiliar animals before farrowing is unavoidable. An individual pen system may therefore provide a necessary compromise solution in providing stock persons with good protection, piglets with an area to avoid sow movements (i.e. being crushed) and the sow some degree of freedom of movement.

In the present study we wished to establish (1) whether an experimental oval pen (which allowed the sow freedom of movement) resulted in a higher mortality compared with the commercial crate (which restricted sow movements) and the reason underlying any increased mortality; (2) when most mortality occurred in relation to age of piglet (in days); (3) whether any differences in rates of mortality were caused by the increased freedom of movement by the sow or differences in the aggregation behaviour of the piglets. This would then allow the possibility of future designs incorporating measures which discourage the performance of any identified high risk behaviours.

Material and methods

Subjects and dry-sow accommodation

A total of eighteen Large White × Landrace sows held in a 50 sow herd at the Pig Unit at the University of Cambridge were farrowed in crates and oval pens. Ten sows were farrowed in crates (mean parity: 2·88, s.e. 0·44) and eight were farrowed in the oval pens (mean parity 3·14, s.e. 0·59). Apart from three gilts (two farrowed in crates, one in the oval-pens) all sows had prior experience of farrowing in crates. Sows were previously held in equal numbers either in an indoor group system with Electronic Sow Feeder or in an outdoor group system with individual feeding stalls. The indoor herd consisted of 25 sows housed with a strawed lying area (7·5 m × 5·5 m) and a dunging area (9·0 m × 5·5 m). Part of the dunging area was occupied by an Electronic Sow Feeder in which the sows were given food (Dalgety Ultrabreed 16 nuts) one at a time from 05:00 h; water was available from nipple drinkers and a trough. The housing system was ventilated and lit by natural and artificial light. The dunging area was cleaned daily and straw was regularly added to the lying area. The second group of 25 was housed outdoors with a covered strawed lying area (10 m × 6 m), adjacent feeding area with individual feeding stalls (10 m × 6 m) and two rooting fields (each *ca.* 150 m × 25 m). Sows were given food daily from individual stalls adjacent to the lying area at 08:00 h; water was available from two troughs. Sows were removed from the herd for service and returned the same day.

Farrowing accommodation

The crate farrowing house contained 12 tubular metal commercial crates on a concrete floor each with trough and water drinker to the front and heated creep to the front-side. The oval pen house contained two individual oval-shaped pens also on a concrete floor with solid sloping sides and individual trough and water drinker. The solid sloping sides of the oval pen terminated 20 cm above a concrete floor allowing piglets to escape sow movements which could have trapped them against a solid wall. The solid wall and slight slope allow the sow greater control when lying down (Baxter, 1991). Each oval pen which was made large enough for a sow to turn around and change posture easily, stood within a 1·5-m high solid walled rectangular area (2·4 m × 2·0 m) with attached heated creep (see Figure 1). This

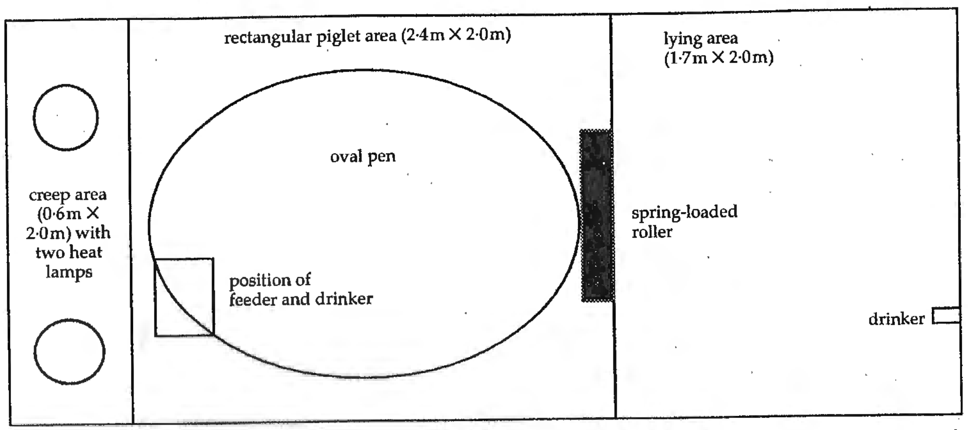

Figure 1 Overview (drawn to scale) of the oval farrowing pen showing piglet creep area, rectangular piglet area (to which sow did not have access), oval pen (where sow farrowed) and lying area (to which sow may exit by depressing spring-loaded roller, but not her piglets until 9 days of age).

was similar to a Canadian design (Lou and Hurnik, 1994). A spring-loaded roller could be depressed to a height of 20 cm to allow the sow to exit to an individual lying area (2·0 m × 1·7 m) where the sow was contained by solid vertical bars with water drinker; this roller returned to a height of 30 cm when not depressed to prevent the piglets leaving the home area until about 9 days of age. This was similar to Dutch designs (Houwers *et al.*, 1992). The sow could choose to access the lying area at any time (including the period of farrowing) although there were no instances of the sow farrowing in this area. Sows were taken in equal number from the indoor system and outdoor group system and entered the farrowing accommodation 5 days before the farrowing date (half farrowed August to November 1996 and half April to July 1997). Feeding was manual twice daily at 08:00 and 15:00 h. Crates and pens were cleaned out and shavings (or straw in the oval pen) added daily. Weekly temperature records were taken in both buildings using a standard mercury maximum/minimum thermometer.

