Animal Welfare 2022, 31: 243-255
ISSN 0962-7286
doi: 10.7120/09627286.31.2.008

Scratch that itch: Farrowing crate scratching enrichment for sows

RK Pritchett*†§, BN Gaskill‡, MA Erasmus‡, JS Radcliffe‡ and DC Lay Jr§

† 270 South Russell Street, West Lafayette, IN 47906, USA
‡ Department of Animal Sciences, Purdue University, West Lafayette, IN 47907, USA
§ USDA ARS, Livestock Behavior Research Unit, West Lafayette, IN 47907, USA
* Contact for correspondence: smit1934@purdue.edu

Abstract

*Developing effective enrichments is important for improving pig (*Sus scrofa*) welfare as it increases species-specific behaviours, decreases abnormal behaviours, and increases time active. However, few enrichments are available for sows in farrowing crates. Pigs are often observed to scratch, or rub against objects, however enrichments designed to provide a scratching outlet have never been tested in sows. We examined the behaviour and welfare of sows in farrowing crates when they were presented with one of two types of scratch-pad enrichment. Sows (n = 18) of parities two (P2) and three (P3) were housed for 25 days and assigned no enrichment (Control) or a scratch-pad made of plastic mats (Plastic) or coir fibre mats (Fibre). Parity two Plastic sows scratched for a longer total duration than P2 and P3 Fibre sows, P3 Plastic sows, and P2 Control sows. Parity two Plastic sows also displayed scratching bouts more frequently than all except P3 Control sows. There were no body lesion differences between treatments. Abnormal behaviour and proportion of time spent in different postures also did not differ between treatments. Plastic scratch-pads may be a suitable enrichment for farrowing crates as they increased the natural behaviour of scratching. More research is needed to refine the scratch-pad design and measure motivation before it can be concluded that scratch-pads are a successful enrichment that should be implemented on-farm.*

Keywords: *animal behaviour, animal welfare, environmental enrichment, farrowing crate, scratching, swine*

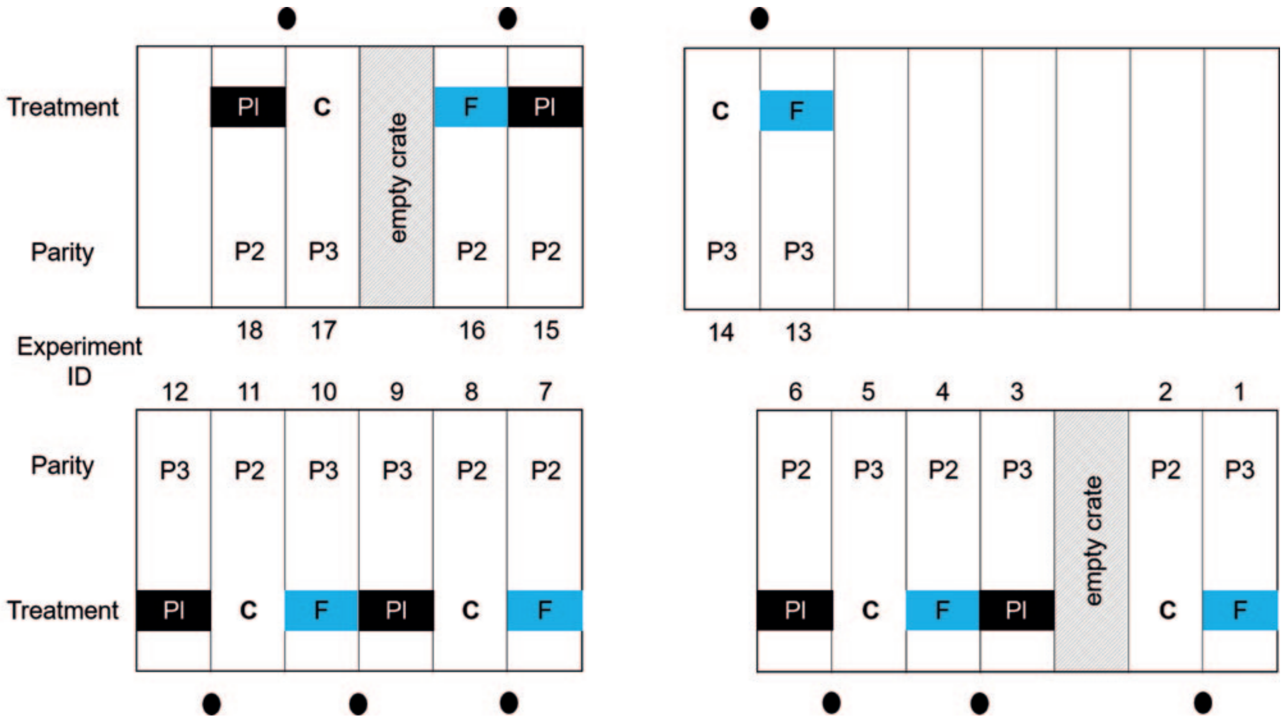
Introduction

Increased public awareness of livestock care and handling has made welfare a growing priority. The barren commercial environment pigs (*Sus scrofa*) live in is a significant concern, particularly for farrowing crates. Farrowing crates do not allow sows to perform natural behaviours in the vacant space, such as foraging for materials and building a nest. Nesting in particular is very important for farrowing sows as they are highly motivated to create a nest for their litter and when deprived of performing this activity they become stressed (Johnson & Marchant-Forde 2009). Farrowing crates also confine the sows to a small space and do not allow them to isolate themselves, decreasing their welfare (Barnett *et al* 2001; Johnson & Marchant-Forde 2009). In the wild, pregnant sows would separate themselves from their group prior to farrowing and locate a secluded site to give birth. They would build a nest from available materials such as grass and branches, give birth, and nurse their new litter (Stolba & Wood-Gush 1989; Webster 2011). This sequence of events and natural behaviours are not allowed to sows in farrowing crates. Providing environmental enrichment may help mitigate the absence of the natural farrowing process by decreasing stress and improving welfare.

Enrichments can increase species-specific behaviours, maintain or improve health, and improve welfare (Newberry 1995; van de Weerd & Day 2009). Many studies exploring pig enrichment have found straw to be the best enrichment so far, especially for sows, as it allows them to perform highly motivated nesting behaviours (Rosvold *et al* 2018; Mkwanazi *et al* 2019). Straw meets pigs' motivations to chew, manipulate and ingest, but is not compatible with the slurry systems found in most commercial barns (Rosvold *et al* 2018). So, currently, no feasible enrichment exists for sows in farrowing crates. Other enrichment options need to be created and tested to help alleviate the stress sows experience in the crate. Sows can perform the natural behaviour of scratching in crates, which may be a good enrichment target.

