The effects of alternative housing on piglet welfare and performance around weaning

1B-103

Report prepared for the

Co-operative Research Centre for High Integrity Australian Pork

By

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July 2014

An Australian Government Initiative

Established and supported under the Australian Government's Cooperative Research Centres

Executive Summary

The current research focus into farrowing and lactation housing offers a huge opportunity, not only to improve the conditions in which sows are housed, but also to provide benefits to piglets. One of the largest stressors a piglet experiences under commercial conditions is the weaning event. Under more 'natural conditions', the piglet is weaned from the sow slowly, with a reduction in sow contact and with it, a reduction in milk consumption and a consequent increase in solid intake, increased time spent outside the nest and consequently introduction to members outside of the litter. The abrupt wean typically witnessed under commercial conditions does not facilitate most of these occurrences and instead, piglets are faced with a sudden change in nutrition, environment and social structure. Introducing a more gradual wean under commercial conditions has been previously shown to improve solid feed intake prior to weaning, and subsequently piglet growth is improved. What is not well understood is whether gradual weaning impacts on other measures of stress such as behavioural expression and hormone release.

The aim of this investigation was to determine if a gradual weaning strategy involving reduced sow contact in lactation would improve piglet welfare and performance after weaning. The two treatments imposed involved sows remaining in constant piglet contact within a farrowing crate (CON), and sows placed in a pen at the rear of the farrowing crate in isolation from piglets from day -17 relative to weaning to replicate a gradual weaning process (SP). The separation regime for the SP treatment involved a gradual increase in the time in which the sow was isolated from piglets from 0hrs from birth to day -17, 5hrs from days -17 to -12, 7hrs from days -12 to -7, and 9hrs from days -7 to day 0 (weaning). Performance and welfare indicators were collected from piglets immediately prior to, and following the weaning event, which occurred at an average of 28 ± 1.3 days after parturition.

SP piglets were lighter than CON piglets at weaning (CON 7.64 ± 0.16 kg, SP 6.83 ± 0.15 kg), however, a 'growth check' occurred in the CON piglets immediately after weaning resulting in no treatment effect on piglet weight being identified at day 7 post weaning (CON 8.60 ± 0.17 kg, SP 8.35 ± 0.1 5kg, $P > 0.05$). Overall, more SP piglets had a tendency to consume more creep/solid feed (SP 64 ± 2.0 %, CON 48 ± 2.0% $P = 0.10$). Belly nosing and aggressive events were longer in duration for CON piglets (belly nosing: CON 6.3 ± 2.0 seconds and SP 2.4 ± 1.3 seconds; aggression: CON 6.5 ± 1.1 seconds; SP 4.2 ± 0.8 seconds; $P < 0.05$) on the day following weaning. Weaning produced an increase in circulating plasma cortisol concentrations in CON piglets (18.7 ± 13.3 nmol/L), whilst inducing little change in the SP piglets (-12.3 ± 14.1nmol/L; $P < 0.05$).

In conclusion, gradual weaning resulted in improved piglet growth in the immediate post-weaning period, which most likely could be attributed to an increase in creep feed consumption, a reduction in agonistic behaviours, fewer injuries, and lower stress hormone release in response to weaning. The piglet growth performance, and behavioural and physiological indicators of stress and welfare all suggest that employing a gradual wean was of significant benefit to piglets in comparison to a more traditional, abrupt wean. How a gradual wean can be implemented commercially however is an issue than requires further investigation. Removal of the sow from the farrowing crate involved significant labour input, so future investigations should target alternate designs for housing sows and piglets that facilitate reduced sow contact with minimal requirement for labour.

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1. Introduction

Optimising sow welfare and productivity throughout lactation is a high priority for both Australian and international pig industries. The majority of Australian sows are housed in farrowing crates during farrowing and lactation (Barnett *et al.* 2001). Farrowing crates were originally designed to protect newborn piglets from being crushed or savaged by the sow (Weber *et al.* 2009). However, there is suggestion that crates have little benefit to either the sow or piglet from mid to late lactation as piglet mortality from sow crushing is minimal (Marchant *et al.* 2000). A reduction in sow confinement may not have significant implications for piglet health or mortalities after mid-lactation (Ahmadi *et al.* 2011). Farrowing crates may also be restrictive in space for the sow and also for piglets to move in, as the standard size of a farrowing crate is $3.2m^2$. Due to these concerns, there is now growing pressure to find practical and commercially viable alternatives to the conventional farrowing crate.

Alternate lactation housing design has largely focused on improving sow welfare through reducing confinement, but now there is increasing concern for how different housing types affect piglet performance and welfare (Ahmadi *et al.* 2001; Baxter *et al.* 2012). Sows have a natural tendency to spend time away from their piglets as lactation progresses and gradually reduce suckling frequency, effectively creating a gradual weaning process (Pajor *et al.* 1999). In conventional farrowing crates, the ability of the sow to modulate her own suckling frequency is reduced, thus weaning is an abrupt event. Farrowing accommodation that allows for a 'sow only' area has been shown to result in a more 'natural' weaning process, whereby suckling frequency can be reduced as lactation progresses (Pajor *et al.* 1999). This may benefit sow welfare through reducing confinement and allowing respite from piglets, but may also influence the piglet's adaptability to weaning (Berkeveld *et al.* 2009).

Abrupt weaning is typically associated with a reduction in growth immediately post-weaning (known as a 'growth check'). Although gradually weaned piglets are often slightly lighter at weaning (Kuller *et al.* 2004), the severity of the post-weaning growth check is reduced. There have been several studies conducted on the performance of piglets in relation to intermittent suckling (sow removed from piglets for defined proportion of day) which results in a gradual wean, and many have shown beneficial effect on productivity post-weaning (Berkeveld *et al.* 2009; Berkeveld *et al.* 2007; Kuller *et al.* 2004). This is thought to occur as creep feed ingestion may be increased by sow separation in lactation (Berkeveld *et al.* 2009; Berkeveld *et al.* 2007; Kuller *et al.* 2010).