Production performance

On the morning following parturition, litter size, composition and birth weights were recorded. Piglets were teeth-clipped and iron injected within 48 h *post partum*. Piglets were fostered on/off in the first 24 h to standardize litter size, maximize production and preserve piglet welfare. Note was also made of litter size at the end of the 1st day following farrowing (including piglets fostered on/off), after week 1 and at weaning. After farrowing, any dead piglets were removed, weighed and the cause of death estimated from external observation, classified as crushings and others (all of which were live born); date of death was also noted. Subsequent *post mortem* allowed final primary cause of death to be ascertained. Crate piglets were weaned on day 24 ± 3 days; oval piglets were weaned at day 23 ± 2. Production parameters were compared using a Mann Whitney U-test.

Sow and piglet behaviour

Twenty-four hour time-lapse video tape recordings were made of the period immediately during and after farrowing. The time taken to farrow tends to differ for individual sows and any analysis of behaviour during farrowing will be affected by the length of time an individual takes to give birth. A designated farrowing day was therefore established for each sow by noting the 24-h period during which the sow gave birth (from 09:00 to 09:00 h). Each sow and litter was then analysed from 12:00 to 20:00 h during the 24 h immediately following this designated farrowing day. The following analyses were conducted. (1) The number and type of each lying event and lying-related posture change was noted: lie sternal, lie lateral, lie sternal move to lateral, lie lateral move to sternal, roll over, sit move to lie. In the oval pen system only the time the sow spent in the pen with her piglets was analysed (since piglets had no access to the lying area and could therefore not be at risk of being crushed. (2) Each sow was scanned every 10-min in the oval pen system and the mean proportion of time the sow spent in the lying area was calculated (no lying area was available in the crate condition). (3) Each litter was scanned every 10-min and the number of piglets within 0·3 m of the sow noted, expressed as a proportion of the total litter size and an index was calculated for each sow based on the mean for all scans. The litter was recorded as greater than 0·3 m from the sow when she was in the lying area; during this period the piglets could not be harmed by the sow. (4) At each lying down event and lying-related posture change the number of piglets within 0·3 m of the sow was noted expressed as a proportion of the total litter size and an index was calculated for each sow based on the mean for all lying down and lying-related events. Sow lying down behaviours and piglet aggregation behaviour were compared using a Mann Whitney U-test.

Results

Table 1 shows there was no significant difference in sow parity between systems and litter size at birth did not differ between systems (although mean litter size was on average one piglet greater in the crate than in the oval pen — mean litter size at birth for crate: 12·00 (s.e. 0·93); for oval pen: 11·00 (s.e. 1·18)). Although not significantly different between systems more piglets were fostered off in the crate (mean of 1·2) and more were fostered on in the oval pen (mean of 1·12). There were no significant differences between litter size at day 1, day 7 or at weaning (median litter size (and range) for crate: 10·50 (8 to 12); oval-pen: 10·00 (8 to 11); U = 29·00; $P > 0·05$).

Total piglet mortality was significantly higher in the oval pen compared with the crate (median total mortality (and range) for crate: 0·50 (0 to 2); oval pen: 2·00 (0 to 4); U = 16·00; $P < 0·05$), the majority of which was due to crushing which was significantly higher in the oval pen (median mortality due to crushing (and range) for crate: 0 (0 to 1); oval pen: 2·00 (0 to 3); U = 9·00; $P < 0·01$) Weights in the oval pen were generally higher but this could be expected because of a smaller litter size due to higher mortality.