In a semi-natural environment, pigs rub against trees and bushes (Stolba & Wood-Gush 1989). In commercial settings, pigs are seen to rub against concrete walls, fences, and often allow handlers to scratch them (Dellmeier & Friend 1991). Although frequently observed, the current literature provides very few definitions and explanations for scratching behaviour in pigs. There have been studies done in dairy cattle (*Bos taurus*) with grooming brushes. When enrichment brushes were introduced into barns, cows

Figure 1



Aerial view of barn layout with experimental design. Each crate with a sow in the project was assigned an experimental ID. Over these 18 crates, treatment was randomly ordered and then repeated so that no treatment was next to the same treatment or two of the same treatments: plastic mat (Pl), fibre mat (F), or control (C). Parity 2 and 3 (P2 and P3) were randomly balanced across treatments. Cameras (black dots) were positioned at the back of the crates so that one camera could capture two crates at a time.

increased their time spent scratching by 508% (DeVries *et al* 2007). Since cattle are covered in hair and pigs are not, their motivations to scratch or groom may be vastly different. Neither the motivation sows have to scratch nor what sort of materials sows enjoy rubbing against is known. Enrichment designed to target scratching behaviour is completely absent in the peer-reviewed literature.

Our objective was to provide scratch-pads to facilitate natural scratching behaviour. We hypothesised that providing scratch-pads to sows in farrowing crates would allow for the expression of natural behaviours such as scratching and improve sow welfare. We predicted that sows would scratch more on the scratch-pads, display more natural behaviours, and have improved welfare as indicated by fewer lesions, more time active, and fewer abnormal behaviours compared to sows with no scratch-pads. Since no scratching enrichment studies have been published with pigs, two materials were provided to see if the sows would scratch on them at all. There was no previous literature to determine if one material would be scratched on more than the other and, for this experiment, all scratching bouts were of interest to obtain more knowledge.

Materials and methods

Study animals, housing and management

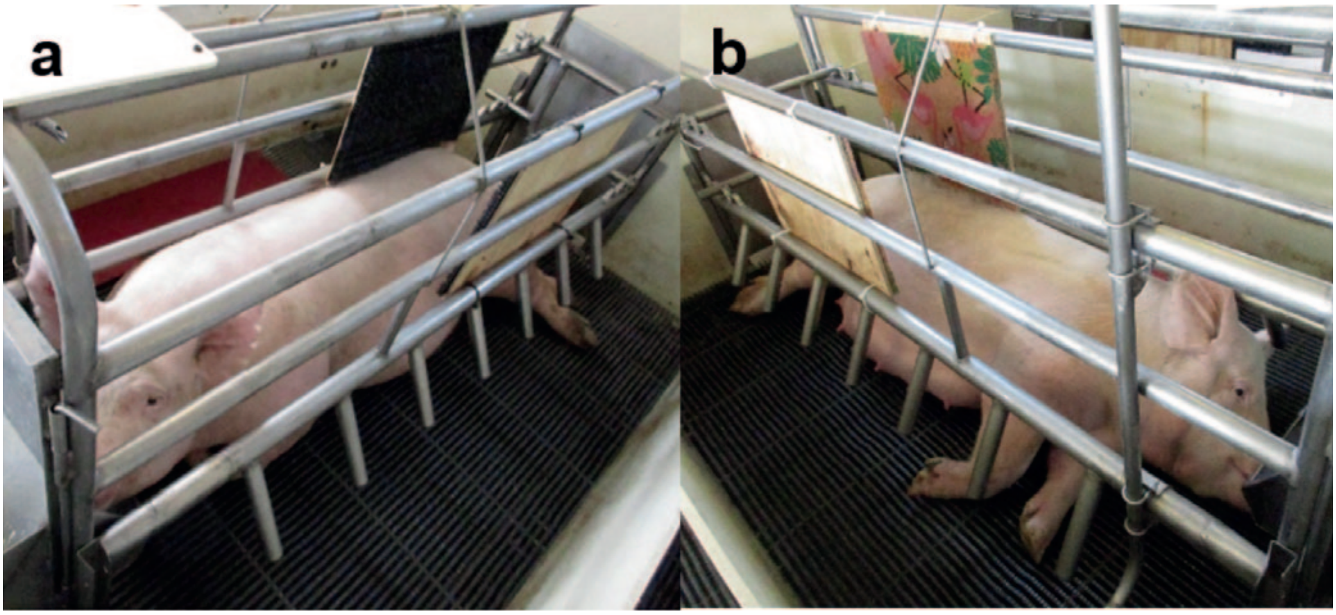
All procedures were approved by the Purdue University Animal Care and Use Committee (PACUC; 1712001667). Sows were moved into a farrowing barn at the Purdue University Animal Science Research and Education Centre (ASREC, West Lafayette, IN, USA), approximately three days before they were due to farrow. They remained in their respective conventional farrowing crates (Advantage Farrowing Crate, Hog Slat, Newton Grove, NC, USA) until weaning; a total of 25 days. Sows were fed approximately 3 kg of feed (lactation ground corn diet) per day at the beginning, and gradually increased to approximately 9.5 kg a day towards the end to meet lactation requirements. Sows were provided water *ad libitum* from a drinker attached to their crate. Each sow had a water dripper situated above them to provide cooling during hot days. Barn lighting was continuous, and a heat lamp provided extra warmth for the piglets. The flooring was a mesh metal flooring. Two data loggers (HOBO U12-112, Onset, Bourne, MA, USA) were placed at opposite ends of the barn to record mean (± SEM) temperature and relative humidity: 29.82 (± 0.10)°C and 59.76 (± 0.31)%, respectively.

Experimental design

Sample size was calculated before the experiment using Mead's resource equation (N – B – T = E; (18–1) – (4–1) – (3–1) = 12; (Mead 1990). Eighteen sows were balanced by parity two and three (P2 and P3) and assigned to one of three scratch-pad treatments: plastic mats (Plastic), coir fibre mats (Fibre), or no mat (Control). Sows were randomly assigned a crate. The three treatments were balanced across crates, so no sow was next to an identical treatment or two of the same treatments (Figure 1).

https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

Figure 2



Sows in conventional farrowing crates with scratch-pads as environmental enrichment. One treatment consisted of (a) a black plastic scratch-pad, (b) another treatment, a colourful fibre/coir scratch-pad, and the last no scratch-pad to serve as the control (not pictured).

Scratch-pads were constructed of plywood (treated handi-panel; Menards Inc, Eau Claire, WI, USA; 54.6 × 38.1 × 1.3 cm [length × width × depth]) and covered with either black plastic mats (76.2 × 45.7 cm [length × width], Clean Machine Metro Entrance Mat, GrassWorx, St Louis, MO, USA) or coir fibre mats (76.2 × 45.7 cm doormat; Meijer Inc, Grand Rapids, MI, USA) trimmed to fit the plywood dimensions. Mats were secured with glue (E6000, Eclectic Products, Eugene, OR, USA) and screwed (Grip Fast #6 × 1 inch Phillips drive zinc flat head sheet metal screw; Menards Inc, Eau Claire, WI, USA) and stapled (9/16 inch Arrow T50, Arrow Fastener Co, Saddle Brook, NJ, USA) into place. Holes were drilled into the four corners of the pads to affix them to the bars of the crates with cable ties (48-inch black UV heavy-duty, Gardner Bender, New Berlin, WI, USA). The scratch-pads were placed into the crates prior to the arrival of the sows and removed on the day of weaning. Two pads of the same type were positioned towards the rear of the farrowing crate, so they did not restrict movement and to prevent the sows from chewing them (Figure 2). The two pads were placed on the sides of the crate as they could be easily attached to the crate frame. There was no scratch-pad option over the top of the sow as the sows were able to tilt slightly to get to most of their back.