Growth performance post-weaning may be further affected as the weaning event is thought to be stressful, and stress and performance and strongly linked (Barnett *et al.*1983). Cessation of maternal contact, introduction of a new social and physical environment, along with the changes in diet are all thought to contribute to this stress response (Weary *et al.* 2008). Circulating cortisol concentration is elevated in response to stress, however no studies have compared cortisol post-weaning due to difficulties in sampling (Jarvis *et al.* 2008; Mason *et al.* 2003; Worsaae and Schmidt 1980). It is therefore still unknown if cortisol levels are influenced by inducing a gradual wean in piglets.

The effect of gradual weaning on HPA parameters remains to be elucidated but behavioural differences in gradually weaned piglets have been reported previously. Negative piglet-directed behaviours are indicators of stress (Dybkjaer 1992) and increased incidences of these behaviours (belly nosing, chewing, aggression, and escape attempts from pen) have been reported in abruptly weaned piglets when compared with those that experienced a more gradual wean (Dybkjær 1992; Newberry *et al.* 1988; Worobec *et al.* 1999). When piglets have satisfied their primary needs such as feeding, resting and comfort, an increase in play behaviours can be observed. Play behaviours are therefore a good indicator of a positive welfare state (Newberry *et al.* 1988). To date, no published information is available on the occurrence of play behaviours in gradually weaned piglets compared with those weaned conventionally.

The aim of this study was to determine if piglets gradually weaned from the sow facilitated by alternate lactation accommodation experience a reduction in the stress typically experienced at weaning, and if this has a positive effect on post-weaning performance. It is hypothesised that if sow- piglet contact is reduced gradually during lactation, an improvement in the piglets behavioural, physiological and performance response to weaning will be observed.

2. Methodology

This study was approved by The University of Adelaide Animal Ethics Committee (Animal Ethics Number: S-2013-081) and was conducted in accordance with the 'Code of Practice for the Care and Use of Animals for Scientific Purposes' (NHMRC 2004). All animal work was conducted at an Australian Pork Farms Group (APFG) commercial piggery over two block replicates and included 50 mixed parity Large White x Landrace sows and their offspring. In total, 469 piglets were used throughout the trial. Three sows were excluded as offspring were breeder replacements and one sow was replaced with a foster mother due to agalactia. A total of 14 piglets were removed from the trial due to morbidity or death.

2.1. *Experimental Design*

2.1.1. Treatment Allocation

Sows were randomly allocated at farrowing to one of two treatments; ten sows per replicate (total n = 20) were allocated to the control (CON) treatment and 15 sows per replicate (total n = 30) to separation pen (SP) treatment. The control treatment experienced no separation, with sows remaining in the farrowing crate in constant contact with piglets throughout lactation resulting in an abrupt wean. In the SP treatment, sows were placed in a pen at the rear of the farrowing crate in isolation from piglets from day -17 relative to weaning to replicate a gradual weaning process. The separation regime for the SP treatment involved a gradual increase in the time in which the sow was isolated from piglets (Table 1).

Table 1 -Separation regime imposed on the SP (separation pen) treatment which involved sows being housed in a pen at the rear of the farrowing crate in isolation from piglets for the specified length of time.

Day relative to weaning	Sow separation for SP treatment
Birth to -17	0 hrs
-17 to -12	5 hrs
-12 to -7	7 hrs
-7 to weaning	9 hrs

2.1.2. *Weaning*

For both treatment groups, weaning occurred at 28 ± 1.3 days of age. At weaning (day 0), piglets were transferred from the farrowing house to a conventional weaner facility where they were sorted according to sex and size, and housed in group pens measuring 3.4 m long by 1.64 m wide. Each pen housed 15 to 20 piglets (dependent on piglet size) of the same treatment. The flooring of each pen consisted of a partially slatted and a solid concrete area. Wood shavings were provided on the concrete area, and sprayers were present at one end of the slatted area of flooring. Water was provided in each pen by a nipple drinker and feed via one *ad libitum* feeder.

2.1.3. *Housing Design*

Lactation housing used in the SP treatment consisted of a conventional farrowing crate (1.7 m x 2.4 m) with a covered creep area, and a 3 m x 1.7 m pen at the rear of the crate (Figure 1). The rear pen consisted of plastic slatted flooring, contained one drinker nipple and allowed fence-line social contact with sows in neighbouring pens. A gate at the rear of the crate which opened into the rear pen was kept closed for the CON sows, ensuring the sows remained in the farrowing crate in constant piglet contact for the duration of lactation. For the SP treatment, the gate was opened and the sow was confined to the rear pen for the designated separation period (Table 1). Piglets from both treatments remained confined within the farrowing crate for the duration of lactation.

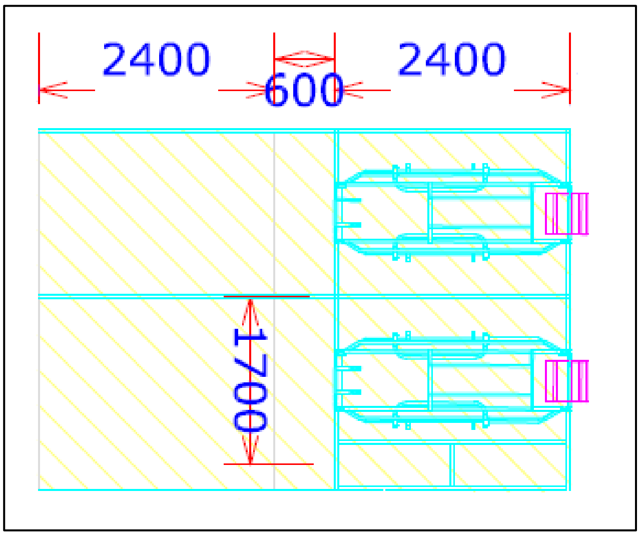

Figure 1 - Design of the lactation housing system employed. The separation pen included a crate (2.4 m x 1.7 m) and a pen that housed only the sow measuring 3.0 m x 1.7 m at the rear of the crate.

2.1.4. *Feeding*

Sows were fed *ad libitum* standard lactation diet (min 14.2 MJ/kg DE) twice daily. The feeding regime was controlled by the SP treatment, and as such, sows were fed at 07:00 (before SP treated sows were moved to the pen) and again at 17:00 (after SP treated sows had been returned to the farrowing crate). In both treatments, piglets had *ad libitum* access to creep feed from day -17 relative to weaning and *ad libitum* access to weaner feed post weaning. The creep and weaner diets were both "starter" diets of 15.5MJ/kg DE (Table 2).