Table 2 shows the number of live-born piglets which died either due to crushing or other causes (e.g. starvation or splay-legged) in relation to days after farrowing. There were no stillbirths in either condition as post-mortem analysis of dead piglets

Table 1 Comparison of medians and ranges for parameters (sow parity, litter size, piglet losses and weights) for crate (no. = 10) and oval pen (no. = 8) litters

	Crate		Oval pen			
	Median	Range	Median	Range	U	P-value
Parity	3·00	1-5	3·00	1-6	30·0	0·61
Litter size (no. of piglets)						
No. at birth	12·50	7-15	11·00	6-15	32·50	0·49
No. fostered on	0·00	0-3	0·00	0-4	31·50	0·34
No. fostered off	0·00	−5-0	0·00	−2-0	28·00	0·18
No. at end day 1 (including fosterings)	11·00	9-14	12·00	10-15	33·50	0·55
No. at day +7	10·50	8-12	10·00	8-13	33·00	0·53
No. at weaning	10·50	8-12	10·00	8-11	29·00	0·31
Losses (no. of piglets)						
Total	0·50	0-2	2·00	0-4	16·00	0·03*
Others	0·00	0-2	0·00	0-2	38·50	0·86
Crushed	0·00	0-1	2·00	0-3	9·00	0·005**
Weight (kg)						
Birth	1·43	1·14-1·72	1·42	1·18-1·70	38·50	0·89
Week 1	2·65	2·30-3·48	3·04	2·37-3·35	19·00	0·46
Week 2	4·55	3·56-5·97	5·36	5·00-5·64	26·00	0·06
Week 3	6·61	4·82-8·85	6·88	5·35-7·99	32·00	0·77

Table 2 Number of live-born piglets killed through crushing by their mother and 'other' causes in relation to days after farrowing for crate (no. = 10) and oval pen (no. = 8) litters

	Day							
	+1	+2	+3	+4	+5	+7	+9	+10
Crate: crushed	1	1	1	0	0	0	1	0
Crate: other	0	4	0	0	0	0	0	0
Oval: crushed	7	2	0	2	0	0	1	2
Oval: other	0	0	1	1	0	1	0	0

showed evidence of all piglets having breathed and/or sucked. The majority of piglets crushed by the sow were within 3 days of farrowing (crushed, crate: 75%; crushed, oval pen: 64%). Within 48 h, 50% of all crushings had occurred in the crate and 64% in the oval pen. Three piglets were crushed in the oval pen after day 7 and only one in the crate. In the oval pen, piglets tended to be more susceptible to crushing later in the post-farrowing period (in the crate there was only one case of crushing after day 3).

The total number of sow lying events and related posture changes on the day after farrowing did not differ between the two systems (Table 3). Only the number of 'roll-over' events (movement from lateral

Table 3 Comparison of medians and ranges for (a) number of lying events or lying-related posture changes; (b) indices of proportion of piglets within 0·3 m of their mother for all 10-min scans and at lying events or lying-related posture changes for crates (no. = 10) and oval pens (no. = 8)

	Crate		Oval pen			
	Median	Range	Median	Range	U	P-value
(a) No. of lying/posture changes						
lie sternal	0·00	0-5	1·00	0-5	37·00	0·77
lie lateral	1·50	0-4	2·00	1-3	30·00	0·35
lateral to sternal	0·00	0-3	0·00	0-2	36·50	0·71
sternal to lateral	1·50	0-6	1·00	0-6	30·00	0·36
roll over	0·70	0-4	1·50	0-6	17·00	0·03*
sit to lie	0·00	0-4	0·00	0-0	32·00	0·19
total	7·00	1-16	7·50	3-15	34·50	0·62
(b) Proportion of piglets						
at 10-min scans	0·47	0·21-0·97	0·69	0·47-0·87	31·00	0·42
at lying and related postures	0·34	0·10-0·63	0·42	0·12-0·73	21·00	0·25

on one side to the other within 10 s) were significantly greater in the oval pen (median number of roll-over events (and range) for crate: 0·70 (0 to 4); oval pen: 1·50 (0 to 6); U = 17·00; $P < 0·05$). This movement was restricted by the confines of the crate (and rarely performed) but in the oval pen the sow was free to roll from side to side in a sudden movement exposing piglets to a greater likelihood of being crushed. Sows in the oval pen system spent a mean of 10·12% (s.e. 5·43) of their time in the lying area. There was no difference in the aggregation behaviour of piglets in relation to the sow either at 10-min scans or at lying and lying-related posture changes in the two systems. There was no significant difference in mean temperatures between buildings (mean range 9 to 18°C).

Discussion

The fact that the crate severely restricts movement and therefore impairs the welfare of the sow is now accepted by many researchers (e.g. Arey, 1997; Edwards and Fraser, 1997). A number of systems which reduce confinement of the farrowing sow have therefore been investigated often with promising initial results (Edwards and Fraser, 1997). For example an ellipsoid crate design which allowed the sow to turn around (Lou and Hurnik, 1994) showed similar levels of mortality amongst the piglets born alive when compared with the conventional crate (crate: 15·0%; ellipsoid crate: 15·4%). Lou and Hurnik (1994) divided the space requirements of sows into static and dynamic. Static space requirements are simply based on the sow's physical body dimensions; dynamic space is determined by the individual behaviour patterns of the sow that are considered. Thus the amount of dynamic space that should be provided for a sow depends on what kind of behavioural activities the sows are allowed to perform (Lou and Hurnik, 1994). The oval pen in the present study was also ellipsoid in shape and allowed the sow freedom of movement and was designed with a dynamic space limit to accommodate a sow's circling action and nest-building activity (Lou and Hurnik, 1994).