Procedures

The visual body lesion score, visual shoulder lesion score, and thermal images were recorded on all sows the day they entered the farrowing crates. Direct observations were taken the next day during the morning feeding. These measurements, taken on days one and two, are considered the baseline measurements. After sows farrowed, they were given two days to acclimate and then data were collected on day two and then every third day thereafter (day 5, 8, 11, 14, and at weaning); data included direct observation of postures and behaviours, visual body lesion score, visual shoulder lesion score, maximum and average temperatures from thermal images, proportions of postures and behaviours from video, and durations of time spent scratching and eating. A final recording for all sows was made at weaning.

Continuous and instantaneous sampling

Nine cameras (KPC-N502NUB, KT&C, Fairfield, NJ, USA) continuously recorded video using management software (GeoVision Network Video Recorder, Taipei, Taiwan); one camera per two farrowing crates. Recording started at noon on the day the sows entered the crates and stopped after piglets were weaned. Video was observed (EzViewLog500, GeoVision, Taipei, Taiwan) in 24-h segments starting at 0000h on data collection days (two days after farrowing and then every third day thereafter). Two behavioural sampling methods were used when watching video. Continuous, focal sampling was used to observe scratching and eating behaviours (Table 1). Instantaneous, scan sampling was used every 10 min to record posture (stand, sit, kneel, sternal lying, left lateral lying and right lateral lying) and behaviour (inactive, nurse, and other; Table 1). Inter-rater reliability using Cohen's κ coefficient for instantaneous, scan sampling was almost perfect among the three observers for sow posture (κ = 0.96) and acceptable for sow behaviour (κ = 0.77; McHugh 2012). Video segments for each sow over the duration of the study were randomly ordered to reduce observer bias.

Table 1 Ethogram for instantaneous scan sampling, postures (revised definitions from Smith *et al* 2018) and behaviours; and continuous focal sampling, events.

Category	Term	Definition
Postures	Stand	Up on four legs
	Sit back	Hind legs folded underneath the body and supporting weight on extended front legs towards the back half of the farrowing crate
	Sit up	Hind legs folded underneath the body and supporting weight on extended front legs towards the front half of the farrowing crate
	Kneel	Front legs folded underneath the body with hind legs extended raising rump in the air
	Sternal lying	Lying down with sternum and belly in contact with the floor
	Left lateral lying	Lying down with left side in contact with floor
	Right lateral lying	Lying down with right side in contact with floor
Behaviours	Inactive	Eyes open or closed, animal not moving
	Nurse	At least three piglets actively nosing/nursing, sow must be lying laterally (Parois *et al* 2018)
	Other	All other activities besides inactive and nursing; drinking,eating, scratching, nosing piglets, walking, rooting, etc
Events	Eat	Head down in trough
	Scratch	Rubbing against the scratch-pads or bars, back and forth motion of head or body against the scratch-pads or bars of the stall

Table 2 Ethogram of behaviours observed using direct observations for focal, one-zero sampling.

Behaviour	Definition
Sham chew	Repeated movement of the mouth up and down as if there was food in the mouth, but there is no food
Bar bite	Sow puts the bars of the crates into her mouth and grinds her teeth against the bars
Bite/Push trough	Sow headbutts trough, picks trough up off the ground and allows it to slam back down
Press drinker	Sow uses nose to push water nipple, enabling water to flow out of the pipe
Inactive	Eyes open or closed, animals not moving
Eliminate	Defaecating or urinating
Eat	Head down in trough
Nurse	At least one piglet nosing/nursing
Nose piglets	Sow nudges piglets with snout
Root	Nosing the floor of the crate repeatedly

Direct observations

On select days, live observations using focal, one-zero sampling were made to collect data on abnormal and normal behaviours. Normal behaviours are defined as species-relevant behaviours that serve a purpose while abnormal behaviours do not serve an obvious function. Abnormal behaviours (sham chewing, bar biting, and aggressively pushing/biting the feed trough) occur most frequently after feed consumption (Rushen 1985; Mason & Rushen 2006). Sows were fed at 0800h and, after 30 min, each sow was observed three times for 5 min with 20-min intervals (Table 2). There were two observers who made all the collections. When recording data, observers stayed several steps back and to the side of the sows' feed troughs to not disturb the sows. Sows were also used to people present in the barn from feedings and checks. Besides abnormal behaviours, normal behaviours (rooting and nosing piglets) were recorded to see if they increased due to the scratch-pads.

Lesions

Body and shoulder lesions were scored to determine if the enrichment was causing damage to the skin and if the sow was being injured from lying on the stall flooring. Body lesions refer to any scratch or wound found anywhere on the

https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

sow's body that are a result of altercations with other pigs or damage caused by the environment. They were visually scored on a zero (< four lesions in an area) to two scale (11+ lesions in an area; Table 3; Blokuis *et al* 2009). Shoulder lesions occur due to prolonged compression of blood vessels on the scapula when the sow is lying laterally, which leads to insufficient blood flow, tissue death, and eventually an open wound or ulcer (Rioja-Lang *et al* 2018). They were visually scored on a zero (no lesion) to three scale (> 2.3 cm broken skin over scapula; Table 4; revised from Zurbrigg 2006).

Thermal images

Prior to ulcer formation, shoulder lesions begin as bruises and the damaged tissue and inflammation on the scapula may be visible with thermal imaging before becoming an open sore (Westin & Rydberg 2010). An infra-red camera (FLIR-T62101; FLIR Systems Inc, Wilsonville, OR, USA) was held above the edge of the farrowing crate, to standardise the distance to the sow, and in line with the scapula while taking pictures. Images were analysed to determine if skin temperature correlated with shoulder lesion scores and could be used to detect an ulcer before formation (FLIR Tools+, version 6.4; FLIR Systems, Wilsonville, OR, USA). The image captured the area of interest and surrounding skin and the whole image was taken into consideration when finding averages and maximum temperatures. On data collection days, a thermal picture was taken of the left and right scapulas for each sow. The maximum and average temperatures for each picture were obtained.

Scratch-pad durability

Environmental enrichment durability was assessed using a scoring system specifically designed for this project. Durability was scored on a scale from zero to four: (0) being like new; (1) a little bit of wear, whole mat attached; (2) less than 1/3 of mat missing or not attached; (3) 1/3 to 2/3 of the mat missing or not attached; and (4) greater than 2/3 of the mat missing or not attached). Enrichment durability was scored at weaning to determine how well the scratch-pads held up during the farrowing duration. The two scratch-pads attached to each crate were each given a score and then added together for a combined score for each crate.

Piglet information

Each sow's previous piglet crushing record was obtained from farm records and subtracted from the current crushing record, recorded at the end of the experiment. This information was collected and analysed to see if sows' performance changed due to the presence of the enrichments. The crushing records from the previous litter were not balanced across the treatments (Control: one sow, Fibre: two sows, Plastic: two sows had crushed piglets). Out of these five sows, all had only crushed one piglet in their previous litter, except one Plastic sow which crushed three piglets. Only three of the sows that had crushed piglets in their previous litter crushed piglets during this experiment.

Piglets were weighed as a group two days after farrowing (during processing) and at weaning. An estimated average daily gain (ADG) per piglet was calculated by subtracting the group weight at two days of age from the group wean weight, divided by the number of days between the two weighing days, divided by the number of piglets. The number of piglets that the sow had at weaning was also recorded.