Table 2. Ingredient and nutrient specifications of the piglet "starter" diet used for both creep and weaner feed.

Ingredient Name	%	Nutrient Name	Amount	Unit
Wheat 12%	25.42	Dry Matter	91.20	%
Ext.Wheat+3.5%Oil	5	D.E. Pigs	15.51	MJ/KG
Peas	7.75	Net Energy Pigs	10.39	MJ/KG
Biscuit Meal -6%	15	Protein	21.27	%
Dextrose	3	Fat	8.07	%
Canola 34 exp. Millicent	2.5	Fibre	2.40	%
Soyabean meal 46%	8	Ash	4.95	%
Soycomil	1.25	Lysine	1.57	%
Nu-pro Yeast Extract	2.5	Methionine	0.50	%
PP-Meatmeal-57%	4	Methionine + Cysteine	0.86	%
Fishmeal 60%	4	Threonine	1.00	%
Blood meal	0.5	Isoleucine	0.89	%
Buttermilk -30P/12F	5	Tryptophan	0.28	%
Whey Powder	10	Calcium	0.9	%
Feed Oil 80:20	3.625	Total Phosphorus	0.72	%
Salt	0.1	Available Phosphorus	0.66	%
Lysine-HCL	0.382	Sodium	2.87	%
Methionine LIQ-80	0.177	Acid Binding Capacity	661.73	MEQ/KG
Threonine	0.157	Choline	2358.74	MG/KG
Tryptophan	0.048	Available Lysine	1.40	%
Zinc Oxide	0.3	Phytate P	0.14	%
Oxicap E2	0.02	Salt	0.71	%
Fysal Fit-4	0.3	Total Legumes	7.75	%
Flavour LQ.VE/VS	0.5	Bulk Density	60.62	KG/HL
Betaine	0.1			
Lysoforte	0.12			
L/A 9854 Creep PMX	0.25			

2.2. *Animal Measures*

2.2.1. Weights

Sow weights were recorded before loading into farrowing accommodation, and again after weaning in order to determine treatment effects on lactation weight loss. Individual piglet weights were collected on days -17, -12, -7,-1, 1, 2, 7 and 14 relative to weaning.

2.2.2. Creep feed consumption

Creep and weaner feed was dyed using indigo carmine (5 kg per tonne of dry feed). Faeces from all individual piglets were assessed for colour by a rectal swab using cotton buds on days -17, -12, -7, -1, 1, 2, 7 and 14 to signify whether individual piglets had consumed the creep. Piglets received a "yes" or "no" status upon inspection of swab for colouration (Pluske *et al.* 2007).

2.2.3. Injury scores

An injury score was collected from each individual piglet in order to subjectively estimate level of aggression. The injury scoring system was adapted from

Widowski *et al.* (2003) and consisted of a four point scale for scratches and redness around the head and ears of each piglet (Table 3). Injury score was collected on days -1, 1, 2, 7 and 14 relative to weaning.

Table 3 - Injury scoring system using scratches and redness adapted from Widowski *et al.* (2003).

Score:	0	1 (Mild)	2 (Moderate)	3 (Severe)
Redness	No redness, swelling, or hair loss is evident	Reddening, swelling, or hair loss is barely detectable	Swelling, redness, or hair loss is obvious	Irritation easily observed as darker reddening, swelling, and patches of hair loss
Scratches	No scratches or skin loss were evident on face and body	1 to three small (≤2 cm) scratches or areas of abraded skin is evident, or scratches on face only or back only	1 to three larger (>2 cm) scratches or areas of abraded skin is observed on back and/or face	More than three scratches (usually >2 cm) or larger areas of superficial skin loss. Scratches on both face and back

2.2.4. Blood Samples & Teat Order

Piglets were observed during a suckling event between days 5 and 10 after parturition, and before the application of the SP treatment, to determine teat order (with one being at the anterior end of the sow and four being posterior). Once teat order was recorded, one piglet from the front teat, one piglet from the rear teat and two from the middle teats were chosen as focus piglets to give a total of four piglets per litter. Blood samples were collected from focus piglets on days -1 and +1 relative to weaning via jugular venepuncture using a 21 gauge needle into a 4 ml heparinised blood tubes. The time of each bleed and order in which piglets was bled within a crate or pen was also recorded. Care was taken to ensure blood sample collection occurred within a 2 minute period from animal restraint. After collection, blood samples were spun for 20 min at 3000 rpm and plasma was pipetted into 2ml tubes where it was frozen and stored at -20°C. Samples were analysed using radio-immunoassay for free cortisol by the Animal Biology Department at the University of Western Australia. The limit of detection for cortisol was 3.5 nmol/L and the mean inter-assay co-efficient of variation was 3.5%.

2.2.5. Video Recording for Behaviour

On days 1 and 2 post-weaning, two female pens and two male pens from each treatment per replicate, giving a total of eight pens per treatment, were recorded using video cameras (Legria HFR26, Canon Australia) from 07:00 until 13:00. Recordings were then analysed for neutral, negative or playful behaviours (Table 4) using Observer XT v11.5 software (Noldus Inc, The Netherlands). Field of vision did not show access to the drinker, therefore prevented drinking from being recorded as a behaviour.

Table 4 - Description of behaviours listed as neutral, positive or negative when examined as a welfare indicator combined from Newberry *et al*. (1988), Dybkjær (1992) and Worobec *et al*. (1999).

Type of Behaviour	Behaviour	Description
Neutral	Laying	Weight of body not supported by legs.
Neutral	Feeding	Head in feeder.
Negative	Belly-nosing	A piglet rubs a pen-mate's belly with rhythmic, up and down movements of its snout.
Negative	Nosing/ chewing pen-mates	Oral-nasal contact with the body of a pen-mate (distinct from belly-nosing).
Negative	Aggression	Pushing, head-thrusting against, biting and chasing pen-mates.
Negative	Aggression at feeder	Aggression (see above) connected with gaining access to the feeder or drinker.
Negative	Mounting	A piglet jumps on the back of another piglet for a prolonged time.
Positive	Playful gestures	Head toss, nudging.
Positive	Hop	Jump up and down on the spot while facing in one direction.
Positive	Scamper	Run slowly with vertical and horizontal bouncy movements.
Positive	Pivot	Jump or whirl around to face in a different direction.
Positive	Toss head	Perform vigorous latero-rotationary movements of the head and neck.