There was no difference in overall litter size in the oval pens at the end of day 1 (following fosterings) at day 7 or at weaning when compared with crates. Mean weekly weights of piglets also did not differ between systems. A slight tendency for a higher weight of piglets at week 2 in the oval pen could be explained by the increased mortality in this system. The higher mortality in the oval pen is consistent with results from numerous other studies which have involved different types of farrowing pens (e.g. Aherne, 1982; Svendsen *et al.*, 1986; McGlone and Morrow-Tesch, 1990; Cronin and Smith, 1992; Blackshaw *et al.*, 1994). While most crushing occurred shortly after farrowing, three times more crushings occurred after the 1st week in the oval pen compared with the crate. It is unsurprising that piglets were most susceptible to crushing in the first 48 h following parturition since this is when piglets spend considerable time near the udder in order to ingest colostrum and keep warm. The newborn piglet has difficulties thermoregulating (Mount, 1972) and has very low energy reserves which are rapidly depleted (Stanton and Carroll, 1974). Piglets may soon become weak through starvation and less able to avoid the restless movements of the sow (English and Smith, 1975). This period immediately following farrowing is therefore crucial; overall survival of piglets may result not only from how the sow lies down but also where she lies in relation to her piglets (Schmid, 1991; Schmid and Hirt, 1993). It is crucial to the future design of a successful alternative system to establish the underlying cause of this increased crushing mortality.

When given a choice to access a lying area in the oval pen sows chose to spend 10·12% of their time in this area during which time piglets were not in danger of being crushed (as they could not gain access to the lying area). Since in this system only the time the sow spent in the pen with her piglets was analysed the number of lying and related events was based on a mean of 89·88% of the total daily time budget (in contrast to 100% for crates). However there was no overall difference in the number of lying events analysed for the two systems but crucially the specific type of lying events was found to differ with more roll-over events (movement from lateral on one side to the other within 10 s) being performed in the oval pen. This roll-over movement was restricted by the confines of the crate (and rarely performed) but in the oval pen the sow was free to 'roll' from side to side in a sudden movement thus exposing piglets to a greater likelihood of being crushed. This finding supports the results of Weary *et al.* (1996) who found that of 22 observed crushings in an open pen, six occurred when the sow lay down from a standing position while 13 occurred when the sow rolled over. Crushing by the sow has been found to be a problem in many of the open-pen free-farrowing systems so far developed (e.g. Nielsen, 1980; Svendsen *et al.*, 1986).

Another potentially important factor which has received attention recently and may influence piglet mortality is the behaviour of piglets (e.g. Bryant *et al.*, 1983; Blackshaw *et al.*, 1994; Cronin *et al.*, 1996). In the present study we specifically investigated how piglets chose to aggregate in relation to their mother since this may affect their likelihood of being crushed. While these behaviours may be potentially affected by the temperature in the farrowing accommodation overall room temperature effects did not differ and both systems contained the same heating systems of heat lamps with clean dry wood shavings. Thus effects of temperature were unlikely to have differed between systems and this is supported by the finding that the proximity with which piglets aggregated in relation to their mother did not differ between the two systems. Blackshaw *et al.* (1994) compared piglet behaviour in a farrowing crate and pen and found piglets spent a similar amount of time resting at the udder in both systems (although piglets rested in the pen area nearly three times as long as in the farrowing crate).

Finally it appeared more difficult to catch piglets and gain access to the sow in the oval pen compared with a commercial farrowing crate (which is consistent with the finding of Lou and Hurnik (1994) for the ellipsoid crate) but these factors were not quantified. In future studies it will therefore be important to quantify stockperson input and access. While there have been some recent studies of pig-stockperson interaction (e.g. Hemsworth *et al.*, 1994, 1996a and b) further research is needed to establish methods which allow assessment of the welfare of the stockperson. In the long run there is little point in designing a viable commercial system (in terms of good sow welfare and low piglet mortality) if this system is then economically compromised by management difficulties.

In conclusion while the oval pen allowed sows freedom of movement this resulted in increased piglet mortality due to crushing. The majority of this mortality in the pen occurred early in the farrowing period but not exclusively so as some piglets were crushed after the 1st week. Crushing was greater in the pen as a result of the increased freedom of movement of the sow and specifically the increased number of roll over events performed by the sow (not because of differences in the aggregation behaviour of piglets). Future modifications to the pen should therefore seek to decrease the frequency of performance of these sudden roll over events.

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