Table 3 **Body lesions* were scored 0 to 2 depending on how many scratches or wounds were on the different body regions (Blokuis *et al* 2009).**

Steps	Categorisation
Sow body regions	Front: head region; forward of the fore rib
	Middle: back, loin, sides, belly regions
	Back: ham region; backwards of side
	Legs: down from elbow/stifle joint
Lesion score for each region	a: ≤ 4 scratches
	b: 5–10 scratches
	c: > 11 scratches
Score for the sow	0: All body regions have a score of 'a'
	1: A body region with score 'b' or just one region with a score 'c'
	2: Two or more regions with score 'c'

* To designate a body lesion score for the sow, a lesion score for each body region would first need to be calculated.

Table 4 **Shoulder lesion scores revised from Zurbrigg *et al* (2006).**

Score	Shoulder lesion definition
0	No current lesion or redness on the scapula
1	Skin is reddened over the scapula
2	Broken skin on the scapula < 2.3 cm in diameter
3	Broken skin on the scapula > 2.3 cm in diameter

Data processing

Continuous, focal sampling

The durations for eating and scratching behaviours were calculated from the difference between end and start timepoints collected during continuous, focal sampling. Since not many papers had watched for scratching behaviour in pigs, continuous, focal sampling was chosen so that all scratching instances and exact durations were captured and each sow was watched as an individual to not miss any of the brief bouts. For scratching, all the durations for all the days were summed per sow. Scratching bouts were infrequent and did not occur on all days resulting in few data, therefore data were summed per sow. For eating, durations were summed for each sow per day because eating took place every day and for longer durations. Frequency of scratching per sow and eating per day per sow were also recorded.

Instantaneous, scan sampling

The occurrence of each posture and behaviour were counted per sow and divided by the total number of observations to calculate proportions.

Direct observations

The frequency for each behaviour was summed per sow to get a total count of how often the behaviours occurred during focal, one-zero sampling for all days.

Lesions

The visual body and shoulder lesion scores taken at the beginning of the experiment created a baseline measurement. Baseline scores were subtracted from scores recorded on preceding days to control for any possible previous lesions. This way, any increase or decrease in the score could be attributed to the farrowing crate environment and not previous experience as some sows came into the crates with body lesions and shoulder ulcers.

Weather

The temperature was recorded every 30 min by two data loggers from the time the sows were moved into the crates until weaning. The average was calculated for each day.

Statistical analysis

Data were analysed in JMP statistical software (version 13.2.0; SAS Institute Inc, Cary, NC, USA) using general linear mixed models. The experimental unit was the sow. Normality and homogeneity of variance were confirmed through visualisation of normal quantile and residual plots. For continuous eating, shoulder lesion scores, body lesion scores, thermal image data, and instantaneous behaviour and posture proportions, sow was nested within treatment and parity and was treated as a random variable. Since continuous scratching, direct observations, scratch-pad durability, and piglet information were summarised over the whole experiment per sow, nesting and treating sow as random was not necessary. For instantaneous, scan sampling, Other was removed from the behaviour proportions and Kneel was removed from the posture proportions for analysis. With Other and Kneel removed, the time budgets do not total 100%, so independent variables were not co-linear. Angular transformations were used for proportion analysis when necessary to meet assumptions. Covariates and blocking factors included breed and number of piglets to control for any affecting variation. When running the ambient average temperature against the average skin temperature of both sides of the sows' shoulders, the average of both sides' visual score for shoulder lesions per sow was added in as a covariate. The threshold for significance for all tests was set at $P < 0.05$. Models were reduced when appropriate. Significant main effects and two-way interactions were analysed using *post hoc* Tukey tests. Significant effects for the continuous independent variable day were analysed using SAS (version 9.4; SAS Institute Inc, Cary, NC, USA). Results are presented as least square means (± SEM).

Results

Results are reported only to the highest order interactions and blocking factors with significant *post hoc* analysis.

Scratching and eating behaviours

Out of the 18 sows, three were not observed to scratch on data collection days (one from each of the three treatments). Further, scratching bouts were not always performed on the scratch-pads. The sows scratched their heads on the available bars as the scratch-pads were positioned farther back in the crate so they would not eat them. Out of the six sows assigned a Plastic treatment, five were seen scratching on the plastic mats on the observation days. Of the six sows assigned to the Fibre treatment, three were observed to scratch on the fibre mats and two only scratched their heads on the crate. The Plastic sows spent an average of 40.2 s scratching while fibre sows spent an average of 20.0 s scratching on the mats.

The total scratching duration for each sow differed among treatments and parities ($F_{2,11} = 11.94$; $P = 0.002$; Figure 3). *Post hoc* Tukey tests show that P2 Plastic sows scratched for a longer total duration than P2 and P3 Fibre sows, P3 Plastic sows, and P2 Control sows. The total frequency that each sow scratched also differed among treatments and parities ($F_{2,11} = 18.46$; $P = 0.0003$; Figure 4). *Post hoc* Tukey tests show that P2 Plastic sows had more scratching bouts compared to all except P3 Control sows. Interestingly, sows with more piglets scratched for a longer total duration ($F_{1,11} = 25.10$; $P = 0.0004$) and more frequently ($F_{1,11} = 42.62$; $P < 0.0001$).

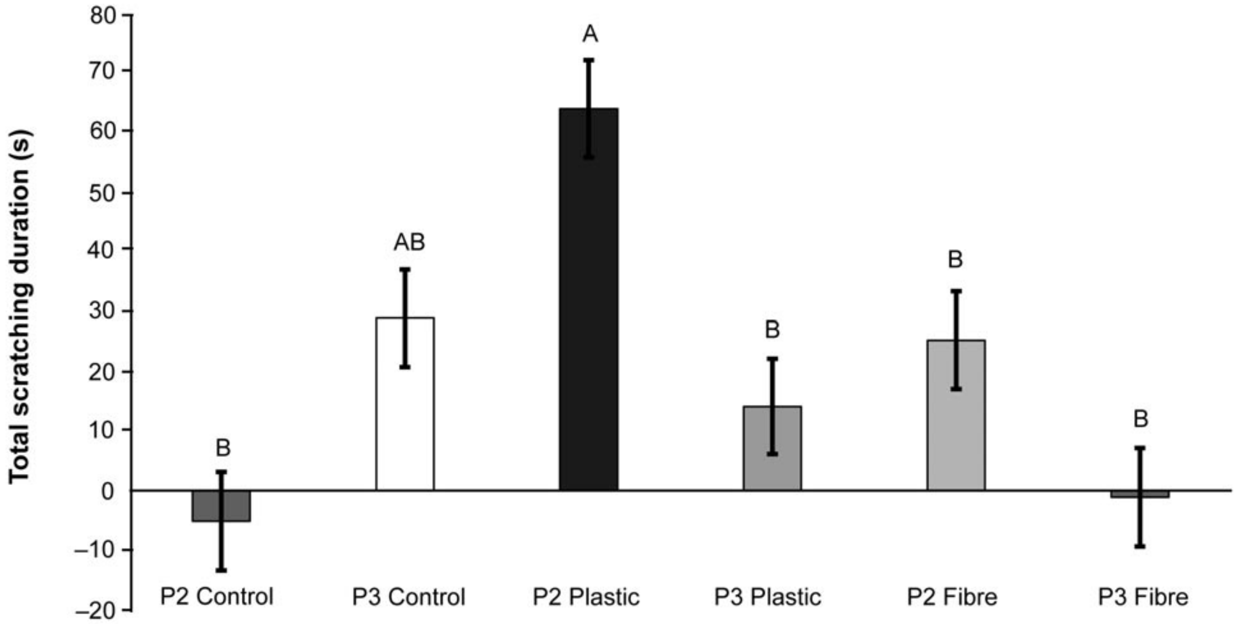
The total duration of time spent eating by each sow per day did not differ among treatment groups (Control: 65.90 [± 6.03] min, Plastic: 57.79 [± 6.03] min, Fibre: 73.77 [± 6.03] min; $F_{2,12} = 1.76$; $P = 0.215$). The frequency of eating for each sow per day also did not differ between treatments (Control: 17.73 [± 4.88], Plastic: 24.80 [± 4.88], Fibre: 25.33 [± 4.88]; $F_{2,12} = 0.75$; $P = 0.491$). However, sows spent progressively more time eating each day ($F_{1,71} = 52.80$; $P < 0.0001$; Figure 5[a]) and with increased frequency ($F_{1,71} = 21.27$; $P < 0.0001$; Figure 5[b]).

