Australian Government
Department of Agriculture

AUSTRALIAN Pork

A Comparison of Sow and Piglet Behaviour and Productivity in the UMB Farrowing Pen Compared to Conventional Farrowing Crates

Final Report
APL Project 2010/1002.387

November 2011

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Acknowledgements – by Dr Greg Cronin (Honours Supervisor), University of Sydney

I am grateful to Australian Pork Limited for providing the operating funds for this Honours research project at the University of Sydney, Faculty of Veterinary Science, Mayfarm pig unit, Camden NSW. The project was conducted by Ms Rebecca (Bec) Matthews as the research component of her Honours studies for the Animal and Veterinary Bioscience degree. Bec has worked tirelessly on this project, and I hope her love of pigs manages to keep her involved with the pig industry / pig research in her future career. The Australian pig industry would benefit from her talents as an animal scientist.

Mr Greg Macnamara (Piggery Manager, University of Sydney, Camden) and Mr Ben Macnamara were also instrumental in the successful completion of the project; many thanks to Greg and Ben. In addition, thanks must go to Associate Professor Peter Thomson for his advice and assistance with the statistical analyses.

Finally, this project could not have occurred except for the generosity of Associate Professor Inger Lise Andersen and Professor Knut Bøe from the Norwegian University of Life Sciences. Both scientists are internationally recognised for their applied research to develop and improve farrowing pen design for reduced piglet mortality and improved sow welfare. I would like to acknowledge the very generous gift by these researchers to the University of Sydney, of four prototype UMB farrowing pens in June 2010. This wonderful gift has enabled the University of Sydney to become an active researcher and educator in non-crate farrowing/lactation systems for pigs.

This project is supported by funding from Australian Pork Limited and the Department of Agriculture.

Honours Project Report - A Comparison of Sow and Piglet Production in a Prototype Non-Crate Farrowing Pen and a Conventional Farrowing Crate

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Abstract

Concern over the welfare of sows housed in conventional farrowing crates around parturition and during lactation has been a driver for the pork industry to seek new non-crate alternatives. This experiment investigated one such alternative system, the prototype UMB farrowing pen, and compared sow and piglet productivity with that achieved in the conventional farrowing crate. Thirty-two sows in four replicates of eight sows were included in the comparison, with four sows in crates and four sows in UMB pens per replicate. The number of piglets born and weaned was recorded, and the causes of piglet mortality were assessed by post-mortem examination. Sow voluntary feed intake was measured from Day 7 to 21 of lactation, with sow feeding behaviour and the frequency of nursing bouts measured from video records on Days 7, 14 and 21. Piglet body weight was measured on Days 1, 7, 14, 21 and at weaning (about Day 25). There was no significant difference in sow voluntary feed intake between the crate and UMB pen treatments (8.02 vs. 8.43 kg/day; $P > 0.05$). Piglets in crates had a higher daily weight gain than piglets in UMB pens (240 vs. 219 g/day; $P = 0.022$), as well as more nursing bouts on Day 21 (28 vs. 24 bouts; $P = 0.018$). However, there was no difference in estimated piglet weight at Day 30 (8.73 vs. 8.01 kg; $P > 0.05$). Stillbirth rate tended to be higher in the crates than UMB pens (6.2 vs. 2.3% of total born; $P = 0.056$) and pre-weaning piglet mortality did not differ between the treatments (18.6 vs. 20.2% of born alive; $P > 0.05$). While this research commenced with the researchers having less than nine months experience of managing sows and litters in the UMB housing system, the results are encouraging. Further investigations are clearly warranted to improve aspects of the pen design and the management of ambient temperature in the pen system, as these factors probably influenced a number of productivity variables.

Introduction

In recent decades, the standard of farrowing accommodation for sows around parturition and during lactation has become an increasingly controversial issue in Australia and around the world (Barnett *et al.* 2001). Conventional farrowing crates have long been the preferred form of farrowing accommodation in commercial piggeries, on the basis that piglet mortality and morbidity due to overlying by the sow (crushing) were decreased (Weber 1997; Weber *et al.* 2007). However, the restrictive conditions imposed on the sow by the farrowing crate around parturition and during lactation raise significant welfare concerns for the behavioural, physiological and social needs of the sow (Vosough Ahmadi *et al.* 2011).