2.3. *Statistical Analysis*

The following analyses occurred using SPSS 20 (IBM, Chicago USA). The model used to analyse piglet weight and injury score was a linear mixed model with lactation length was fit as a covariate, sow ID as the random effect and fixed effects of replicate (one or two), sow parity (two to seven), litter size (seven to 12), weaning pen (one to 14), teat order (front, middle or rear), day (-17 to 14), treatment (CON or SP), and the interactions day by treatment, a day by teat order, and day by treatment by teat order.

Creep feed intake was analysed in ASReml 3.0 (Gilmour *et al*. 2009) using a binomial regression analysis with a logit function. Weaning pen, farrowing crate, piglet ID were fitted as random effects and fixed effects included replicate, piglet grade (small, medium or large), sow parity, litter size, sex, teat order, day, treatment, day by treatment interaction and day by teat order interaction.

Remaining analyses were conducted in SPSS 20. Cortisol concentration was not normally distributed so transformed using $\log^{10}$ transformation. A general linear model was fit with lactation length and weight as covariates and fixed effects of replicate, pen, litter size, parity, sex, teat order, sampling order and treatment. The change in cortisol concentration was also examined by subtracting the value recorded on day -1 from day 1 and analysed using the same model. Behaviours were also transformed ($\log^{10}$) and analysed using a linear mixed model. The model included weaning pen as the random effect, number of piglets in a pen (14-20) as the covariate and fixed effects of replicate, sex, grade, treatment, day, and a day by treatment interaction.

3. Outcomes

3.1. *Piglet weights*

At the commencement of the trial, piglets in the separation pen (SP) treatment weighed the same as the control (CON) treatment (Table 5). CON piglets were heavier than SP piglets on the day prior to weaning and on days 1 and 2 post-weaning. However, on days 7 and 14 post-weaning live weight was similar for CON and SP piglets.

Table 5 - Average weight of piglets (mean ± SEM) in separation pen (SP) and control (CON) treatment groups for days -17, -12,-7, -1, 1, 2, 7 with weaning at day 0 (superscript represents significant effect (P < 0.001) of treatment within day).

Day relative to weaning	Treatment	Mean	SEM
-17	CON	3.40	0.16
	SP	3.42	0.15
-12	CON	4.67	0.16
	SP	4.64	0.15
-7	CON	6.00	0.16
	SP	5.75	0.15
-1	CON	7.61^{a}	0.16
	SP	6.83^{b}	0.15
1	CON	7.64^{a}	0.16
	SP	7.27^{b}	0.15
2	CON	7.91^{a}	0.16
	SP	7.42^{b}	0.15
7	CON	8.60	0.17
	SP	8.35	0.15
14	CON	10.81	0.17
	SP	10.61	0.15

3.2. *Creep feed consumption*

There was a tendency for a higher percentage of SP piglets to consume creep feed than the CON piglets (64 ± 3 % versus 48 ± 2 %; P = 0.10). There was also a significant effect of day irrespective of treatment on creep consumption with more piglets consuming creep feed as lactation progressed (Figure 2). On the day preceding and following weaning there was no difference in the percentage of piglets eating creep feed (day -1 28 ± 2 %, day 1 31 ± 2 %; P > 0.05). At day 2, 55 ± 3 % of piglets were consuming feed and by day 7 post-weaning, 100 ± 3 % of piglets were consuming solid feed (Figure 3). There was no day by treatment interaction observed for piglet creep consumption (P > 0.05).

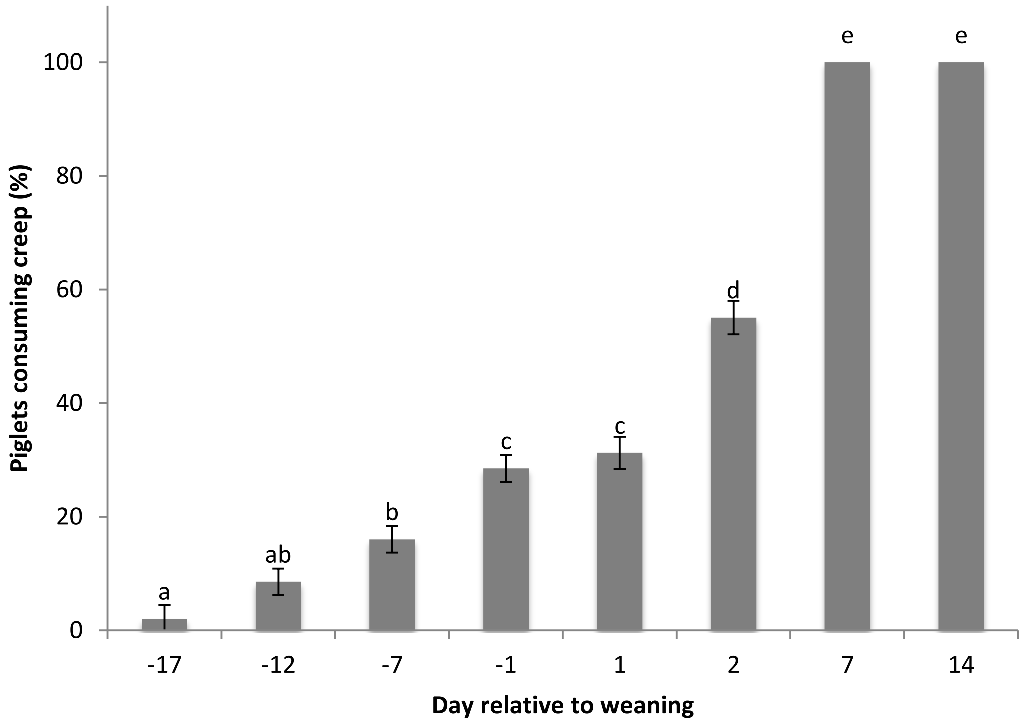

Figure 2 - Percentage of piglets consuming creep feed (irrespective of treatment) on days -17, -12, -7, -1, 1, 2, 7 and 14 with day 0 representing the day of weaning (differing superscripts represent a significant difference (P < 0.05) across day).