Posture and behaviour proportions

The proportion of time sows spent Inactive and Nursing did not differ among treatments ($F_{2,12} = 2.09$; $P = 0.167$), however more time was spent Inactive than Nursing (Inactive: 0.637 [± 0.011], Nurse: 0.214 [± 0.011]; $F_{1,17} = 404.78$; $P < 0.0001$). The proportion of time sows spent in different postures also did not differ among treatments ($F_{2,12} = 0.04$; $P = 0.966$). However, the proportion of time sows spent in different postures differed ($F_{5,85} = 319.56$; $P < 0.0001$; Table 5). In general, sows spent most of their time lying laterally and sternally according to a *post hoc* Tukey test.

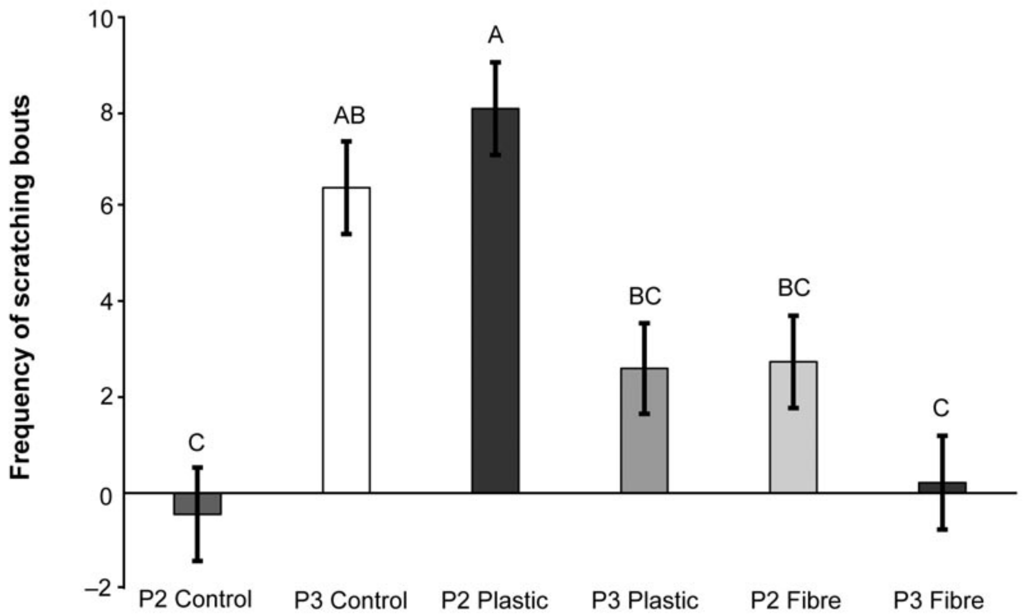
https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

Figure 3



Total duration of scratching per sow averaged according to parity 2 and 3 (P2 and P3) and treatments (Control, Plastic, Fibre; LSM [± SEM]). Negative values indicate unlikeliness to scratch compared to the other groups. Different letters represent a significant difference. Significance was set at $P < 0.05$.

