Effects of timing of burlap provision on piglet behaviour, welfare, and performance

by

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ABSTRACT

Many factors contribute to high stress at weaning in commercial pigs. Increased stress can lead to increased aggressive behaviours such as tail biting, displacements, and belly nosing. Enrichment, such as burlap, may provide an outlet for stress, providing a positive source of enrichment and allowing piglets to perform natural behaviours. The first objective of this study was to determine if providing burlap as enrichment can reduce the stress of weaning on piglets through reduced aggressive behaviours and fewer lesions. The second is to determine if there is a stage of life (pre- or post-weaning) when it would be most beneficial to introduce burlap to piglets. Piglet behaviour, lesion scores, mortality, and mass data were collected for three weeks pre-weaning and five weeks post-weaning. Four treatments were used to assess the timing of burlap provision: control (no burlap), post-weaning in the nursery room only (N), pre- and post-weaning in farrowing and nursery rooms (FN), and finally to the sow as well as to piglets pre- and post-weaning (SFN). Results of this experiment suggest that burlap enrichment positively impacts piglets through increased socialization and reduced aggressive behaviours. Results showed that burlap may have the greatest positive impact on piglets when provided in both farrowing and nursery rooms through increased piglet interaction with the burlap and fewer displacement behaviours. In summary, burlap is a promising low-cost enrichment option to improve the welfare of commercial piglets.

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INTRODUCTION

Background Information

Starting at an early age, animals raised in commercial environments cope with many physical and psychological stressors. One common stressor faced by all piglets in commercial barns is weaning (Wosrsaae and Schmidt, 1980). On weaning day, the piglets are separated from the sow and moved from the farrowing room to the nursery room. Farrowing is the term used for when the sows give birth to the piglets, and piglets are housed in the farrowing rooms for three weeks after birth. The piglets are housed in the nursery room after weaning. In the nursery room, the piglets receive a new diet and adjust to a new environment. Although piglets are provided with a solid feed prior to weaning, they are abruptly weaned off the sow and no longer have the comfort of nursing (Cambell et al. 2013). These changes are stressful for the piglets (Wosrsaae and Schmidt 1980), which can have adverse effects on productivity and mass gain (McCracken et al. 1999), as well as causing increased aggression toward other piglets (Forkman et al. 1995).

Commercial piglets are housed in relatively barren environments. Therefore, providing forms of environmental enrichment may provide an outlet for stress, reduce harmful behaviours, as well as encourage positive behaviours such as exploring, chewing, and playing (Oostindher et al. 2011; Martin et al. 2015; Yang et al. 2018; Swan et al. 2021). Positive behaviours improve animal welfare, quality of life, and production through increased mass gain (Oliveira et al. 2016). A lack of environmental enrichment to help piglets cope with these stressors can lead to increased aggressive behaviours such as tail biting, ear biting, and belly nosing (Oostindher et al. 2011; Yang et al. 2018; Swan et al. 2021). Tail biting occurs when a piglet bites or chews on another piglet's tail, causing

raw tissue or blood/scabs at the end of the tail (Hakansson and Bolhuis 2021). Ear biting occurs when one piglet chews or bites on another piglet's ear, leading to raw tissue or blood/scabs on the edges or tip of the ear(s) (Hakansson and Bolhuis 2021). Belly nosing is a behaviour often performed by young piglets post-weaning, where they rub their nose vigorously on the underbelly of a pen mate as they would to their mother to stimulate milk production (Fraser 1978; Widowski et al. 2007). This behaviour can lead to serious skin irritation, bruising, and lesions (Straw and Bartlett 2001). Other adverse outcomes associated with increased stress include reduced mass gain and increased lesions, which include any scratches or abrasions on any part of the pig, including the piglet head, body, back, and hind end (McCracken et al. 1999; Widowski et al. 2003; Vanheukelom et al. 2011). Providing enrichment to the piglets can reduce these effects (Beattie et al. 2001) by giving them an outlet for their aggression and redirecting oral behaviours from pen mates to the enrichment.

Many studies have previously investigated whether providing enrichment to piglets can increase positive social behaviours in piglets and reduce adverse behaviours. Oostindher et al. (2011) looked at the impact an enriched environment had on commercial piglets pre- and post-weaning. They compared a barren environment with different types of enrichment including increased space, straw, wood shavings, peat, and branches. Results showed that piglets housed in the enriched pens performed lower levels of belly nosing in proportion to more beneficial behaviours such as chewing, play behaviours, and food exploration. A similar result was seen in a study by Yang et al. (2018), who looked at the effects different types of enrichment (hanging objects or a substrate box with tree bark) had on the ability of piglets to cope with stressors during nursing up to 10 days post-

weaning. Piglets provided with enrichment showed a greater proportion of piglets engaged in play behaviours and they performed fewer aggressive behaviours, while also having lower cortisol levels at weaning than piglets in the control group (Yang et al. 2018). Cortisol is a steroid hormone associated with stress levels and the flight-or-flight response; the lower cortisol levels in the groups with enrichment indicate that enrichment may lead to reduced physiological stress levels in piglets (Wosrsaae and Schmidt 1980). However, cortisol levels are also elevated in times of high energy, such as exercise and cortisol levels alone do not indicate the valence (positive or negative affect, or affective state), only arousal (Düpjan et al. 2013). Providing enrichment also improves socio-cognitive abilities, which can benefit long-term welfare in commercial pigs through an increase in positive emotional states (resulting from play) and a reduction in chronic aggression post-weaning (Martin et al. 2015).

Different forms of enrichment have previously been tested in many studies; however, the effect of burlap on reducing stress in piglets has not often been examined in detail. Burlap offers many beneficial qualities as an enrichment item. Burlap is flexible and easily digested by piglets, allowing them to perform oral manipulation, which is a natural behaviour of pigs (Camerlink et al. 2012). Enrichment with hessian (a product similar to burlap) was compared to bamboo by Schmitt et al. (2020) by examining the behavioural effects of each enrichment item on piglets from birth until weaning. They found that hessian was more favourable for piglets as it allowed oral manipulation, such as biting and shaking, which were the most frequently performed behaviours in the hessian treatment; they also noted that piglets preferred hessian as it was easily

destructible, and interactions with the hessian increased over time rather than the piglets losing interest in the enrichment (Schmitt et al. 2020).

Providing sows along with the piglets with enrichment may also improve the productivity of sows. Fynn et al. (2021) provided burlap to both sows and piglets. In this study, burlap was first provided pre-farrowing to sows and sows with burlap had fewer stillbirths and fostered more piglets than those without the enrichment. Throughout the study, farm staff noted that the piglets engaged with the burlap performing positive behaviours, however, these behaviours were not looked at in detail like in Fynn et al. (2021). The observations of piglets suggest that further research into the effects of burlap as enrichment at farrowing for piglets may be needed. In previous work by our research group (Scott et al. submitted), burlap promoted positive behaviours in piglets. However, the most beneficial age of providing enrichment has yet to be investigated.

Research Objectives

There are two main objectives of my study. The first is to determine if providing burlap as enrichment can reduce the stress of weaning on piglets through reduced aggressive behaviours and fewer lesions. The second is to determine if there is a stage of life (pre- or post-weaning) where it would be most beneficial to introduce burlap to piglets to prevent aggressive behaviours and encourage positive social behaviours.