In the days preceding parturition, it is common for sows in the wild to travel distances of up to 6.5 km to locate a safe nesting site for parturition (Wischner *et al.* 2009). Once the nest site is selected, pregnant gilts and sows are instinctively motivated to scrape a depression in the ground, gather nesting materials and construct a nest in preparation for the birth of their litter (Damm *et al.* 2003; Wischner *et al.* 2009). In contrast, conventional farrowing crates limit the space available to the sow for ambulation and nesting materials are not provided. Thus, the performance of 'natural' behaviour is inhibited, which under the Five Freedoms Concept for guaranteeing animal welfare, raises a potential welfare concern (Webster 2001). Several studies report that sows housed in farrowing crates, compared to loose or pen farrowing systems, experience physiological and behavioural stress responses, and can develop unfavourable maternal behaviours, indicating that sow welfare is compromised in a farrowing crate system (Lawrence *et al.* 1994; Jarvis *et al.* 1997; Jarvis *et al.* 2002; Damm *et al.* 2003). In spite of these concerns, producers ultimately require a farrowing system that will offer optimal sow and piglet productivity to ensure their enterprise is economically viable. Productivity measures such as litter size, piglet growth and piglet survival are important, as the number of piglets weaned is a major determinant of enterprise profitability. Although most comparative studies of farrowing pens and crates have reported poorer piglet survival in pens (for a recent review see Baxter *et al.* 2011), the data-mining analysis by Weber *et al.* (2007) involving production records from more than 800 piggeries in Switzerland found that there was no significant difference in piglet mortality between farms using farrowing pen and farrowing crate systems. This suggests that the supposed need to restrain sows in crates during farrowing and lactation may be redundant, and that it may in fact be feasible to consider less restrictive farrowing systems for commercial use. Over recent years, a considerable amount of research has focused on developing alternative non-crate farrowing systems, which are intended to promote sow and piglet welfare, whilst sustaining optimal livestock productivity.

This experiment aimed to evaluate the effect of the farrowing/lactation environment on sow and piglet productivity by comparing two farrowing systems, the prototype UMB farrowing pen and the conventional farrowing crate, on sow feeding behaviour and intake, suckling behaviour, and piglet survival and growth to weaning. The prototype UMB farrowing pen is a Norwegian design derived in part from an earlier system, the Werribee farrowing pen (Cronin *et al.* 2000). The UMB farrowing pen is comprised of a nesting area and an activity area (Photo 1 and Figs. 1a and 1b), offering the sow space for movement, as well as incorporating several design attributes that promote piglet survival. Farrowing pen systems need to be profitable in order to be considered as a commercially viable option in the pork industry. Therefore, this study focused on sow and piglet productivity, in particular sow feed intake and piglet growth and survival, to establish whether performance differed in the non-crate farrowing/lactation environment compared to conventional crates.

Photograph 1: Sow in a prototype UMB farrowing pen with 5-day-old litter, at the Mayfarm Pig Unit Camden. The sow is lying on the sow zone and the piglets are in the heated piglet zone (see Figure 1a). Note, the 'pop-hole' on the right end of the piglet barrier is open, providing access for the piglets between the nest and the non-nest areas.

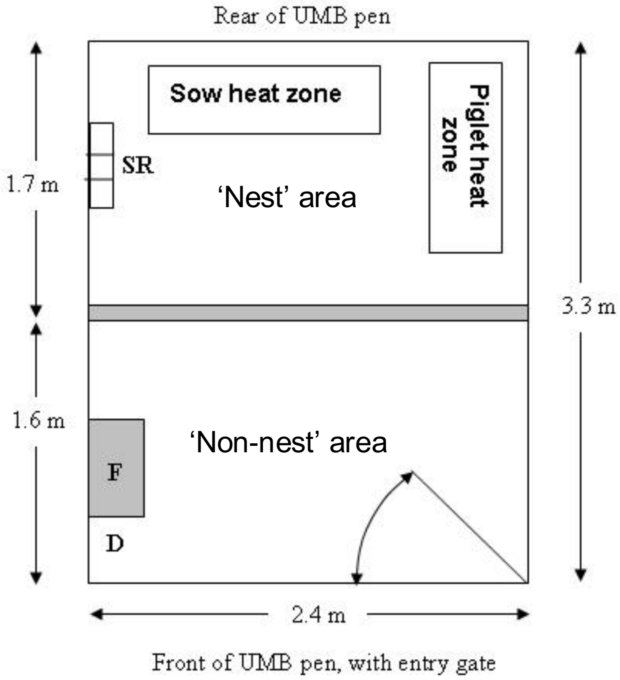

Figure 1a: Schematic floor plan of the UMB farrowing pen with measurements. The thick grey line indicates the position of the 280 mm high piglet barrier with inward-curled top (90 mm diameter curl) which separates the upper ("nest" area) and lower ("non-nest") area. The piglet barrier also contains a 'pop-hole', which once opened, enables piglets to move between the two areas. The floor slopes from the rear to the front of the pen. The floor in the nest area is covered by a rubber mat.

F = sow feeder
D = sow and piglet drinker
SR = straw rack

The sow and piglet heat zones measure 1.2 m x 0.5 m. Heat is generated electrically via wire grids about 20 mm below the surface of the concrete. The heat output from the two heating zones is controlled independently by two thermostats, one in the floor adjacent to the heating wires and the other in a control box above the pen. The heat wire grids sit above polystyrene insulation panels in the concrete.