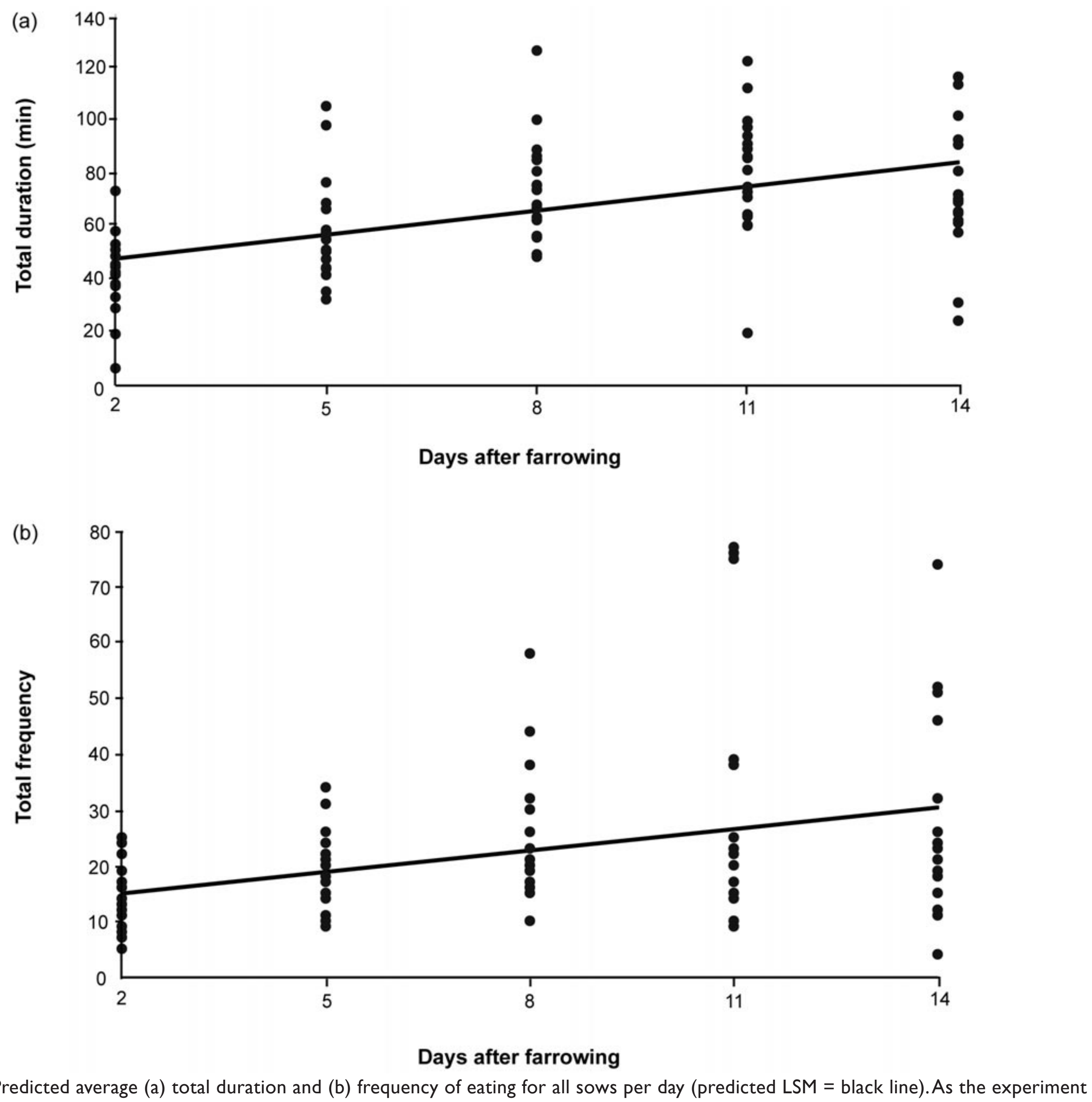
Figure 4



Frequency of scratching bouts per sow averaged according to parity 2 and 3 (P2 and P3) and treatments (Control, Plastic, Fibre; LSM [± SEM]). Negative values indicate unlikeliness to scratch compared to the other groups. Different letters represent a significant difference. Significance was set at $P < 0.05$.

https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

Figure 5



Predicted average (a) total duration and (b) frequency of eating for all sows per day (predicted LSM = black line). As the experiment progressed the sows spent more time eating (a) $F_{1,71}$ = 52.80; P < 0.0001 and ate more frequently (b) $F_{1,71}$ = 21.27; P < 0.0001. Scatterplot dots are (a) the total durations and (b) total frequencies of eating per sow over each data collection day.

Normal and abnormal behaviours

No differences in behaviour were found among enrichments (P > 0.05). This includes sham chewing (Control: 8.33 [± 0.998], Plastic: 5.17 [± 0.998], Fibre: 7.00 [± 0.998]; $F_{2,14}$ = 2.54; P = 0.115) and bar biting (Control: 1.17 [± 0.53], Plastic: 1.17 [± 0.53], Fibre: 0.50 [± 0.53]; $F_{2,14}$ = 0.54; P = 0.595). Parity two sows nosed their piglets more frequently than P3 sows (P2: 4.22 [± 0.43] nosing events, P3: 2.56 [± 0.43] nosing events; $F_{1,14}$ = 7.61; P = 0.015).

Lesions

Treatment had an interaction with day when analysing body lesions ($F_{2,87}$ = 5.93; P = 0.004). However, when *post hoc* Tukey tests were conducted in SAS, there were no differences (Bonferroni corrected alpha; P > 0.008; Figure 6).

Control sows' right-side scapulas had worse lesions compared to left and right sides of Fibre sows and left sides of the Control sows ($F_{2,194}$ = 11.31; P < 0.0001; Figure 7). Lesion severity increased over the course of the experiment

https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

($F_{1,194}$ = 13.81; P = 0.0003). The proportion of time spent lying laterally on the right and left side, however, did not affect the shoulder lesions ($F_{1,159}$ = 0.29; P = 0.589).

Shoulder skin temperatures

The average temperature taken from the thermal images of the sows' scapulas did not differ among treatments (Control: 35.10 [± 0.45]°C, Plastic: 34.24 [± 0.45]°C, Fibre: 34.67 [± 0.45]°C; $F_{2,12}$ = 0.90; P = 0.432). However, the average skin temperature increased as the experiment progressed ($F_{1,197}$ = 54.76; P < 0.0001; Figure 8[a]).

The maximum temperature taken from the thermal images of each side of the sow did not differ by treatment (Control: 36.83 [± 0.35]°C, Plastic: 36.17 [± 0.35]°C, Fibre: 36.57 [± 0.35]°C; $F_{2,12}$ = 0.93; P = 0.419). The maximum temperature similarly increased as the experiment progressed ($F_{1,197}$ = 40.91; P < 0.0001; Figure 8[b]).

Breed, number of piglets, and the side the temperature was taken from (left or right) were taken out of the model for both average and maximum temperatures as they were not significant (P > 0.05). No relationship was found between the visual shoulder lesion scores and thermal images when the shoulder lesion scores were added as covariates to the average temperature analysis ($F_{1,208}$ = 0.37; P = 0.544) or the maximum temperature analysis ($F_{1,208}$ = 0.74; P = 0.391).

The daily average ambient temperature did not affect the mean of the averaged temperatures of sows' scapulas ($F_{1,105}$ = 0.001; P = 0.973). The visual shoulder lesion average per sow per day also did not correlate with the averaged sows' scapula mean temperature ($F_{1,105}$ = 0.002; P = 0.967).

Scratch-pad durability

The plastic (2.33 [± 0.59]) and fibre mats' (1.33 [± 0.59]) score did not differ in durability ($F_{1,10}$ = 1.45; P = 0.256).

Piglet information

The difference in crushing rate from previous to current litter was not affected by treatment (Control: 0.50 [± 0.34], Plastic: 0.00 [± 0.34], Fibre: 0.17 [± 0.34] crushed piglet difference; $F_{2,15}$ = 0.57; P = 0.580). The estimated ADG per piglet was different among treatments ($F_{2,15}$ = 5.29; P = 0.018). Fibre sows' litters gained more weight per day than Plastic sows' litters according to *post hoc* Tukey tests (Control: 247.25 [± 11.39] gain per day per piglet [gdp], Plastic: 231.98 [± 11.39] gdp, Fibre: 283.01 [± 11.39] gdp).

Table 5 Average proportion of time sows spent in different positions each day.

Posture	Proportions*	
	LSM	SEM
Left lateral lying	0.672[a]	0.014
Right lateral lying	0.665[a]	0.014
Sternal lying	0.348[b]	0.014
Standing	0.279[c]	0.014
Sit back	0.152[d]	0.014
Sit up	0.051[d]	0.014

* Proportions were transformed with an angular transformation; Superscripts differ by P < 0.05.