Hypothesis & Predictions

My first hypothesis for this experiment is that if enrichment reduces stress, then providing burlap to piglets will reduce adverse behaviours associated with weaning. I predict that piglets provided with the burlap enrichment will perform fewer aggressive

behaviours (tail biting, ear biting, belly nosing, fighting) and have fewer lesions post-weaning. In addition, there will be increased positive outcomes in treatment groups with the burlap, such as increased mass gain. My second hypothesis is that if the age at which burlap is introduced to piglets has an impact on their use of the enrichment, then there will be differences observed between when burlap is provided, either pre-weaning or post-weaning. I predict that providing the burlap earlier to the piglets will allow them to become more accustomed to engaging with it; therefore, in treatment groups where burlap is provided pre-weaning, there will be more interaction with the burlap post-weaning. In treatment groups where the sow is also provided with the burlap, I predict that the additional interactions between the sow/piglet/burlap will increase the piglets' use of the burlap both pre- and post-weaning.

MATERIALS & METHODS

Animal Housing & Management

My study occurred at the Glenlea Research Station's intensive operation facilities. The Glenlea Research Station Swine Facility includes four farrowing rooms and four nursery rooms. The farrowing room is where the sows give birth and where the sows and piglets are housed throughout lactation until weaning (occurs on day 14). Each farrowing room contains 12 standard farrowing crates, that are 2.3 x 1.7 meters. In a standard farrowing crate, the sow is restricted to a stall in the middle of the crate to prevent her from crushing the infant piglets (Appendix B, Figures 1 and 2). When the piglets are weaned from their sows, they are moved to the nursery room. The nursery room is where the piglets are housed post-weaning for four weeks. Each of the nursery rooms contains 12 pens (1.8 x 1.5 meters), and each can house a maximum of 12 piglets (Appendix B, Figures 3 and 4). As standard practice, every nursery pen was equipped with a pen toy. The pen toys are made of a thick rubber material (similar to a dog toy) and were either hanging from a chain in the middle of the pen or placed on the ground. Burlap was fastened to pen dividers using C-clamps for piglets and was tied in a knot and placed into a specifically designed slot for sows (Appendix B).

Piglets were enrolled in the trial when they were approximately 7 days old, at which time burlap was placed in the pens according to the assigned treatment (Table 1). Burlap was placed in the pens at a reachable length of less than 10 cm off the ground. Observations of piglet behaviour began when the piglets were 14 days old. Farrowing room observations continued until weaning (day 21), followed by behavioural observations once per week for five weeks in the nursery. In total, there were 6 weeks of

behavioural observations. Based on the current standard practice at the barn, litter size was balanced by the ratio of the number of piglets to their sow's number of functional teats. This balance means that if a sow births more piglets than she has functional teats, the extra piglets are fostered onto another sow. Litter sizes are also balanced by the number of piglets per litter per room; if there is an unequal ratio of piglets birthed by sows (for example one sow has 7 and another has 16), the piglets will be fostered onto another sow to balance the number of piglets per sow and per room. Piglets from each litter (either born or assigned to) are kept together after weaning; the exceptions are smaller piglets and large litters. Smaller piglets are grouped into a runt pen when moved into the nursery rooms and large litters are split up to accommodate the maximum number of 12 piglets per nursery pen.

Experimental Design

We used a randomized block design, where each room is considered one block, with four treatments to analyze the effects of burlap provisioning at various times on piglets. Because treatments were applied at the litter level where all individuals in a litter received the same treatment, the litter was considered the experimental unit. In this trial, there were four treatment groups (Table 1).

Table 1. *Description of each treatment group for both pre- and post-weaning piglets. Burlap is provided at different stages farrowing (F), nursery (N), and in some groups the sow (S). The pre-weaning stage occurs in the farrowing rooms and the post-weaning stage occurs in the nursery rooms. See Appendix C for a figure depicting a farrowing/nursery room setup.*

Burlap Treatment	Pre-weaning	Post-weaning
C	No burlap	No burlap
N	No burlap	Piglets provided burlap
FN	Piglets provided burlap	Piglets provided burlap
SFN	Piglets and sow v burlap	Piglets provided burlap

The sample sizes were based on sample size calculations determined with previously published data considering injury scores, social behaviour, and growth rates (Salazar et al. 2018; Camerlink et al. 2021; Van Kerschaver et al. 2021). Based on these factors we needed a sample ranging from 2 to 14 litters per treatment group (Salazar et al. 2018; Camerlink et al. 2021; Van Kerschaver et al. 2021) for one-sided tests with an alpha of 0.05 and power of 80% to determine differences between treatments from those studies as well as differences of 5 or 10% between treatments.

During the first trial, there were 20 sows available in two farrowing rooms (2 blocks, n = 5 per treatment). In each of the farrowing rooms, there were 2 crates kept open per room that were “not on trial” (N.O.T) to allow for cross-fostering where necessary. Each of the 20 litters was followed through to two nursery rooms (2 blocks, n = 5 per treatment). During the second trial round, there were 40 sows available in four farrowing

rooms (4 blocks, n = 10 per treatment). However, due to standard operating procedures and health/performance concerns, one sow was culled. This litter was removed from the trial, leaving 39 sows/litter in the trial (4 blocks, n = 9 to 10 per treatment). Because one nursery room was only set up to house pigs in two large groups, only 3 nursery rooms were available and one nursery pen had to be kept available as a sick pen; therefore, we followed 35 litters through to the nursery in three rooms (3 blocks, n = 8 to 10 per treatment).

Data Collection

Current practice at Glenlea Research Station is that the staff record sow and litter health data regarding piglet mortality, the number of piglets born alive, and sow parity. These data were used for analysis. In-person behavioural observations conducted by trained researchers were used to document piglet behaviour (such as lying, nursing/eating, exploring/active), including adverse behaviours (tail biting, belly nosing, ear biting, fighting). Each of the behaviours was categorized and defined using a specific ethogram (Appendix D; Table 2), and observations were recorded on the datasheets provided (Appendix A). All observers were trained and interobserver reliability (IOR) tests were conducted before observations to ensure reliability between observers (Appendix F, Table 3).

During every behaviour observation for each pen, there was first an instantaneous scan sample followed by two 30-second observations for each pen. A given observation day would be conducted as follows: starting with the first pen in the room the observer conducted an instantaneous scan of piglets in the pen and recorded the number of piglets performing burlap engagement, eating/drinking, active, and resting behaviours. The

observer then conducted continuous behaviour observations divided into two 30-second intervals where each of the following behaviours was recorded based on being present or not present: fighting, biting, belly nosing, socializing, pen object engagement, and burlap engagement. The observer then moved to the second pen in that room. After each pen in the room had been observed the observer then moved to the next room. The observer would go through all four rooms before taking a short break before repeating behaviour observations. There were two observers each observation day and each would conduct two rounds of behaviour observations, each round including both instantaneous scan observations and continuous behaviour observations, resulting in a total of four behavioural observations per pen each observation day. Pre-weaning behavioural observations were performed on day 14 and day 21, with data recorded on the data sheets provided (Appendix A). Post-weaning behavioural observations were conducted one day after weaning (day 22) and then continued once a week for five weeks (weeks 3 to 7). Instantaneous scan observations were scored on the number of piglets performing each behaviour in that instant. These results were averaged per day and over time to calculate the mean percent of the proportion of piglets engaged in each activity/behaviour during observations. Continuous behaviour observations were scored on a scale of one to indicate that the behaviour was present and zero to indicate that the behaviour was not present. Data was then averaged to determine the mean percent of observations the piglets performed each behaviour.