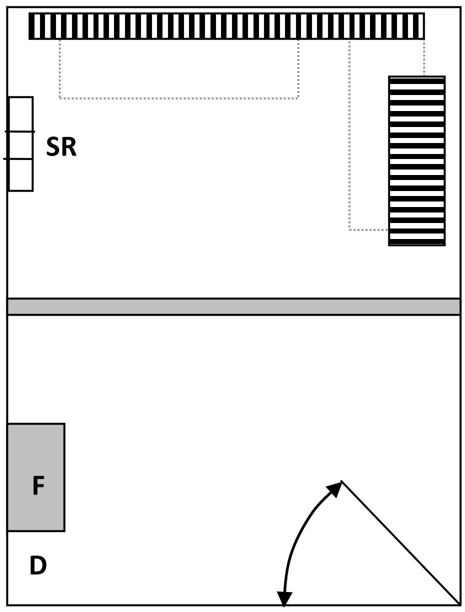

Figure 1b: Within the "nest" area, the heavy striped rectangles represent the positions of the two sloping panels, which assist sow posture changing behaviour and are piglet safety zones on the pen periphery.

Straw (or hay) is provided for the sow in the straw rack. It is especially important that the sow has straw available during the day before farrowing. About 20 litres of wood shavings (2 buckets) was also spread on the floor surface of the nest area before the sow entered the pen.

Materials and Methods

Animals and Treatments

Thirty-two breeding herd sows were selected for this experiment, which was conducted over four replicates with eight sows per replicate, at the University of Sydney, Mayfarm piggery, Camden. The experiment was conducted between April and September, 2011, under approval of the University of Sydney Animal Ethics Committee. In each replicate of the experiment, four sows were randomly allocated to be housed in UMB farrowing pens and four in conventional farrowing crates. Sows were introduced into their allocated farrowing treatment approximately 107 days after mating, and remained there until weaning at about Day 25 of lactation. The farrowing crates and UMB pens were located in adjacent rooms. However, the farrowing crate room was fully insulated and heated to suit the thermal requirements of piglets, whereas the four UMB farrowing pens had been constructed in a room which was used to house breeding boars and dry sows, was poorly insulated and had an open ridge vent.

Farrowing crates measured 2.2 m in length and 1.68 m in width in total, however the sow was restricted to a 0.65 m wide stall and the remaining area was allocated as a piglet creep zone (Fig. 2). The farrowing crates had fully slatted metal floors, and the piglet creep zone included a heating mat on top of the metal floor, which was located beneath a heat lamp. No bedding material was provided in the crate treatment.

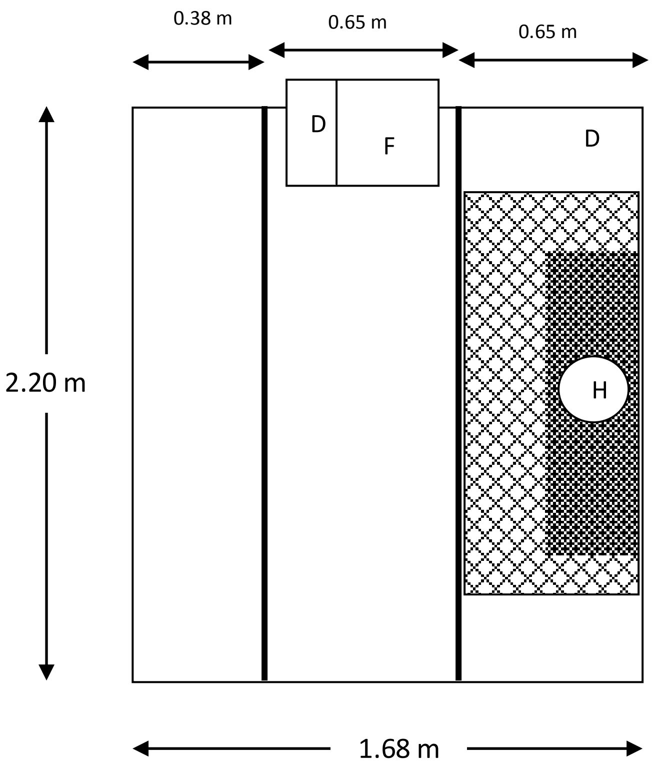

Figure 2: Floor plan of the conventional farrowing crate, with measurements.

D: sow and piglet drinkers
F: sow feeder
H: overhead piglet heat lamp

The larger cross-hatched area represents solid (plastic) floor forming the piglet creep area. A heated panel (represented by the darker, close-hatched area) was on top of the solid plastic floor to provide additional heat for the piglets.

The prototype UMB farrowing pens consisted of two areas; the 'nest' area and the 'non-nest' (dunging and activity) area (Fig. 1a & b). The two areas were separated by a 28 cm high metal barrier so that piglets remained in the nest and the sows were able to exit the nest to eat, drink, defecate and urinate by stepping over the barrier. After approximately four days, a pop hole in the barrier was opened so that piglets could also move between the nest and the non-nest areas. The floor of the nest area consisted of a rubber mat over a concrete floor that sloped towards the non-nest area. Approximately 20 mm below the surface of the concrete there were two thermostatically-controlled heat panels, which were independently controlled to regulate floor-surface temperature in two zones: the sow-zone and the piglet-zone (Fig. 1a). Leading up to and during parturition, both the sow and piglet zones were set to 34°C. The day after farrowing, the sow zone thermostat was reset to 20°C. About seven days after farrowing, the piglet zone thermostat was reset to 30°C. The UMB pens also included a straw dispenser so that the sows were able to gather bedding material for nest-building prior to farrowing. Approximately 20 litres of wood shavings (2 standard buckets) was spread on the floor of the nest area before the sow was introduced to the pen. Two of the walls surrounding the nest area had sloping panels to assist sows when lying down as well as providing a safety zone for piglets in the gap underneath. The non-nest (dunging and activity) area comprised sections of solid concrete and slatted metal floor for ease of cleaning.