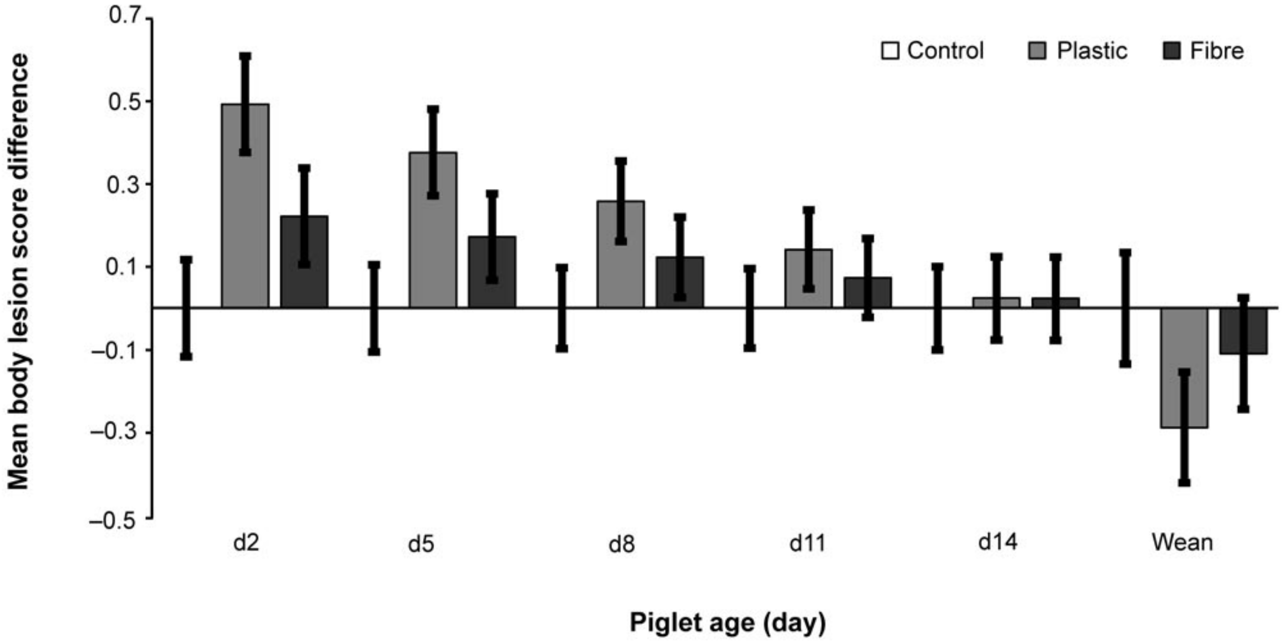
Discussion

With and without enrichment, sows scratched while in the farrowing crates. Scratching occurred infrequently and for short durations but was still part of the sow's routine. The P2 Plastic sows scratched more often and for a longer duration than P2 Control and Fibre sows but the P3 sows did not differ among treatments. This suggests that younger sows may be more motivated or interested in scratching; however, investigating scratching behaviour over a wider range of parities or following a group of sows through multiple parities would provide a more robust conclusion.

Even though scratching did not occur often, that does not mean that the sow does not value this behaviour or find pleasure in performing it. Sows in this experiment scratched an average of 40 s on plastic mats and 20 s on fibre mats, which is longer than the one to 10 s range recorded for pigs with mange (Loewenstein *et al* 2006). Sows with more piglets scratched for a longer duration and more frequently than sows with fewer piglets. Possibly, sows with more piglets may have been trying to stand and get away from their piglets more than sows with smaller litters. If the sows stood up more, they would have had more opportunities to scratch. However, not much is known about scratching as a behaviour or the sows' motivation to scratch. To speculate, scratching may be a luxury behaviour. The sows' basic needs have been met and now they will perform behaviours that are not necessary for survival (Young 2003). Luxury behaviours increase when stress decreases and when time and resources are plentiful (Mandel *et al* 2013). On the other hand, scratching may be a coping mechanism to manage stress. Scratching may allow sows to cope with the restricted movement and limited opportunity to express a range of behaviour, by scratching and eliciting pleasurable feelings. Another explanation is that the sows are itchy. When the skin experiences an irritating sensation, it triggers a desire to rub or scratch the area (Bautista *et al* 2014). Sows are housed in farrowing barns that can range in humidity, temperature, and air quality. These factors may impact the sows' skin, however studies would need to be carried out as there is currently no literature. Further studies are also needed to determine why pigs are motivated to scratch and whether they do indeed find it pleasurable.

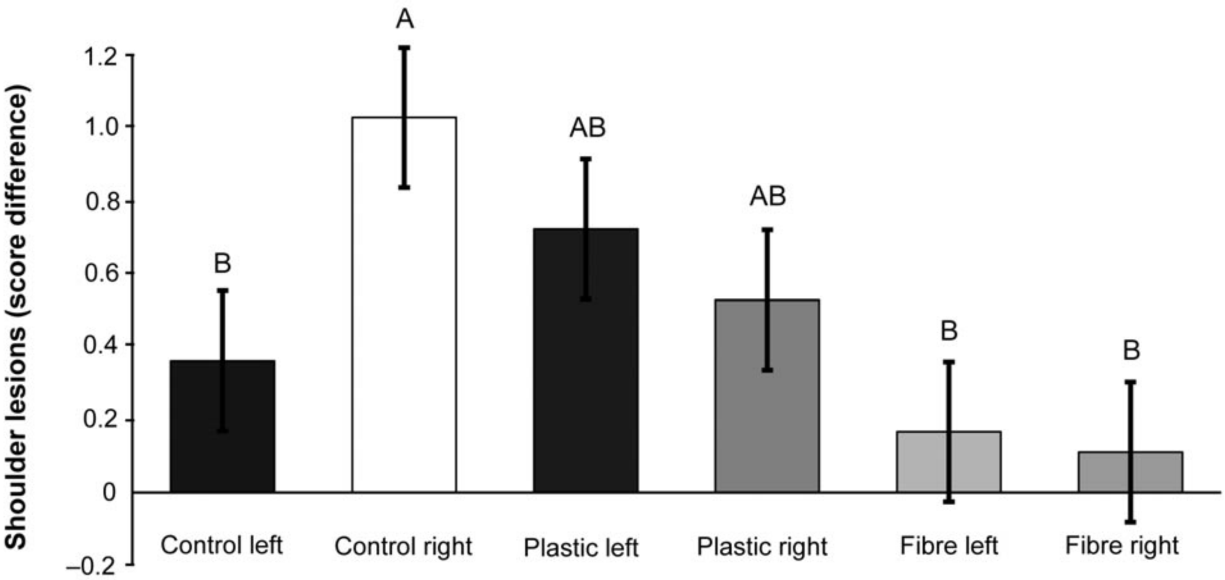
If sows became more active and stood up to scratch, they may also have eaten since they were already standing. Eating was recorded continuously because it did not occur for long durations. However, sows did not spend more time eating or standing in treatments with enrichment. There were also no differences between parities for eating duration and frequency, which is similar to other findings (Tanaka & Koketsu 2007). Sows spent more time eating, and ate more frequently, as the experiment progressed. This reflects the

Figure 6



Average body lesion scores per sow (LSM [± SEM]) on data collection days after farrowing (days 2, 5, 8, 11, and 14 after farrowing and at weaning) according to treatment (Control, Plastic, Fibre). The score difference represents the scores taken during data collection days minus the baseline score (score taken when sows first entered the crates) so that previous injuries were taken into account. Negative values indicate that the sows had fewer lesions on data collection days than compared to the baseline. Significance was set at $P < 0.008$ (Bonferroni alpha correction).