Lesion scoring was conducted on day 21 (the morning before weaning) based on the Turpin et al. (2017) scoring system, which outlines the assessment of severity for lesions (red marks and scabs) on the piglets' body, tail, and ears. All lesions (ears, nose,

tail, and body) were recorded on the data sheets provided. Lesion scoring was conducted again one day after weaning (day 22), followed by lesion scoring once a week for the remaining five weeks of the trial. We then calculated the number of lesions per experimental unit (number of all lesions per pig per pen) (Appendix E). Lesions were expressed as the mean number of lesions per piglet in each group to standardize across different litter sizes.

Piglet body masses were recorded three times during the experiment: 1) at birth, 2) day of weaning (week 3 of life), and 3) when the piglets left the Glenlea Research Station (week 9 of life). Piglets were weighed as a litter and the mean mass per piglet in each litter was calculated to standardize piglets' masses across different litter sizes.

The remaining amount of burlap was scored at the end of the experiment to assess the burlap used by the piglets. At the beginning of the experiment, each pen received the same amount of burlap, at the end of the study the burlap was removed from each pen and measured to determine how much was remaining. The amount of burlap was then scored on a scale of one to five, where one indicated no burlap remaining and 5 indicated full burlap remaining. These results were then averaged across treatment groups and compared as burlap remaining score between treatment groups.

Data Analysis

We used a generalized linear model to determine the effects of our fixed effect (replicate and treatment). As parity can influence a sow's care of piglets, where more experienced sows may provide better maternal care (Anderson et al. 2005), we balanced the parity of sows across all treatments. Therefore, we will not analyze the effect of parity

in our study. Outcome variables included behavioural observations, lesion/biting scoring, and performance parameters such as mass gain and mortality. I collected data on behavioural observations, lesion scores, burlap usage, and mass gain and data are presented as the mean for each litter per treatment. Statistical analyses were performed as follows: The Bartlet test and Shapiro-Wilk test were used to test for normality. A two-way ANOVA linear model was run on all data that met the normality criteria, and from these significant differences were declared where $P \leq 0.05$ and tendencies at $P > 0.05$. Non-normal conforming data were analyzed using the Kruskal-Wallis test. All statistical analyses were run in Rstudio © (Version 2023.03.0+386).

RESULTS

Piglet Behaviour

Based on pre-weaning behaviour observations in the farrowing rooms, there were significant differences in the number of observations where positive socialization behaviours were present, including both piglet-piglet and piglet-sow interactions (Kruskal-Wallis, $X^2 = 7.8$, df = 3, $P = 0.05$; Figure 1). Positive socialization behaviours occurred more in the SFN treatment (n = 15) groups than in the control (n = 14) treatment groups (Z = 2.7, Holm method, $P_{adj} = 0.036$; Figure 1). The other treatment groups, N (n = 14) and FN (n = 15), did not differ in the proportion of observations where socializing behaviours were observed in the farrowing rooms (Holm method, $P_{adj} > 0.1$). Post-weaning socializing behaviours did not differ among the treatment group rooms (Kruskal-Wallis, $X^2 = 3.4$, df = 3, $P = 0.34$).

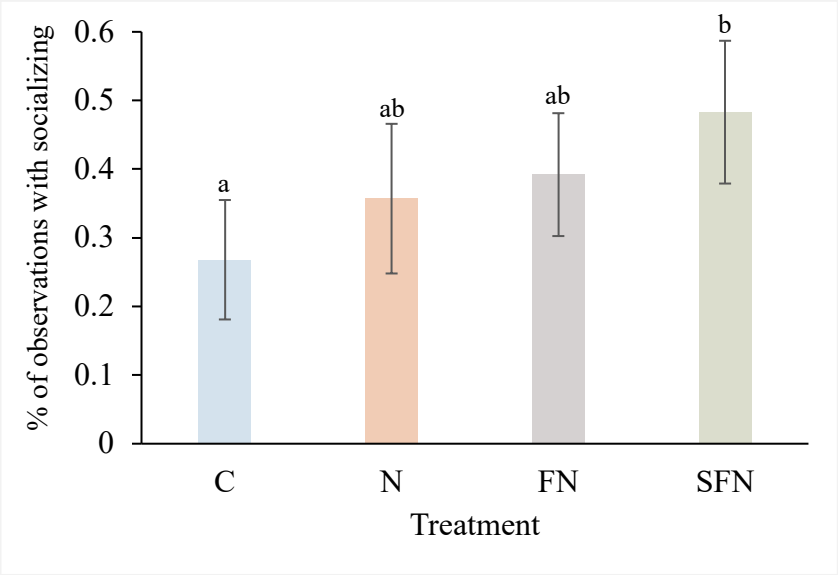

Figure 1. *Mean of the percent of observations where piglets were seen socializing with each other or their sow pre-weaning. Observations were calculated and averaged combining data from Trial 1 and Trial 2 for each treatment: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), and sow/farrowing/nursery (SFN, green).*

Before weaning, the number of observations with observed fighting differed between treatment groups (Kruskal-Wallis, $X^2 = 7.8$, df = 3, $P = 0.051$). However, results from direct comparisons between treatment groups specifically there was no significant difference between each control (n = 14, 0.14 ± 0.13%, $P > 0.1$), N (n = 14, 0.098 ± 0.059%, $P > 0.1$), FN (n = 15, 0.058±0.059, $P > 0.1$), and SFN (n = 15, 0.058±0.069%, $P > 0.1$) groups (Figure 2). Pre-weaning observations in the farrowing rooms also showed no significant differences between treatment groups for biting (Kruskal-Wallis, $X^2 = 1.5$, df = 3, $P = 0.69$), belly nosing (Kruskal-Wallis, $X^2 = 0.60$, df = 3, $P = 0.89$) and displacement (Kruskal-Wallis, $X^2 = 2.2$, df = 3, $P = 0.53$) behaviours.

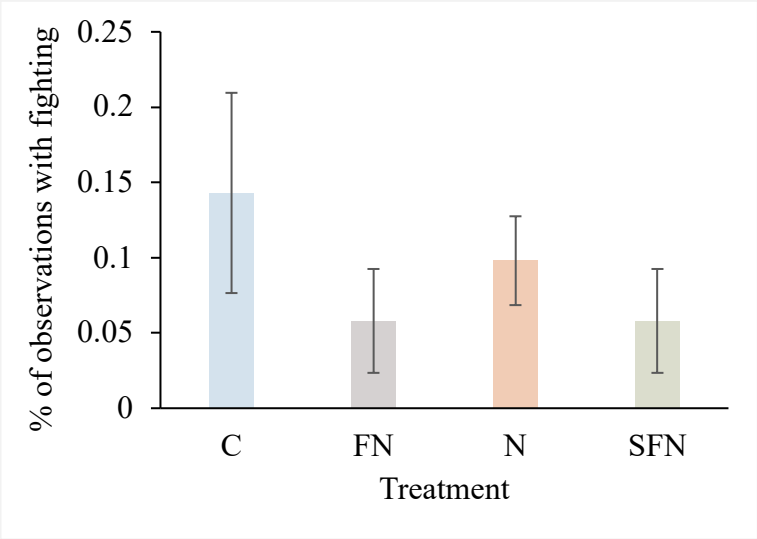

Figure 2. *Mean presence of pre-weaning fighting behaviours from continuous behaviour observations in the farrowing rooms. Fighting behaviours were measured as present or not, and the mean was calculated and compared across the four different treatment groups: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), and sow/farrowing/nursery (SFN, green). Results showed no significant difference across treatment groups.*

After weaning, there were differences between treatment groups in terms of fighting behaviours (Kruskal-Wallis, $X^2 = 7.7$, df = 3, $P = 0.05$). Pigs on the control (n = 13) treatment exhibited more fighting behaviours during observations than the N (n = 14) treatment (Z = 2.4, Holm method, $P_{adj} = 0.084$; Figure 3) and the FN (n = 14) treatment (Z = 2.4, Holm method, $P_{adj} = 0.097$; Figure 3).