Husbandry and Management
Sows and litters were checked daily for health and were fed once daily around 0800 h. Prior to farrowing, sows were fed 2.5 kg per day of a pelleted commercial lactating sow diet containing 12.8 MJ DE (digestible energy) and 0.46 g/MJ of digestible lysine. Water was continuously available via a bite drinker. After farrowing, the amount of sow feed offered was increased so that from Day 4 of lactation, sows had *ad libitum* access to the lactation diet. Piglets were weaned at about Day 25 of lactation. Pens and crates were cleaned daily, and soiled bedding in the UMB pen system was removed and replaced as required with fresh material. After parturition, additional straw was generally not added to the straw racks as the sows tended not to utilise the straw.

A minimum-maximum thermometer was positioned in each room against the common wall between the rooms, 1.6 m above floor level. The minimum and maximum ambient temperatures from the previous 24 h were recorded in the UMB pen and crate rooms every morning.

Video Monitoring
Video cameras (LIRBIS Series Color Camera, GeoVision, Clayton Victoria) with wide-angle lenses were positioned above each pen and crate to enable continuous recording of sow and piglet behaviour during farrowing and lactation. In each replicate, the total number of times the sows fed (defined as head in the feeder), the duration that each sow spent with the head in the feeder, as well as the total number of nursing bouts were collated from the digital video record (MSH Video System, Latvia) for 24-h periods on Days 7, 14, and 21 of lactation. Although a feeding bout was defined as the head in the feeder for both treatments, the crate design included the drinker in the feeder, making it difficult to distinguish the duration of eating and drinking from the video records in the crate treatment. Due to time limitations, sow and piglet behaviour observations could not be collated for replicate 4.

Sow Feed Trial
On Day 7 of lactation sow feeders were emptied. Thereafter until Day 21 of lactation, all amounts of feed that were added to the feeders were weighed (Wedderburn Scales, Ingleburn NSW) and recorded. Each sow was allocated a separate feed storage bin so that pre-weighed amounts of feed could be stored for ease of sow feeding by piggery stockpeople throughout the 14-day trial. If the

storage bins required re-filling during the trial, the added feed was weighed and the weight recorded in a logbook. Voluntary sow feed intake was calculated from the total amount of feed added to the bins, less feed refusals, that is the weight of uneaten feed in the sow feeders and storage bins on Day 21.

Piglet Body Weight, Growth and Production

Litters of piglets were weighed on Days 1, 7, 14, 21 and at weaning using platform scales (Wedderburn Scales, Ingleburn NSW). Average piglet weight gain per day was then calculated. If piglets were weaned prior to Day 30, an estimated litter weight for Day 30 was calculated based on the Day 21 and weaning weights, using a linear trend line model in Microsoft Office Excel. The cause of piglet mortalities was assessed by post-mortem examinations.

Statistical Analyses

The treatment was the farrowing accommodation (UMB pen vs. crate), and the differences in productivity measures were determined using analysis of variance (ANOVA), with replicates in time as the blocking structure (GENSTAT 13th edn, VSN International, Hemel Hempstead, UK). The experimental unit was the individual litter. A logistic regression was also used to analyse piglet mortality considering litter size in the two treatments (GENSTAT 13th edn, VSN International, Hemel Hempstead, UK). The statistical program R was used to conduct a Fisher's Exact test for count data to analyse the distribution of causes of piglet mortality in the two treatments (R Development Core Team (2010). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria).

One sow in the UMB farrowing pen treatment in replicate 3 became ill soon after parturition, and despite veterinary treatment developed mastitis and her milk production declined. The sow's piglets received insufficient milk from the sow, and the decision was made to foster them to a non-experimental sow in a crate. The data for this sow and litter were omitted from the experiment and were replaced as a missing value in the ANOVA. Another sow, in the crate treatment in replicate 3, continually tossed her feed out of the feeder. Thus, it was not possible to measure her feed intake accurately and the data were omitted from the sow feed trial and video observation analyses, and replaced as a missing value in the ANOVA. However, the piglet production and mortality data from this litter were included in the statistical analysis of the experiment.

Results

Daily Mean Minimum and Maximum Ambient Temperatures

The daily mean minimum and maximum ambient temperatures in the UMB pen room and the crate room are presented in Table 1. As shown in Table 1, the mean minimum temperature in the UMB pen room was consistently lower than the temperature in the farrowing crate room.

Table 1: Comparison of the daily mean minimum and maximum ambient temperatures in the conventional farrowing crate room and the UMB farrowing pen room during the four replicates of the experiment.