3.3. *Behaviour of piglets on days following weaning*

The number of times a particular behaviour was observed within a pen differed across days (Table 6). Piglets lay three times more often on day 1 when compared with day 2 after weaning. Piglets also had 31 more feeding events per pen on day 1 than on day 2. Some play behaviours differed between days and were performed more often on day 1 than day 2. Both pivot and scampering was performed twice as much on day 1 than on day 2, and head tossing occurred over twice as much on day 1. There was no difference in any of negative behaviours scored over days (P > 0.05).

Table 6 - The number (mean ± SEM) of times a particular behaviour was performed (irrespective of treatment) within a pen on days 1 and 2 post-weaning (ns = not statistically significant, * = P < 0.05, ** = P < 0.01 and *** = P < 0.001).

Average number of times a behavior was observed	Day 1	Day 2	P-value
Laying	21.5 ± 3.9	6.9 ± 3.9	**
Feeding	146.0 ± 14.8	115.0 ± 14.8	*
Active	11.9 ± 2.3	12.6 ± 2.3	ns
Belly nosing	1.9 ± 0.9	1.3 ± 0.9	ns
Nosing/chewing pen-mates	28.6 ± 5.2	28.4 ± 5.2	ns
Aggression	254.8 ± 30.1	195.5 ± 30.1	ns
Aggression at feeder	2.8 ± 1.3	1.6 ± 1.3	ns
Playful gestures	10.8 ± 1.7	8.0 ± 1.7	ns
Scamper	42.5 ± 8.5	21.7 ± 8.5	**
Mounting	39.4 ± 14.5	50.7 ± 14.5	ns
Hop	40.4 ± 6.7	28.2 ± 6.7	ns

Average number of times a behavior was observed	Day 1	Day 2	P-value
Pivot	40.0 ± 5.2	19.6 ± 5.2	**
Toss head	22.4 ± 3.1	10.5 ± 3.1	***

In addition to the number of times a behaviour was performed, the average length of time a behaviour was performed for differed across days (Table 7). The mean duration of an aggressive event was longer on day 1 when compared with day 2. The mean duration of an aggressive event at the feeder was also longer on day 1 than on day 2. All other behaviours examined did not differ in duration across days (P > 0.05).

Table 7 - The average duration (seconds) a behaviour was performed irrespective of treatment (mean ± SEM) on days 1 and 2 post-weaning (ns = not statistically significant, * = P < 0.05, ** = P < 0.01 and *** = P < 0.001).

Average duration of behavior (sec)	Day 1	Day 2	P-value
Laying	1796.5 ± 1442.1	4657.9 ± 1442.1	ns
Feeding	56.8 ± 38.5	67.3 ± 38.5	ns
Active	2075.9 ± 395.9	1458.0 ± 395.9	ns
Belly nosing	4.4 ± 1.2	3.2 ± 1.2	ns
Nosing/chewing pen-mates	6.8 ± 4.9	14.8 ± 4.9	ns
Aggression	5.4 ± 0.7	4.0 ± 0.7	*
Aggression at feeder	2.3 ± 0.5	0.8 ± 0.5	*
Playful gestures	4.0 ± 0.8	4.4 ± 0.8	ns
Scamper	3.0 ± 0.4	3.2 ± 0.4	ns
Mounting	10.0 ± 2.0	7.8 ± 2.0	ns
Hop	-	-	-
Pivot	-	-	-
Toss head	-	-	-

The total length of time piglets spent performing a given behaviour within a pen also differed across days (Table 8). The total time piglets spent laying was significantly higher on day 2 than on day 1 post weaning. Total duration of activity was longer on day 1 than on day 2 post-weaning. The total time piglets spent performing aggressive behaviours was higher on day 1 than on day 2. Piglets also spent a higher amount of time scampering on day 1 compared with day 2.

Table 8 - The total duration (minutes) of a given behaviour (mean ± SEM) observed within a pen (irrespective of treatment) on days 1 or 2 post weaning (ns = not statistically significant, * = P < 0.05, ** = P < 0.01 and *** = P < 0.001).

Total duration of behavior (sec)	Day 1	Day 2	P-value
Laying	290.2 ± 20.4	324.4 ± 20.4	**
Feeding	107.0 ± 13.4	125.3 ± 13.4	ns
Active	310.6 ± 12.9	272.8 ± 12.9	*
Belly nosing	4.36 ± 1.27	3.15 ± 1.27	ns
Nosing/chewing pen-mates	3.58 ± 1.0	5.4 ± 1.0	ns
Aggression	21.0 ± 2.7	13.7 ± 2.7	*
Aggression at feeder	0.2 ± 0.1	0.0 ± 0.1	ns
Playful gestures	0.7 ± 0.2	0.7 ± 0.2	ns
Scamper	2.0 ± 0.4	1.2 ± 0.4	*
Mounting	9.0 ± 3.9	11.2 ± 3.9	ns

Total duration of behavior (sec)	Day 1	Day 2	P-value
Hop	-	-	-
Pivot	-	-	-
Toss head	-	-	-

A number of agonistic behaviours differed between treatments across days. Whilst the frequency of belly nosing was unaffected, the mean duration of a belly nosing event was longer on day 1 post-weaning in the CON compared to SP piglets (6.3 ± 2.0 versus 2.4 ± 1.3 sec; $P < 0.05$), but this treatment effect had disappeared by day 2 (Figure 3).