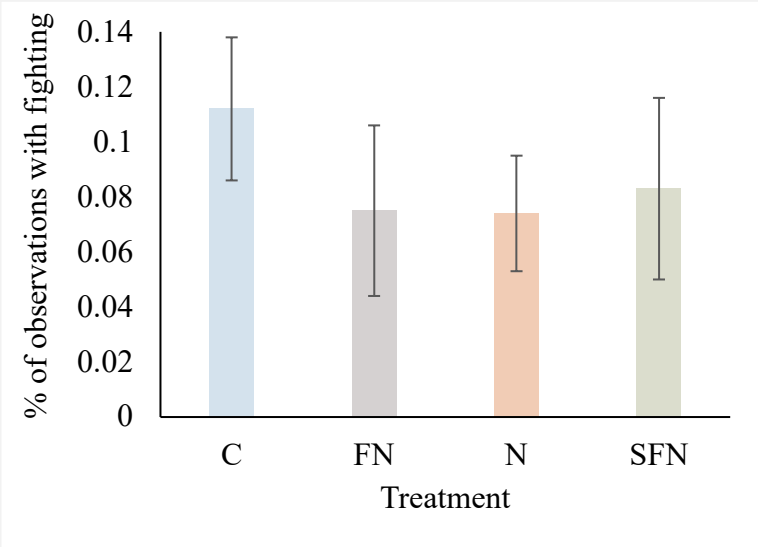

Figure 3. *Mean presence of post-weaning fighting behaviours from continuous behaviour observations in the nursery rooms. Fighting behaviours were measured as present or not, and the mean was calculated and compared across the four different treatment groups: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), and sow/farrowing/nursery (SFN, green). Results showed no significant differences across treatment groups.*

Post-weaning observations demonstrated a significant difference between treatment groups in biting behaviours (Kruskal-Wallis, $X^2 = 11.19$, df = 3, $P = 0.01$). The control (n = 13) group had more observations with biting than the FN (n = 14) group (Holm method, $P_{adj} = 0.039$; Figure 4) and the SFN group (Holm method, $P_{adj} = 0.048$; Figure 4).

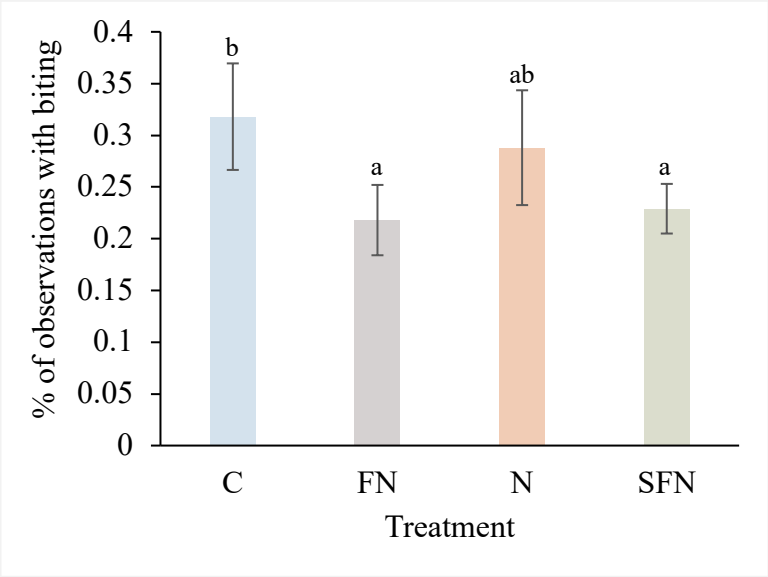

Figure 4. *Mean presence of post-weaning biting behaviour from continuous behaviour observations in the nursery rooms. Biting behaviours were measured as present or not, and the mean was calculated and compared across the four different treatment groups: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), sow/farrowing/nursery (SFN, green).*

There was a significant difference between treatment groups for displacement behaviours after weaning (Kruskal-Wallis, $X^2 = 11.7$, df = 3, $P = 0.008$). There were more observations with displacements in the control (n = 13) pigs than in the N (n = 14) treatments (Z = 2.7, Holm method, $P_{adj} = 0.034$; Figure 5a) and the FN (n = 14) treatment (Z = 3.1, Holm method, $P_{adj} = 0.012$; Figure 5a). In groups provided with burlap enrichment, the N pigs tended to have more displacements at the burlap compared to the

FN treatment (Z = 2.1, Holm method, P_{adj} = 0.075; Figure 5b) and the SFN (n = 14) treatment (Z = 2.3, Holm method, P_{adj} = 0.066; Figure 5b).

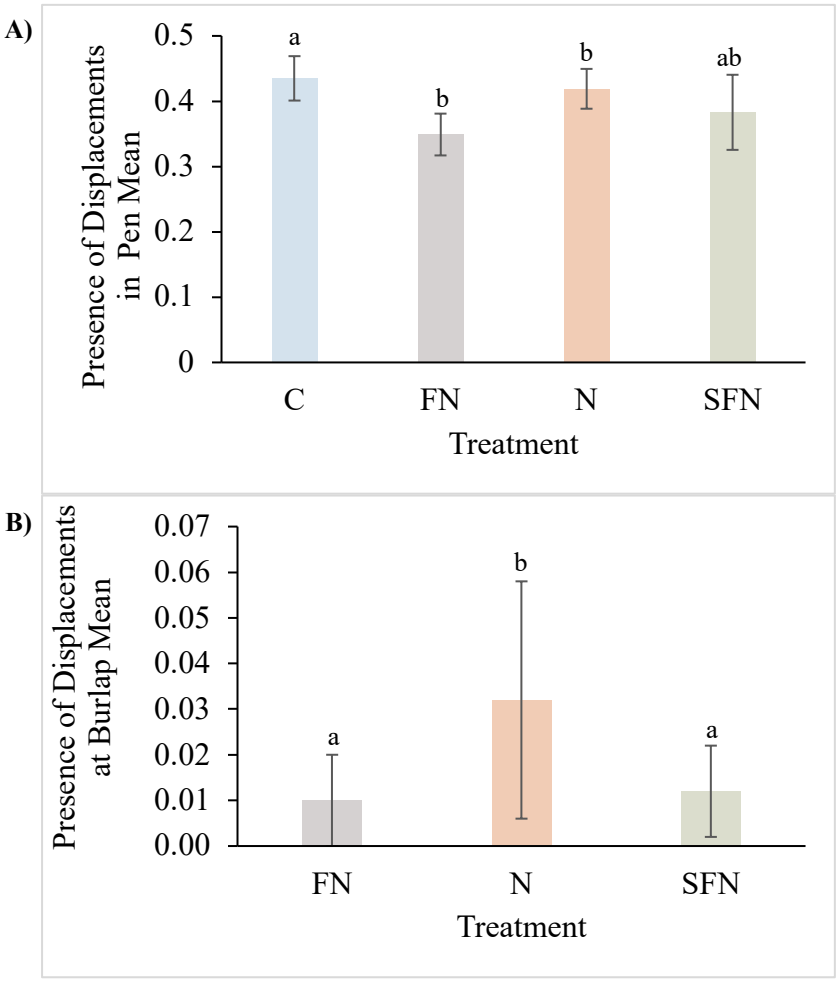

Figure 5. ***A)*** *Mean presence of post-weaning displacement behaviour (total at all locations throughout the pen?) from continuous behaviour observations in nursery rooms.* ***B)*** *Mean presence of post-weaning displacement behaviour specifically at burlap from continuous behaviour observations in nursery rooms. Displacement behaviours were measured as present or not, and the mean was calculated and compared across the three different treatment groups provided with burlap: nursery (N, orange), farrowing/nursery (FN, brown), sow/farrowing/nursery (SFN, green). Results showed no significant differences across treatment groups.*