	Room	Minimum (°C)	Maximum (°C)
Replicate 1 (April)	Crates	19.9	23.8
	UMB Pens	16.7	22.8
Replicate 2 (June/July)	Crates	17.1	23.3
	UMB Pens	12.4	19.9
Replicate 3 (July/Aug)	Crates	16.0	23.6
	UMB Pens	12.5	19.7
Replicate 4 (Aug/Sept/)	Crates	16.3	22.1
	UMB Pens	15.7	24.4

Sow Feed Trial

Although sow feed intake per day was higher in the UMB than crate treatment, the difference was not significant ($P > 0.05$; Table 2). The mean feed intake per day for sows in the UMB farrowing pens was 8.43 kg compared to 8.02 kg in the farrowing crates. On Day 7, sows in the UMB pens had significantly more feeding bouts than sows in the crates ($P = 0.043$; Table 2). However, there were no differences between the UMB pens and crates in the number of sow feeding bouts on Days 14 and 21 ($P > 0.05$; Table 2). On Day 21, sows in the crates spent a significantly longer duration at their feeder than did sows in pens ($P = 0.019$; Table 2). There were no differences between the UMB pens and crates in the duration spent at their feeders on Day 7 and Day 14 ($P > 0.05$; Table 2).

Table 2: Comparison of mean sow feeding behaviour, sow feed intake and piglet suckling measures in conventional farrowing crates and UMB farrowing pens. Measurements were recorded from midnight for 24 h on each observation day.

Variable	Units	Crates	UMB Pens	P-value
N sows		11	11	
Sow feed intake per day	kg	8.02	8.43	0.402
No. of sow feeding bouts Day 7		9.92	13.42	0.043
No. of sow feeding bouts Day 14		10.06	10.72	0.661
No. of sow feeding bouts Day 21		10.58	12.24	0.396
Duration at feeder Day 7	min	14.35	10.43	0.060
Duration at feeder Day 14	min	17.2	11.4	0.072
Duration at feeder Day 21	min	22.8	11.6	0.019
No. of nursings Day 7		29	27	0.091
No. of nursings Day 14		29	27	0.234
No. of nursings Day 21		28	24	0.018

Piglet Body Weight and Growth Rate

While there was no difference in mean live weight of piglets at birth, there was a significant difference in daily weight gain per piglet between the UMB farrowing pens and the conventional farrowing crates ($P = 0.022$; Table 3). Piglets in the UMB pens gained an average of 219.3 g per day, whereas piglets in the farrowing crates gained an average of 240.3 g per day. On Day 21, piglets in crates were recorded to have more nursing bouts than piglets in the pens ($P = 0.018$; Table 2). There was no difference in the number of nursing bouts between UMB pens and crates on Day 7 and Day 14 (P > 0.05; Table 2). Despite this, there was no significant difference regarding the estimated mean piglet bodyweight at Day 30 between the two treatments (P > 0.05; Table 3).

Table 3: Comparison of mean productivity variables in conventional farrowing crates and UMB farrowing pens.

Variable	Units	Crates	UMB Pens	s.e.d.	P-value
N sows		16	15		
Sow parity		2.5	2.0	0.28	0.086
Piglet production/litter					
• total born (TB)†	piglets	13.1	11.6	1.32	0.282
• born alive (BA)	piglets	12.2	11.3	1.22	0.462
• stillborn	piglets	0.81	0.27	0.31	0.092
• pre-weaning deaths of BA	piglets	2.25	2.34	0.784	0.907
• weaned	piglets	9.75	8.86	0.601	0.128
Mean piglet weight					
• day 1 of lactation	kg	1.31	1.32	0.062	0.818
• day 7	kg	2.55	2.39	0.1423	0.249
• day 14	kg	4.38	4.10	0.222	0.219
• day 21	kg	6.09	5.66	0.226	0.068
• day 30 (estimated)	kg	8.73	8.01	0.381	0.072
Piglet weight gain/day					
• birth to weaning	g	240.3	219.3	8.65	0.022

† Note: One sow in the UMB pen treatment had a litter of 3 piglets, while one sow in the Crate treatment had a litter of 19 piglets.

Raw data

Variable	Units	Crates	UMB Pens
N litters†		16	15
Total number of piglets born (TB)		209	174
Piglets born alive (BA)		196	170
Stillbirths – Pre-partum deaths		1	1
Stillbirths – Intra-partum deaths		12	3
Piglets fostered ON to sow		+10	+15
Piglets fostered OFF from sow		-13	-17
Piglets dying before weaning (of BA)		36	34
Piglets weaned		157	134
Stillbirths (of TB)	%	6.2	2.3
Preweaning mortality (of BA ± Fostered)	%	18.6	20.2

†: Note. The omitted sow in replicate 3 of the experiment in the UMB pen treatment had 7 piglets born total and alive. Unfortunately the sow became ill and it was necessary to foster off all her piglets and remove the sow and litter from the experiment.