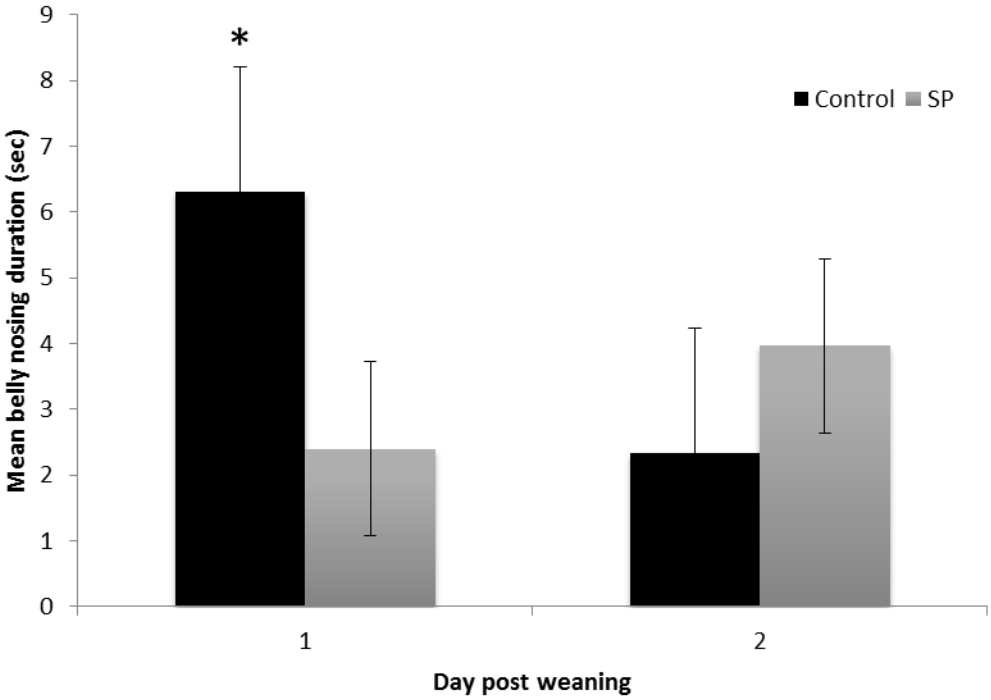

Figure 3 - The mean length of time (sec) a belly nosing event was performed (mean ± SEM) on days 1 and 2 post weaning for both control (CON) and separation pen (SP) treatments (* represents significant effect of treatment within day ($P < 0.05$)).

Similarly, the frequency of aggressive events was unaffected by treatment across days, however the mean duration of an aggressive event was longer on day 1 in the CON compared to SP piglets (6.5 ± 1.1 versus 4.2 ± 0.8 seconds; $P < 0.05$), but this treatment effect had disappeared by day 2 (Figure 4). There were no further treatment effects across days for any of the other behaviours examined ($P > 0.05$).

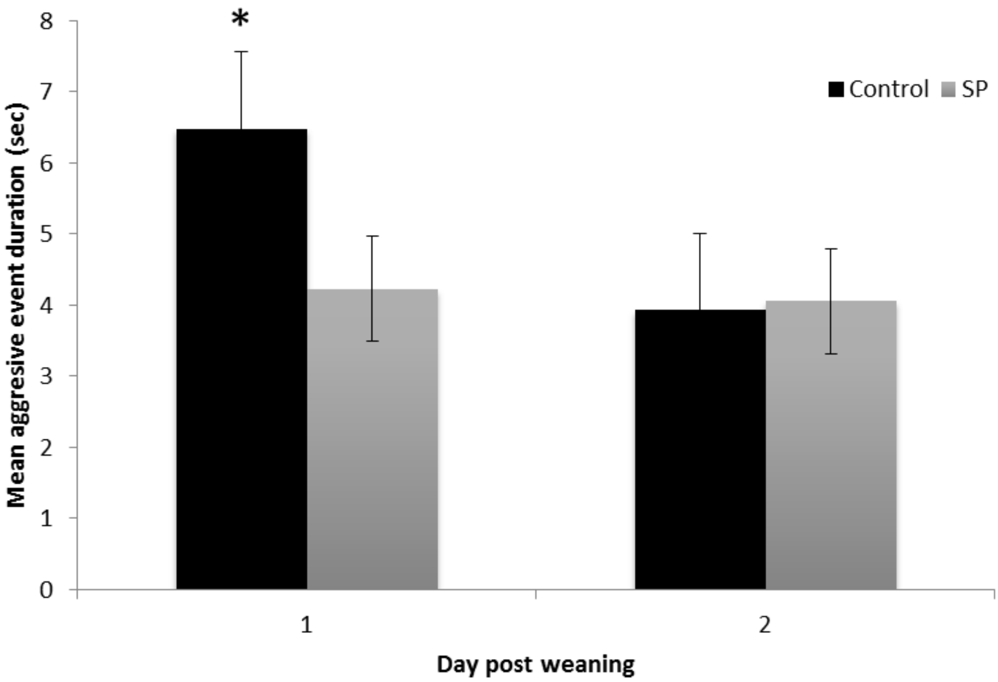

Figure 4 - The mean length of time (sec) an aggressive event was performed (mean ± SEM) on days 1 and 2 post weaning for both control (CON) and separation pen (SP) treatments (* represents significant effect of treatment within day (P < 0.05)).

3.4. *Injury Score*

The scores used to subjectively quantify the level of aggression in piglets differed between treatments across days. Scratch score was significantly lower in SP piglets (Figure 5; $P < 0.001$) on all days, with the exception of day 14 (day -1 0.32 ± 0.06, day 1 0.78 ± 0.06, day 2 0.95 ± 0.06, day 7 0.48 ± 0.06) when compared with CON (day -1 0.52 ± 0.06, day 1 0.99 ± 0.06, day 2 1.30 ± 0.07, day 7 0.87 ± 0.07). By day 14, there was no longer a treatment effect on scratch score.