Observations in the nursery room showed that there were differences in the amount of toy engagement between the different treatments (Kruskal-Wallis, $X^2 = 9.07$, df = 3, $P = 0.028$). The control (n = 13) pigs engaged with the toy more than the SFN (n = 14) pigs (Z = 2.7, Holm method, $P_{adj} = 0.039$; Figure 6); the control pigs also tended to engage with the pen toy more than both the N treatment (Z = 2.4, Holm method, $P_{adj} = 0.084$; Figure 6) and the FN treatment (Z = 2.2, Holm method, $P_{adj} = 0.10$; Figure 6).

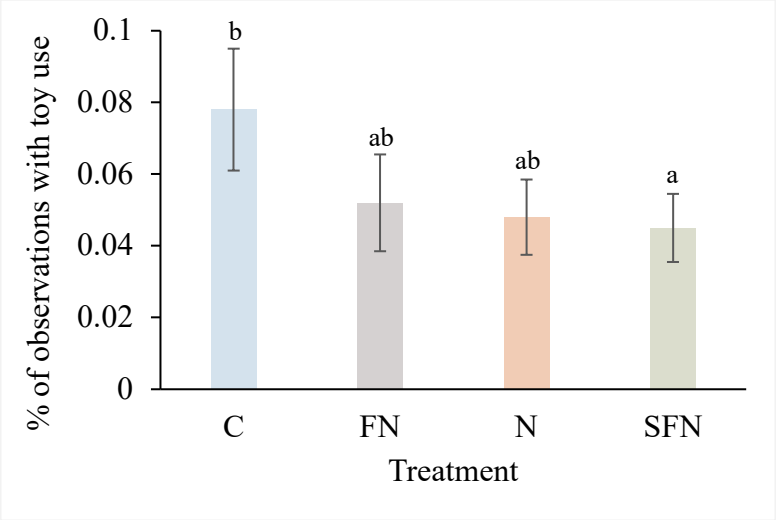

Figure 6. *Mean presence of post-weaning toy use from continuous behaviour observations in the nursery rooms. Toy engagement behaviours were measured as present or not, and the mean was calculated and compared across the four different treatment groups: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), sow/farrowing/nursery (SFN, green).*

Before weaning, when piglets had the opportunity to engage with the burlap, they rarely did so (Table 2). Post-weaning data demonstrate that when piglets were given the option of both enrichment items (N, FN, and SFN treatments), the proportion of piglets engaging

with enrichments was split almost evenly between the pen toy (5.5%; Table 2) and the burlap (4.0%; Table 2). The control groups showed a proportion of 7.8% of piglets engaging with the toy during scans (Table 2).

Table 2. *Breakdown of the proportion of piglets engaged with different activities including eating/drinking, active, resting, engaged with burlap, and engaged with the pen toy. Data was collected from instantaneous scan observations in both the farrowing and nursery rooms, averaged between treatment groups and the mean proportions of piglets (shown as a percentage) engaged with each activity was calculated.*

	Treatment	**Eating/ Drinking**	**Active**	**Resting**	**Burlap**	**Toy**
Farrowing	C	21%	24%	55%	-	-
	N	20%	25%	55%	-	-
	FN	15%	22%	60%	2.3%	-
	SFN	24%	23%	51%	2.0%	-
	Overall	20%	23%	55%	2.0%	-
Nursery	C	8.1%	34%	50%	-	7.8%
	N	7.8%	38%	46%	4.3%	4.8%
	FN	7.9%	36%	47%	3.3%	5.2%
	SFN	7.8%	36%	48%	3.4%	4.5%
	Overall	7.9%	36%	48%	4.0%	5.5%

Lesion Scoring

Lesions scores were compared across treatment groups one day post-weaning (observation day 4, D4) and shipment day (observation day 8, D8) (Figure 7). The lesion scores did not differ by treatment (Bartlet test, $K^2 = 3.6$, df = 3, $P = 0.31$; Shapiro-Wilk, W = 0.99, $P = 0.76$).

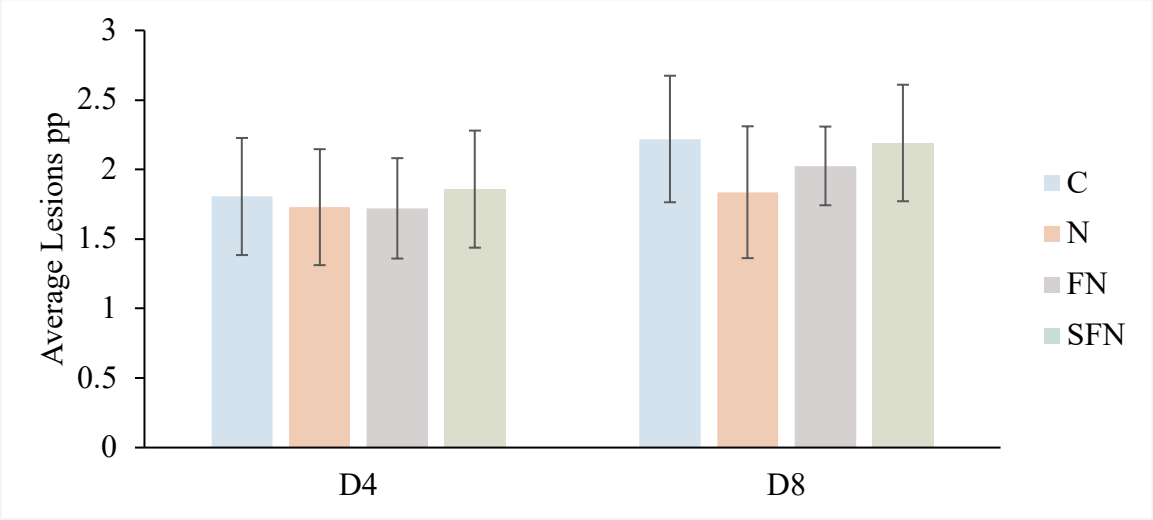

Figure 7. *The mean lesion scores per piglet (pp) post-weaning. Data are from each observation day post-weaning, beginning on the day after weaning, observation day 4 (D4) through till the last observation day (D8). Data compare lesion scores across the four different treatment groups: control (C, blue), nursery (N, orange), farrowing/nursery (FN, brown), sow/farrowing/nursery (SFN, green). Results showed no significant differences across treatment groups.*