Piglet Production and Mortality

The mean number of piglets born (alive and stillborn) per litter, the number dying between birth and weaning and the number weaned are presented in Table 3. Although mean total born per litter was lower in the UMB pen than the crate treatment, this was not significant, and was largely due to one sow in the UMB pen treatment having a litter of 3 piglets whereas one sow in the crate treatment had a litter of 19 piglets. The number of live-born deaths to weaning did not significantly differ between UMB farrowing pens and farrowing crates ($P > 0.05$; Table 1). The mean number of deaths to weaning (per litter) was 2.34 and 2.25 piglets in UMB farrowing pens and farrowing crates, respectively. Mortality of live-born piglets did not differ between treatments when litter size was taken into account ($P > 0.05$; Table 3). Piglet mortality was 20% and 18% in the UMB pens and crates, respectively (Table 3). However, there was a significant difference regarding the distribution of causes of piglet mortality between the two treatments ($P = 5.28 \times 10^{-7}$) (Table 4), and there was some evidence of stillborn rates being higher in crates than UMB pens ($P = 0.056$; Table 3).

Table 4: Comparison of distribution of causes of pre-weaning live-born piglet mortality between conventional farrowing crates and UMB farrowing pens.

Cause of death	Farrowing Crates	UMB Farrowing Pens
Overlain	7	28
Illness	9	0
Chilled	10	3
Small/weak	4	3
Savaged	2	0
Splayed legs	2	0
Congenital defect	2	0
P-value	5.28×10^{-7}	

Discussion

The standard of farrowing/lactation accommodation has become a contentious issue in the pork industry due to opposition against the intensity of production, and the associated welfare implications for sows and their litters (Vosough Ahmadi *et al.* 2011). The development of alternative farrowing systems, such as farrowing pens, has been a major focus of research over recent years. Despite the welfare advantages that farrowing pens appear to offer the peri-parturient sow, such as increased freedom to ambulate and to perform nest-building activities, evidence suggests that piglet mortality remains high compared to conventional farrowing crates (Andersen *et al.* 2005). The failure to reduce piglet mortality is a concern of producers who ultimately work to maximize productivity and profitability (Baxter *et al.* 2011). In order for farrowing pens to be adopted by the pork industry, alternatives to the farrowing crate must contribute to improved sow and piglet welfare, and prove to be economically viable by maintaining an equal or superior level of productivity to the crate system (Baxter *et al.* 2011). The present study contributes by building knowledge of productivity outcomes by sows and litters in conventional farrowing crates compared to an alternative system, the UMB farrowing pen, under Australian conditions.

Several studies have reported that the farrowing/lactation environment effected sow feed intake (Farmer *et al.* 2006; Loudon 2008; Sulabo *et al.* 2010). Farmer *et al.* (2006) found that sows housed in farrowing pens consumed more feed than sows in crates, particularly at higher ambient temperatures (29°C). In the present experiment, although the sows in the UMB farrowing pens consumed more feed between Day 7 and 21 of lactation than the sows in the crates, the difference (~0.4 kg/day) was not significant. This outcome could possibly be attributed to the small sample size in the experiment. Feeding bouts for the sows in the crate treatment were difficult to observe and measure from the video records as the drinker was also positioned in the feeder, making it hard to distinguish whether the sows were eating or drinking. Consequently, further research is required to more accurately compare sow feeding behaviour between UMB farrowing pens and farrowing crates.

Increased feed intake has been shown to increase litter performance during lactation (Kruse *et al.* 2011). Sows mobilise body fat reserves as an energy source if they are not fed enough to maintain milk production for their litter (Bergsma *et al.* 2009). If deterioration in sow body condition is excessive or occurs too rapidly during lactation, there can be a negative impact on reproductive performance in the next farrowing cycle (Bergsma *et al.* 2009). Consequently, feed intake is an important measure of sow productivity that producers will consider when selecting farrowing accommodation for their enterprise. Genetic selection for leaner pigs with higher feed conversion efficiency is encouraging a trend towards lower feed intake, however this could be detrimental to piglet growth during lactation (Bergsma *et al.* 2009). The latter authors suggest that increasing energy efficiency during lactation, viz. by increased milk output through balancing feed intake and body fat mobilization, may be a feasible solution for producers to benefit from favourable finishing qualities of the sow as well as maintaining optimal piglet growth.

In the present experiment there was a significant difference in daily weight gain of piglets between the two treatments. Piglets in the farrowing crates achieved a greater weight gain per day than the piglets in the UMB farrowing pens. There are several possible explanations for this outcome. The first, and more likely explanation, is the effect of low ambient temperature on piglet growth. Although the two rooms housing the UMB pens and the crates were under the same shed roof, the room with the UMB pens was much larger, less well insulated and exposed to a greater amount of natural ventilation than the farrowing crate room. The UMB pens had thermostatically controlled heat mats within the concrete floor of the nest area, however it was difficult to manage these in relation to the variable ambient temperature in the shed, and ultimately this proved to be a limitation of the study. Over the four replicates, the ambient temperature in the room with the crates was higher than the room with the UMB pens (Table 1). In particular, the minimum room temperature was lower, reflecting colder overnight ambient conditions in the UMB pen room. In addition, the UMB pens did not have overhead piglet heaters, which were present in each farrowing crate, and which would also have contributed to increased room temperature in the crate treatment, and certainly at the level of the litter. At birth, the lower critical temperature of piglets is 34 to 35°C, which is often much higher than the actual temperature achieved in farrowing pens or crates (Kammersgaard *et al.* 2011). Thermoregulation in piglets is critical, and it is likely that in this study the piglets in the UMB pens had to utilize more energy for heat production than growth, possibly explaining the lower daily weight gain. Quiniou *et al.* (2002) suggest that piglet birth weight has a continuing effect on growth during lactation. Piglets that are heavier at birth have a greater daily weight gain throughout lactation and post-weaning compared to littermates with a lower birth weight.