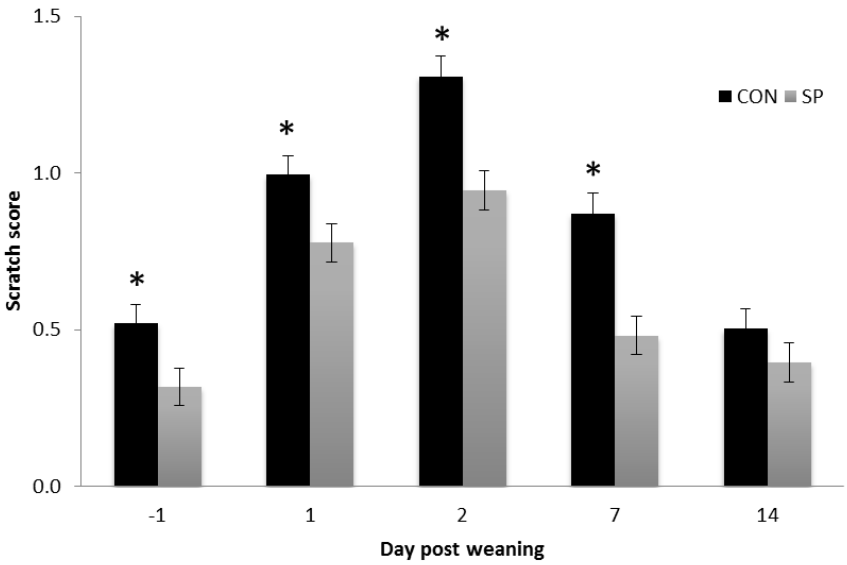

Figure 5 - Scratch score (mean ± SEM) for control (CON) and separation pen (SP) treatments on days -1, 1, 2, 7 and 14 relative to weaning (* represents significant effect of treatment within day (P < 0.05)).

Similarly, redness score was influenced by treatment across observation days (Figure 6). Redness score was significantly lower in SP piglets ($P < 0.001$) on all days with the exception of day -1 (day -1 0.14 ± 0.06, day 11.22 ± 0.06, day 2 1.53 ± 0.07, day 7 1.11 ± 0.07 and day 14 0.55 ± 0.06) when compared with CON piglets (day -10.22 ± 0.0.62, day 1 1.07 ± 0.06, day 2 1.08 ± 0.06, day 7 0.82 ± 0.64 and day 14 0.85 ± 0.07).

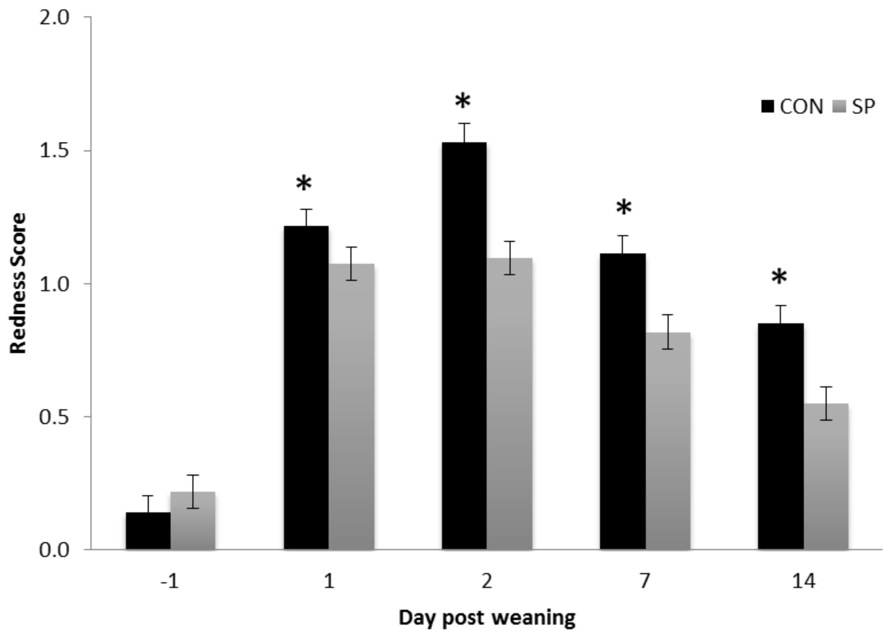

Figure 6. Redness score (mean ± SEM) for control (CON) and separation pen (SP) treatments on days -1, 1, 2, 7 and 14 relative to weaning (* represents significant effect (P < 0.05) of treatment within day).

3.5. *Cortisol*

The order in which blood samples were collected from a crate or pen had no effect on circulating plasma cortisol concentration ($P > 0.05$). However, cortisol concentrations were lower on day -1 for CON compared to SP piglets (44.7 ± 5.0 versus 66.8 ± 5.1 nmol/L; $P < 0.05$). This treatment effect had disappeared by day 2 (Figure 7).

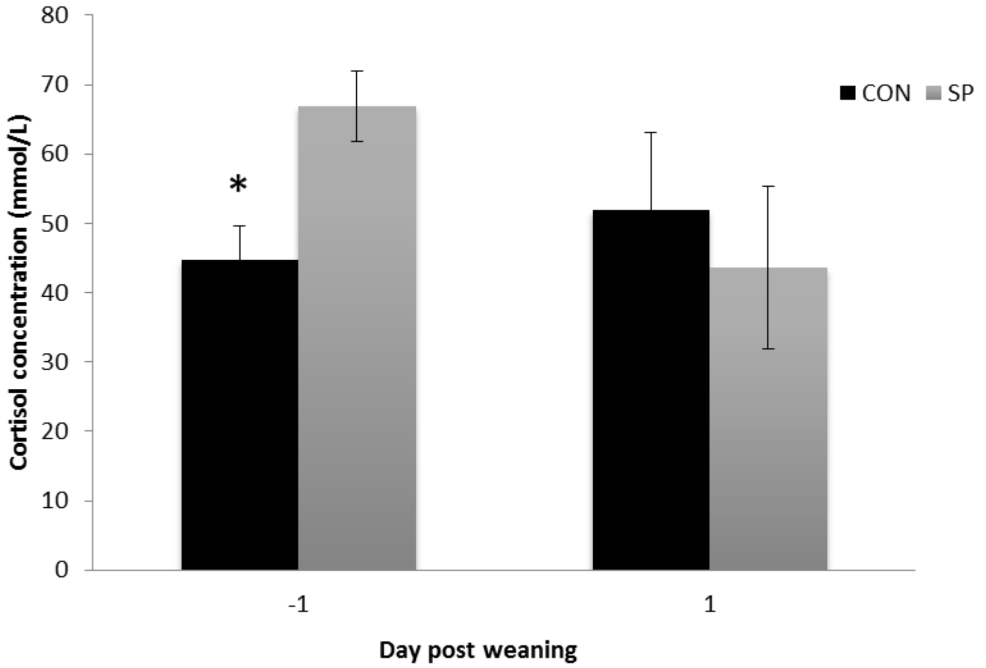

Figure 7. Cortisol concentration (nmol/L; mean ± SEM) for control (CON) and separation pen (SP) treatments on days -1 and 1 relative to weaning (* represents significant effect (P < 0.05) of treatment within day).