Performance

Piglets were weighed at birth, weaning, and shipping. Body masses were averaged for each litter by treatment group as a response variable (Figure 8). Birth masses were similar across treatment groups ranging between 1.1 to 2.2 kg/piglet ($F = 0.24$, $df = 3$, $P = 0.87$; Figure 8a). Weaning masses were similar across treatment groups with no significant differences ($F = 0.38$, $df = 3$, $P = 0.77$). The mean piglet mass at weaning for each treatment was as follows: control group 6.4 ± 0.88 kg/piglet (n = 14), N 6.3 ± 0.75 kg/piglet (n = 14), FN 6.2 ± 1.0 kg/piglet (n = 14), and SFN 6.3 ± 0.65 kg/piglet (n = 15). There was no significant difference across treatment groups for mean piglet shipping mass (Bartlett test, $K^2 = 1.0$, df, $P = 0.79$; Figure 8b). The mean shipping piglet mass across each treatment group was as follows: control group 47.9 ±6.4 kg/piglet (n = 8), N 45.9±5.1 kg/piglet (n = 10), FN 46.3±4.9 kg/piglet (n = 8), and SFN 50.2± 4.4 kg/piglet (n = 9). There were no significant differences in mass gain between treatment groups in farrowing from birth to weaning ($F = 1.8$, $df = 3$, $P = 0.17$) or in the nursery from weaning to shipping ($F = 2.1$, $df = 3$, $P = 0.12$; Shapiro-Wilk, $W = 0.98$, $P = 0.63$). Results from weight data overall from birth to shipping showed no significant differences between treatment groups ($F = 1.9$, $df = 3$, $P = 0.71$).

Mortality

Mortality was recorded for piglets across the entire experiment, and these data were compared across treatments as well as between piglets provided with burlap and piglets without burlap at that stage. Results across all four treatment groups (control, N, FN, and SFN) from birth to shipping showed no significant difference in piglet mortality ($F = 2.1$, $df = 3$, $P = 0.13$). Pre-weaning mortality showed a tendency for higher mortality of piglets with no burlap (the control and N treatments) compared to the piglets that had burlap (FN and SFN treatments) ($F = 2.3$, $df = 5$, $P = 0.057$; Figure 9). Post-weaning results from the nursery room showed no significant differences in mortality of piglets with no burlap (control treatment) compared to piglets with burlap (N, FN, and SFN treatments) ($F = 0.74$, $df = 1$, $P = 0.33$).

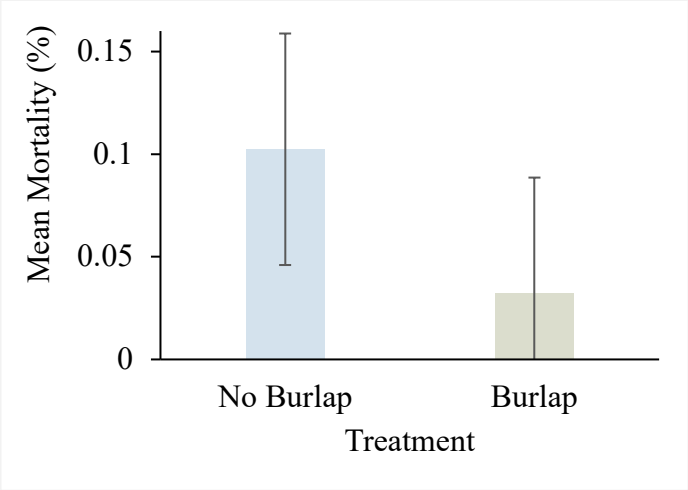

Figure 8. *Comparison of mean pre-weaning litter mortality percentage between treatment groups without burlap and those provided with burlap. The no-burlap group includes the control and N treatment groups (blue), the burlap group includes the FN and the SFN treatment groups (green). Results showed no significant differences across treatment groups.*

Burlap Use

There were no significant differences between treatments for the amount of burlap remaining at the end of the experiment ($X^2 = 1.7$, df = 2, $P = 0.79$). Results from the burlap remaining scores showed the following results for each treatment: N = 1.2 (n = 9), FN = 0.88 (n = 9), and SFN = 0.88 (n = 9) (Figure 10).

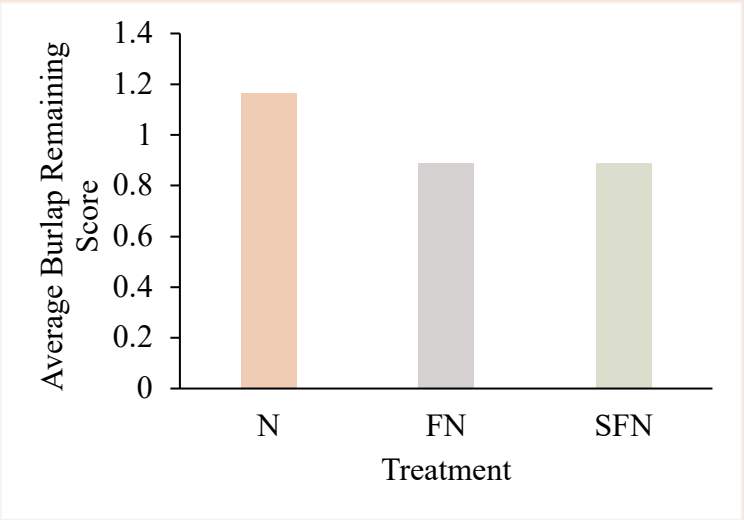

Figure 9. *The amount of burlap used by the piglets is based on the mean amount of burlap remaining at the end of each trial. Burlap remaining was scored on a scale of 0 = no burlap remaining to 5 = full burlap remaining. These data were compared across the four treatment groups nursery (N, orange), farrowing/nursery (FN, brown), and sow/farrowing/nursery (SFN, green).*

DISCUSSION

Overall, I found that burlap enrichment is successful in encouraging positive piglet behaviours and reducing negative behaviours. There was lower mortality across the treatment groups with burlap provided than in groups with no burlap enrichment. However, burlap enrichment did not have a major effect on lesion scores or mass gain.

Burlap Reduces Weaning Stress-Related Behaviours

In the farrowing rooms, there were more socializing behaviours (piglet-piglet and piglet-sow) exhibited in the SFN treatment groups than in the control, N, or FN treatment groups. These results were expected, as piglets in enriched environments socialize more than piglets in a barren environment (Oosindher et al. 2011; Vanheukelom et al. 2011; Ledergerber et al. 2015; Fynn et al. 2020). It is important to encourage positive socializing behaviours in piglets because there is a relationship between increased positive socialization with reduced levels of stress in terms of cortisol and fewer adverse behaviours (Colson et al., 2012). This relationship suggests that environmental enrichment, such as burlap, encourages piglet socialization, which is ideal for reducing stress in piglets.

In the nursery rooms, the treatment groups with only the pen toy as enrichment engaged the most with the toy compared to groups that also had burlap. On the other hand, in treatment with both types of enrichment, piglets split their attention almost equally between both enrichment options. Providing piglets with both the pen toy and burlap enrichment gives the piglets more opportunities to engage with enrichment and reduces competition for enrichment. More opportunities to interact with enrichment

encourage more frequent use of these items, encouraging positive manipulative behaviours and reducing negative behaviours (Oostindjer et al. 2011). Results comparing displacement in the nursery, specifically in groups with burlap enrichment showed increased displacements at the burlap in the N treatment than in the FN or SFN treatments. These results are as expected, as in treatment group N, burlap is introduced as a novel object in the nursery, whereas groups FN or SFN have had opportunities to interact with the burlap in the farrowing room before weaning.