Bøe (1993) and Pajor *et al.* (2000) present a second possible explanation for the lower daily weight gain experienced by piglets housed in farrowing pens. The authors propose the notion that farrowing pen systems are 'sow-controlled' systems, and subsequently give the sow the opportunity to move away from the nest area and piglets at will. Bøe (1993) states that, when given the opportunity, some sows will leave their litters at such an early stage of lactation that it will negatively impact piglet growth and health. Van der Hel and Verstegen (1987) state that the metabolic rate of piglets, and thus their ability to produce heat, is dependent on their milk intake. Therefore, by providing the sows with more space and the ability to move away from their litters in the UMB pens, piglets may not be receiving the required milk intake, in turn adversely impacting thermoregulation and growth. The data collected from the video observations in the present experiment demonstrate that the UMB pen sows suckled less frequently on Day 21 than the sows in the crates. The report by Bøe (1993) supports the possibility that this result may be due to the sows in the UMB pens having more space and the ability to move away from the piglets at will, compared to the sows in the crates.

Piglet mortality is a major concern of producers as the number of piglets weaned is a major determinant of enterprise profitability. In the present study there was no significant difference in the number of piglet deaths to weaning (of live-born piglets) between the UMB farrowing pens and the farrowing crates. When taking litter size into account, there was also no difference in live-born piglet mortality between the two treatments. Weber (1997) and Weber *et al.* (2007) presented comparable results in Swiss trials, reporting no differences in total piglet mortality between farrowing pens and farrowing crates. Cronin *et al.* (2000) studied the performance of sows and litters in the 'Werribee Farrowing Pen', which was installed alongside conventional farrowing crates on a commercial farm, and also found no difference in piglet mortality between farrowing pens and crates. The authors suggest that pens may be equivalent to crates in terms of encouraging piglet survival, which elicits the question of whether the use of farrowing crates in the pork industry is necessary. Although a greater proportion of piglet deaths occur due to crushing in pens than crates, there are significantly less piglet deaths in pens as the result of other causes (Cronin *et al.* 2000; Weber *et al.* 2007). Andersen *et al.* (2005) state that the proportion of deaths due to overlying by the sow in farrowing pens accounts for 50-80% of the average 5-25% of pre-weaning mortalities per litter in commercial piggeries, supporting the findings from our trial. In the UMB farrowing pens, overlying of piglets by the sow accounted for 76% of pre-weaning piglet deaths, compared to 19% of pre-weaning deaths in crates. However, there was a higher proportion of pre-weaning piglet deaths due to other causes (illness, chilling, splayed legs) in the farrowing crates compared to the UMB pens. Further research is required to investigate pen design features that would improve piglet survival during farrowing and lactation, without having to restrict the sow's movement.

Despite differences between the different accommodation treatments, variation in piglet mortality also exists between litters when studied within a single farrowing system (Andersen *et al.* 2005). The authors suggest that, along with factors such as age and experience, genetics contribute to the sow's maternal behaviour and interaction towards her litter. Baxter *et al.* (2011) also suggest that genotype-by-environment interactions have an impact on piglet survival in pen farrowing accommodation, and that breeding strategies should focus on selecting sows with favourable mothering abilities. Individual behavioural differences and maternal abilities of sows may account for the varying proportion of live-born piglet pre-weaning deaths per litter in this present experiment. Genetic selection for sows that demonstrate a careful mothering style would be advantageous, particularly in the UMB pen system, to reduce piglet mortality due to overlying.

Oliviero *et al.* (2008) found that both the duration of farrowing and the interval between piglet expulsions were significantly longer in sows in crates compared to pens, which increases risk of hypoxia. These results from Oliviero *et al.* (2008) may offer a possible explanation for the tendency for the higher proportion of stillborn piglets in the farrowing crates in the present study, compared to farrowing pens. Further, Kammersgaard *et al.* (2011) observed that piglets that experience hypoxia during parturition take longer to have their first suckle from the sow. That is, the piglet is less 'viable'. This affects where the piglet will be positioned in initial two hours after birth, which, if isolated from the sow and litter, can predispose them to hypothermia (Kammersgaard *et al.* 2011). Hypothermia accounts for a significant proportion of neonatal deaths in commercial piggeries, as well as predisposing piglets to other causes of mortality such as starvation, disease and overlying by the sow (Kammersgaard *et al.* 2011). The suggestion that there is a connection between prolonged duration of farrowing in crate systems and predisposing piglets to hypothermia may offer an explanation for the higher proportion of deaths due to chilling and disease in the farrowing crates compared to the pens in this study. Further research focusing on the farrowing process in the two treatments could be beneficial to investigate the possible increased incidence of stillbirths and hypothermia due to prolonged duration of parturition in farrowing crates.