Change in plasma cortisol concentration from day -1 to day one relative to weaning also differed across treatment (Figure 8). Cortisol was increased in CON piglets post-weaning (18.7 ± 13.3 nmol/L), whilst the weaning event induced a decrease in cortisol in the SP piglets (-12.3 ± 14.1 nmol/L; $P < 0.05$).

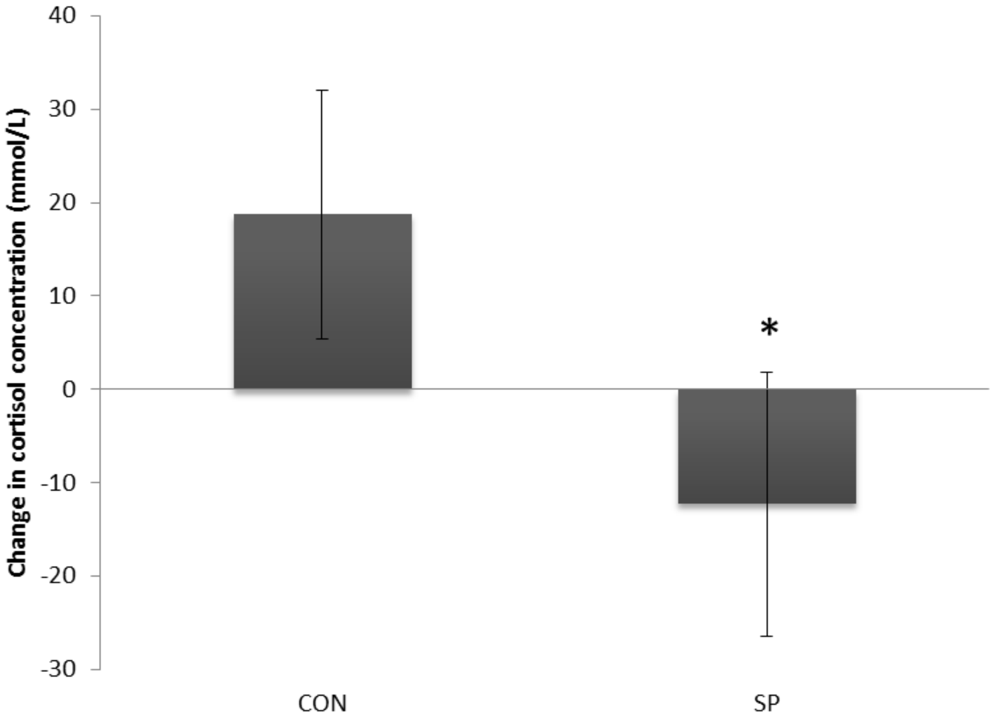

Figure 8 - Change in plasma cortisol concentration (mean ± SEM; nmol/L) over weaning (day -1 to day 1) for both the control (CON) and separation (SP) treatments (P < 0.05).

4. Application of Research

Results from this project indicate that gradually decreasing the contact a sow has with her litter as lactation progresses to induce a more gradual wean has beneficial effects for the piglets response to weaning. Specifically, the main findings were that piglets who received sow separation did not suffer the typically reported 'growth check' after weaning, were more likely to consume creep feed, displayed lower levels of agonistic behaviours, reduced injury scores and stress hormone release was attenuated in response to the weaning event. This project supports the notion of others that the welfare of piglets who are weaned abruptly from the sow, as is common commercial practice, may be compromised and that gradual weaning will result in physiological, behavioural and performance improvements.

Whilst welfare improvements are clear, how to achieve a gradual wean under commercial conditions is more difficult. The project was initially designed to investigate the effect of a 'sow controlled' gradual wean, whereby the sow could remove herself from the farrowing crate to reduce piglet contact. However, before the experiment started it was discovered that sows would not voluntarily remove themselves from the crate, so the enforced separation regime was employed. Labour associated with moving the sow was significant, and so for such a housing option to be commercially relevant, more research needs to be conducted into crate and pen design aspects to allow more voluntary separation of sows from their litter. The most likely cause for the sows failure relocate to the rear pen is the direction in which she was required to move. The pens were housed at the rear of the crate, meaning the sow had to back out over a roller (acting to contain piglets), a behavior which she refused to perform. Future investigations into 'sow controlled' gradual weaning should be performed to benefit piglet welfare around weaning. These investigations should be focused around design aspects of the crate and pen that allow/facilitate desirable sow behavior (she DOES remove herself from piglets, she DOES return to piglets, and that the time spent away increases gradually as lactation progresses).

5. Conclusion

The weaning event results in marked nutritional, environmental and social changes for piglets and is often cited as being a time of significant stress. Gradually reducing sow contact as lactation progresses has been shown to result in increased solid feed consumption by piglets prior to weaning which leads to improvements in growth immediately following weaning. What is not well understood is if reduced maternal contact improves physiological and behavioural responses to weaning in piglets. Results from this project have confirmed previous effects of gradual weaning on creep feed ingestion, and growth after weaning. Additionally, piglets from gradually weaned litters showed little to no increase in HPA axis activity in response to the weaning event, and experienced reduced levels of agonistic behaviours in weaner accommodation. Given the improvements in performance, physiology and behavior, it can be confirmed that gradual weaning results in enhanced piglet welfare.

6. Limitations/Risks

Application of findings at a commercial level is limited at this stage given the impracticality of the housing design utilized in this project. Further work on housing design is recommended before gradual weaning can be successfully implemented in the commercial environment.

7. Recommendations

Given the benefits of gradual weaning on piglet welfare and performance, the investigators would like to see future work conducted into housing design and husbandry methods that can be employed to reduce sow contact with litters as lactation progresses to enable a more gradual weaning process.

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