As predicted, there were fewer aggressive behaviours observed in treatment groups with burlap than in treatment groups without burlap. Pre-weaning observations in the farrowing room displayed minor differences between the treatment groups, however, post-weaning observations in the nursery room displayed notable differences between treatments. In the nursery observations, there were significantly fewer biting, fighting, and displacement behaviours observed in treatment groups with burlap than those without. These results are similar to observations in previous studies (Beattie et al. 2001; Martin et al. 2015, Yang et al. 2018). Weaning piglets from their sow is stressful for piglets (Stanton and Mueller, 1976). As a result, there is often an increase in aggressive behaviours among piglets to cope with this stress (Oostindher et al. 2011; Yang et al. 2018; Swan et al. 2021). By providing enrichment, these piglets have an outlet for oral manipulation, resulting in fewer displays of adverse behaviours like biting and fighting (Beattie et al. 2001; Martin et al. 2015; Oostindher et al. 2011; Yang et al. 2018; Swan et al. 2021).

Behaviour observations support that burlap is a useful enrichment to promote animal welfare. Encouraging positive behaviours and reducing negative behaviours in piglets supports two of the three major concepts of animal welfare: natural behaviour and

affective states (Fraser 2008). Burlap provided the piglets with an opportunity to perform oral manipulation, a natural behaviour. The standard toys placed in the piglet pens in this experiment were made of rubber and hung from a chain or situated on the ground. While the piglets can chew on the rubber, burlap is more flexible and can be chewed off in small pieces. This factor allows the piglets to achieve successful destruction of the burlap, promoting a positive affective state. Overall, the results from this experiment support the first hypothesis, in that burlap reduced stress-induced adverse behaviours and encouraged positive behaviours in piglets throughout farrowing, weaning, and nursery stages of life.

Timing of Burlap Enrichment

Across the different treatments, the FN and the SFN treatments had the least amount of burlap remaining at the end of the experiment whereas the N treatment had the most. These results supported the prediction that the groups who had the most exposure to the enrichment made the most use of the enrichment. However, the N treatment group showed a greater proportion of piglets interacting with the burlap than the FN and SFN treatment groups. A factor to consider here is that the burlap was not replaced during the study. At some point, the burlap may reach a length that is no longer as easily accessible to the piglets. The FN and SFN treatment groups had the least amount of burlap remaining at the end of the study, and perhaps if the burlap was consistently supplied to the piglets the proportion of piglets engaged with the burlap may differ. These conflicting results, between the proportion of piglets engaged with the burlap and the amount of burlap remaining, suggest more research with greater detail is needed to test if supplying burlap consistently will impact the piglets' engagement with the enrichment.

Based on the positive associations of sows with burlap described by Fynn et al. (2021), we expected that the piglets would take well to the burlap and readily interact with it. From observations in the nursery room, there was more displacement at the burlap in the N treatment than in both the FN and the SFN treatments. The difference in displacement behaviours suggests that the piglets want to engage with burlap, in combination with the weaning stress and the excitement of a novel enrichment item, piglets will push and shove to interact with it. There were fewer cases of this behaviour in treatment groups where burlap had been introduced to the piglets pre-weaning in the farrowing room.

In combination, these results show support for the second hypothesis, where differences were observed between piglets provided with burlap pre-weaning and post-weaning or just post-weaning. These results suggest that providing burlap to the piglets in the farrowing room would provide the greatest benefit. While there were no major differences in the piglet behaviour, lesion scores, or mass gain when burlap was provided to both the sow and the piglets or just to the piglets in farrowing, providing burlap to the sow may still be beneficial. In many of the farrowing pens where the sow was also provided with burlap, the sows would chew, tug, and manipulate the sheets of burlap until they were completely used up. This observation aligns with previous research by Fynn et al. (2021), who found that burlap enrichment correlated with fewer stillbirths and increased successful fostering of sows. More research into providing sows with burlap enrichment and the positive effects it can have on behaviour and performance is still needed.

Burlap Effects for Production

There was also no significant difference between the treatment groups' mean weaning masses, shipping masses, or mass gain. The results for the weaning masses are similar to those seen by Yang et al. (2018). In the current study, enrichment had no significant impact on pre-weaning masses but did encourage object play behaviour among the piglets. A previous study by Vanheukelom et al. (2011) found no variation in weaning masses in groups with enrichment. A positive outcome of the current study for production was that piglets that had burlap enrichment had lower mortality than piglets that had no burlap enrichment.

A study by Oliveira et al. (2016) looked at the production effects of post-weaning enrichment given to piglets in the nursery room. This study compared the production of commercial piglets provided with pen enrichment of wood shavings and a hanging rubber toy with a control group with no enrichment. Results showed that piglets provided with enrichment gained more mass overall and had higher average daily gains than the piglets without enrichment. There were no differences in mass gain between piglets with different types of enrichment (toy, shavings, or toy and shavings) in that study (Oliveira et al. 2016).

Burlap was a low-cost effective form of enrichment for commercial piglets. Whenever burlap was available, both the piglets and the sows would engage with the burlap through investigative behaviours or oral manipulation. An important factor that makes burlap an ideal form of enrichment for pigs is that it meets the standards set by the National Farm Animal Care Council of Canada (NFACC 2021). Burlap successfully

achieves five of the “Six Ss” used for choosing enrichment set by the NFACC in that it is safe, sanitary, soft, simple, and suspended.

Study Limitations

While the burlap was provided fresh at the start of the experiment in the farrowing rooms and again when the piglets were first moved into the nursery rooms, the burlap was not replaced when it was chewed up by the piglets in either room. The reason the burlap was not replaced was to mimic a management practice that would require a very low amount of labour. However, in some pens by the end of the treatment the burlap was chewed up to the point that the piglets were no longer able reach it easily. Replacing the burlap after it is no longer easily reached by the piglets may impact the piglets’ engagement. In a future study, I would replace the burlap so that the piglets had consistent access to it throughout the experiment, and measure the amount used after each replacement to determine the total amount of burlap used by the piglets. The burlap would need to be replaced approximately every three to four weeks in the farrowing pens and every two to three weeks in the nursery pens.

Conclusion

In summary, piglets were observed to engage and use the burlap almost entirely by the end of the five weeks in the nursery. The results of this experiment show that burlap enrichment is successful in encouraging positive piglet behaviours and reducing negative behaviours. There was lower mortality across the treatment groups with burlap provided than in treatment groups with no burlap enrichment. However, burlap enrichment did not

have a major effect on production through decreasing lesion scores or increasing mass gain.