The present study investigated pig performance in a new prototype farrowing system that had been in operation for less than nine months (5 farrowing batches) in the Camden piggery. Hence, while the researchers and stockpeople were on a steep learning curve in relation to understanding how to manage sows and litters in the UMB pen system, the data collected nevertheless highlight areas where further research could be beneficial towards the implementation of alternative farrowing accommodation in the pork industry. A major limitation of our study was the effect of low ambient temperature on piglet growth, and in particular overnight minimum temperatures. The UMB pen design did not include overhead piglet heaters, which were used in the crate treatment. The occurrence of overlying of piglets after Day 3 of lactation in the UMB pens was most likely associated with the difficulty encountered controlling the under-floor heaters, and thus the floor surface temperatures, in our climatic conditions in the poorly insulated UMB farrowing room. Future studies could focus on adapting the UMB pen system to Australian piggery sheds if they are not environmentally controlled, as they are in Norway, where the prototype design was developed. Maintaining a more stable ambient temperature in farrowing pens during farrowing and lactation, for example through better thermal insulation of the building, could potentially increase the growth rate of piglets, and therefore improve productivity.

Overlying by the sow was a large contributor to pre-weaning piglet deaths in the UMB pens in this study. Pen design needs to be improved in order to decrease piglet mortality due to overlying. The inclusion of a piglet creep area with an overhead heater in UMB pens could potentially decrease piglet mortality, and also possibly increase piglet growth rate due to the additional source of heat. Genetic selection for sows with favourable maternal traits that respond well to their litter in the UMB pen system could also be a plausible option to reduce overlying of piglets. The fact that piglet mortality due to other causes was significantly less in the UMB pens compared to crates emphasizes the necessity to reduce crushing so that overall mortality can be reduced to potentially lower than the current mortality in crates.

Conclusions

The proportion of piglet losses in the UMB farrowing pens was similar to that achieved in conventional farrowing pens. Thus, further research on the UMB pen as a potential alternative to conventional farrowing crates is fully warranted. Although the level of operator experience in managing sows and litters in the UMB pen system was relatively low in this experiment, the project high-lighted a number of areas where improvement to husbandry and management could be made to improve pig production, specifically to reduce piglet mortality in the pens due to overlying by the sow. Other encouraging findings were the tendency for sows farrowing in the UMB pens to have proportionally fewer stillbirths, and the higher, although not significantly higher, level of voluntary feed intake by sows in the UMB pens.

Outcomes of Project Activities

- A replicated experiment involving 32 breeding herd sows at the University of Sydney, Mayfarm Pig Unit was successfully completed as part of the Honours research project of Ms Rebecca (Bec) Matthews.
- The main findings of the research were that there was no difference in piglet mortality between litters in the prototype UMB farrowing pen and conventional farrowing crates.
- There was a tendency for sows that farrowed in the UMB pens to have proportionally fewer stillbirths compared to sows in conventional farrowing crates.
- No significant difference was found in the level of voluntary feed intake between days 7 and 21 of lactation, although sows in the UMB pen treatment on average consumed an additional 0.4 kg per day.
- Piglets in the UMB pens grew slower, gaining about 20 g less per day from birth to weaning, compared to piglets in farrowing crates. In part, this was thought to be associated with cooler overnight temperatures experienced by the piglets in the room with the UMB farrowing pens.
- The number of suckling bouts per 24 hours, later in lactation, was lower in the UMB pen treatment compared to the farrowing crate treatment. This may have been associated with the sows being able to move away from the piglets in the UMB pen system.

Recommendations for Future Research

Further research is required to better adapt the UMB pen design for Australian climatic and production conditions, although it is anticipated that design changes would be relatively minor. The extent of design modifications required would depend on the shed environment in which the pens are likely to be installed. The UMB pens were designed for use in well-insulated, environment-controlled farrowing/lactation sheds. However, it is probable that Australian producers would install farrowing/lactation pens in (existing) pig sheds that are inadequately insulated and/or ventilated for the efficient management of the thermal requirements of sows and piglets under the local seasonal climatic variations in heat and cold. Within this limitation, it is recommended that further research investigate (1) the incorporation of a protective heated creep area (with thermostatic heat control) within the nest area of the UMB pen, (2) the permanent opening of the 'pop-hole' in the piglet barrier for piglets and (3) under-floor cooling in the nest area for the sow. In relation to the first of the three points, research should also be conducted to improve understanding the use of heating and cooling within the nest area to manipulate sow and litter preferences for lying location around parturition and during early lactation.

There is a clear need for research around the initiation of a genetic selection program by industry for 'careful' or 'successful' sows, in order to improve sow and piglet productivity in farrowing pens. Ultimately producers require a farrowing system that maximizes the profitability of their enterprise.

The possibility that sow voluntary feed intake is higher in farrowing/lactation pens than crates presents an opportunity for industry to improve sow reproductive efficiency. Future research could include the measurement of sow P2 back-fat thickness as another productivity determinant to complement sow feed intake measurement. Recording the P2 back-fat thickness before farrowing and at weaning would assess the change sow body condition due to lactation, and could provide a link between voluntary feed intake, milk production and litter performance.

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