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APPENDIX A

Sample of farrowing room behavioural observation sheet:

		PEN #	
#	SCAN	Behaviour	00:00
		Burlap	
		Eating/Drinking	
		Active	
		Resting	
Y/N	CONT. Behaviour	0:30-1:00	1:00-1:30
	AGONISTIC		
	Fighting	T / P / B	T / P / B
	Tail/Ear Biting		
	Belly Nosing *(piglets)*		
	Displacement	T / P / B	T / P / B
	INVESTIGATE		
	Socializing		
	Pen Objects		
	Burlap	I / M	I / M
	Cross- Sucking		

Sample of nursery room behavioural observation sheet:

		PEN #	
#	SCAN	Behaviour	00:00
		Burlap	
		Toy in Pen	
		Eating/Drinking	
		Active	
		Resting	
Y/N	CONT Behaviour	0:30-1:00	1:00-1:30
	AGONISTIC		
	Fighting	F / P / B / T	F / P / B / T
	Tail/Ear Biting		
	Belly Nosing *(piglets)*		
	Displacement	F / P / B / T	F / P / B / T
	INVESTIGATE		
	Socializing		
	Pen Objects		
	Toy in Pen	I / M	I / M
	Burlap	I / M	I / M
	Other		

APPENDIX B

Figure 1. *Image of the farrowing crate at Glenlea Research Station. Farrowing crates are 2.3 x 1.7 meters.*

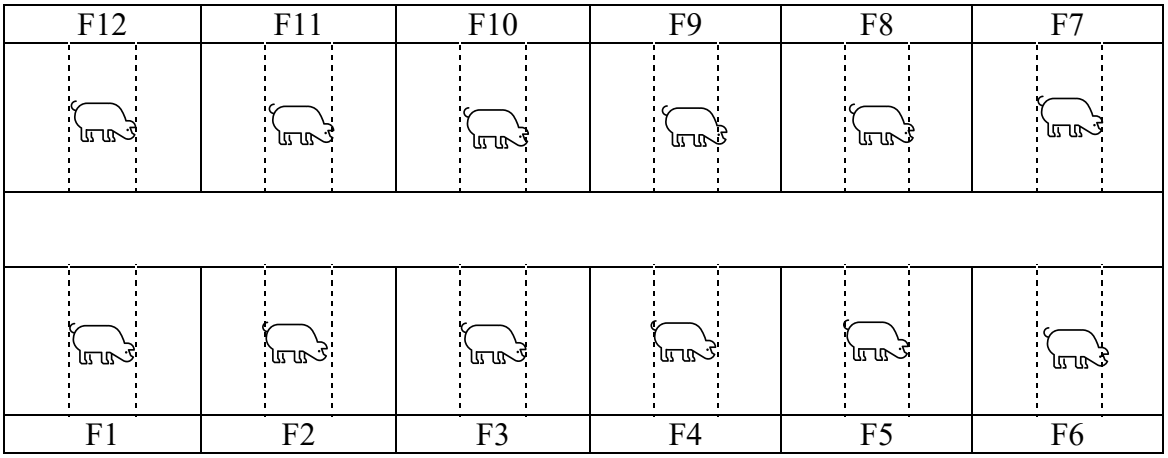

Figure 2. *Figure depicting farrowing room layout at GlenLea Research Station. Each farrowing room has 12 standard farrowing crates with a capacity for 12 sows and each litter is generally between 9-16 piglets.*

Figure 3. *Image of nursery pen at GlenLea Research Station. Nursery pens are 1.8 x 1.5 meters.*

N12	N11	N10	N9	N8	N7
N1	N2	N3	N4	N5	N6

Figure 4. *Figure depicting nursery room layout at GlenLea Research Station. Each nursery room has 12 nursery pens, each with a capacity for 12 piglets.*

APPENDIX C

Table 1. *Room design descriptions: specific configurations will be randomized for different rooms.*

C	Control (no object enrichment for litter or sow).
FN	Enrichment for litter in both farrowing crate and nursery, no enrichment for sow.
N	Enrichment for litter in nursery only, no enrichment for the sow.
SFN	Enrichment for litter in both farrowing crate and nursery and enrichment for sow.

F1/N1		**F2/N1**		**F3/N3**		**F4/N4**	
1 - C	12 - NOT	1 - NOT	12 - C	1 - SFN	12 - N	1 - N	12 - FN
2 - SFN	11 - NOT	2 - NOT	11 - SFN	2 - FN	11 - NOT	2 - SFN	11 - NOT
3 - N	10 - FN	3 - SFN	10 - C	3 - NOT	10 - N	3 - FN	10 - NOT
4 - N	9 - C	4 - N	9 - FN	4 - C	9 - NOT	4 - C	9 - NOT
5 - NOT	8 - SFN	5 - FN	8 - N	5 - C	8 - NOT	5 - N	8 - SFN
6 - NOT	7 - FN	6 - NOT	7 - NOT	6 - FN	7 - SFN	6 - NOT	7 - C

Figure 5. *Setup of assigned treatments in the farrowing (F1/2/3/4) and nursery (N1/2/3/4) rooms. See Table 3 for a description of treatments.*

APPENDIX D

Table 2. *Ethogram used for instantaneous scan behaviour observations and continuous behaviour observations.*

Behaviour	**Description**	**Sampling Type**	**References**
Antagonistic			
Fighting	Physical encounters between at least two pigs including head-to-head fights, biting another pig, as well as pushing or knocking another pig with the head	*Continuous sampling*	Ledergerber et al. (2015) Wenbo et al. (2021)
Tail/Ear Biting	Pigs engaged in oral manipulation of pen mate's tail or ear, may or may not result in wounds.	*Continuous sampling*	Hakansson and Bolhuis (2021)
Belly-nosing	Piglet engaged in rhythmic nudging of another piglet's abdomen (belly) with their nose	*Continuous sampling*	Widowski et al. (2007)
Investigative			
Socializing	Pigs engaged in actions that did not cause the recipient to react negatively. Ex: nudging: snout of piglet is used to gently touch another piglet's or sow's	*Continuous sampling*	Morgan et al., (2014) Yang et al. (2018)

	body, not including any behaviour directed at the sow's udder.		
Pen facilities	Nosing or chewing any object that is part of the pen (e.g., feeder or bar of sow crate), but excluding the enrichment object. Any behaviour toward the drinking device will not be recorded.	*Continuous sampling*	Yang et al. (2018)
Manipulating burlap	Manipulating the enrichment objects (toys or substrates that were deliberately put into the pen by the researcher) with mouth or snout, resulting in visible movement of the target.	*Continuous sampling*	Yang et al. (2018)
Suckling	Piglet massages or sucks at the [sow's] udder	*Scan sampling*	Ledergerber et al. (2015)
Eating (Creep feed)	Piglets were deemed as eating creep feed if they were interacting with feed.	*Scan sampling*	Morgan et al. (2014)
Active			
Locomotion	Including scampering, running, and walking. Normally associated with using large areas of the pen.		Yang et al. (2018) Morgan et al. (2014)

Climbing	The piglet uses its feet to elevate itself onto the body of the sow or another piglet. A minimum of two feet must be off the floor and on the sow/ piglet.	*Scan sampling*	Yang et al. (2018)
Standing	All four legs support the body with no ambulation or touching anything with their nose or mouth	*Scan sampling*	Morgan et al. (2014)
Resting			
Lying	The whole length of the body is on the floor or on other pigs, i.e., not supported by their legs. Piglet's body has contact with the ground	*Scan sampling*	Morgan et al. (2014) Ledergerber (2015)
Sitting	Hindquarters on the floor, front legs supporting the body	*Scan sampling*	Morgan et al. (2014)
Other	Piglet performing behaviour out of the ethogram.		Yang et al. (2018)

APPENDIX E

Lesion scoring datasheet:

# of Piglets per Score	Pen Number	EARS	NOSE	TAIL	BODY

APPENDIX F

Table 3. *Results from interobserver reliability (IOR) tests (kappa values). IOR results are divided up by scan and continuous observations as well as lesion scoring. For each observation day, there were two observers collecting data.*

	Category	**Kappa Value**
Scan Observations	Burlap	0.92
	Toy in Pen	0.42
	Eating/Drinking	0.91
	Active	0.28
	Resting	0.93
Continuous Observations	Fighting	0.72
	Biting	0.58
	Belly Nosing	0.70
	Displacement	1
	Socializing	0.65
	Pen Objects	0.77
	Burlap	0.59
Lesions Scoring	Ears	0.48
	Nose	0.73
	Tail	0.22
	Body	0.80