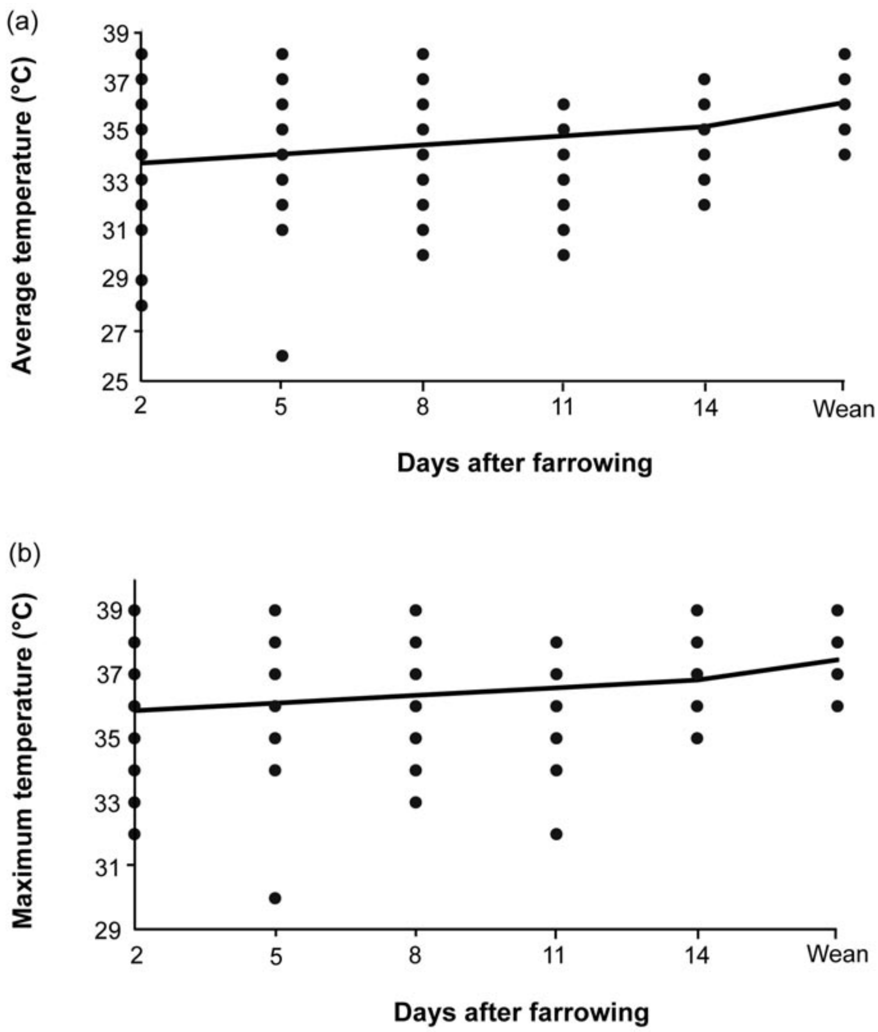
Figure 7



Average shoulder lesion scores per sow according to treatment (Control, Plastic, Fibre) and the side which the sow's scapula was scored (left or right; LSM [± SEM]). Negative values represent score improvement as each data collection day score had the baseline score (score taken when sows first entered the crates) subtracted from it to account for previous injuries. Different letters represent a significant difference. Significance was set at $P < 0.05$.

https://doi.org/10.7120/09627286.31.2.008 Published online by Cambridge University Press

Figure 8



Predicted mean of (a) average and (b) maximum skin temperatures (°C, predicted LSM = black line) increased as the experiment progressed (days after farrowing; [a] $F_{1,195.9}$ = 31.91; P < 0.0001; [b] $F_{1,195.9}$ = 24.16; P < 0.0001). The scatterplot dots are the (a) average and (b) maximum skin temperatures (°C) per side of the sows on each data collection day.

lactation demands on the sows as they need more nutrients as their piglets get larger and demand more milk. The number of times the sows were fed each day also increased during the experiment, which helps explain why their eating time and frequency increased.

Sows spend most of their time inactive and lying down in farrowing crates (Chidgey *et al* 2016). Enrichments can increase the time spent active; however, provision of scratch-pads did not decrease time spent inactive. Sows still spent about 90% of their day lying down (sum of left and right lateral lying and sternal lying). The nursing demands and space constraints of a crate may be too much for an enrichment to influence and make such a drastic change in the sows' behaviour. The relatively high mean (± SEM) temperature and humidity in the building (29.82 [± 0.10]°C and 59.76 [± 0.31]%), respectively, may have influenced the sows' posture. Cooler temperatures may have encouraged the sows to be more active. Building temperature was not accounted for in the statistical analyses as it was not part of the main question but would make an interesting future experiment/consideration. Also, all sows were in the same barn at the same time and no significant posture changes were seen across treatments.

Successful enrichments prevent or decrease abnormal behaviours (van de Weerd & Day 2009; Mkwanazi *et al* 2019). Abnormal behaviours did not differ among treatments in this study with sows in farrowing crates. Farrowing time is stressful on the sow. The sow is confined for a long duration with no nesting materials. They cannot perform natural nesting behaviours which results in frustration and stress and then they undergo painful labour (Thodberg *et al* 2002). The scratch-pads may not have provided a motivating enough outlet to influence abnormal behaviours as the sows may have already formed a habit and not had significant motivation to alter the habit so no decrease in abnormal behaviours occurred.

The body lesions were not different among treatments indicating that the enrichments did not cause any additional injury to the sows. All the body lesion scores were close to zero indicating that all the sows did not sustain many injuries while in the crates. Shoulder lesions were scored on a scale of zero to three and the highest average score was a one for the right side of Control sows. Even with significant differences, the averages were between zero (no redness or lesion) and one (redness over the scapula) so were not deemed to be severe and or did not result in open wounds. The proportion of time lying on each side did not affect shoulder lesions as seen in another study (Rolandsdotter *et al* 2009). Since this experiment only included two parity groups and both were relatively young, the sows may not have had lesions when previously in farrowing crates, which increases the chance of a shoulder lesion occurring (Pork Checkoff 2016). Low body condition score is a major contributor to shoulder lesions (Rioja-Lang *et al* 2018). The sows in this experiment seemed to be at the correct conditioning so the risk of shoulder lesions was low; however, body condition scores were not recorded.

The increase in skin temperature over time during the experiment is similar to previous findings (Westin & Rydberg 2010). We hypothesised that sows that scratched would lie less often and therefore not put as much pressure on their shoulders. We further hypothesised that the crushed blood vessels of an ulcer starting to form, due to the sows spending a lot of their time lying down, would show up in the thermal camera as an increase in skin temperature. This was not the case. The null correlation between the average and maximum skin temperatures and shoulder lesion scores suggests that the two methods, thermal imaging and shoulder ulcer scoring, cannot be used interchangeably, and thermal imaging may not be able to correctly identify shoulder lesion damage. This was also the conclusion of the only other previous study to compare thermal imaging and visual scores (Westin & Rydberg 2010).

The results of our study provide a possible method for providing enrichment for farrowing sows; scratch-pads or surfaces could easily be incorporated in production of new farrowing crates. As this was a preliminary study, the pads were designed simply and with easy-to-access materials. The durability scores suggest that even though the materials were simple, the design endured during the whole experiment. So, scratch-pads based on the design described would require minimal maintenance. The pads also did not affect the performance of the piglets; piglet crushing did not increase. There was a statistical increase of ADG per piglet in Fibre sows, however the weight differences were small and if a similar study was performed the same result may not occur. Increasing species-specific behaviours, decreasing or keeping constant abnormal behaviours, increasing positive use of the environment, and increasing an animal's ability to manage stress are all needed for an environmental enrichment to be considered successful (Young 2003; Mench *et al* 2010). Providing scratch-pads in farrowing crates did not change bar biting and sham chewing occurrence, but increased scratching behaviour for P2 Plastic sows. Therefore, plastic scratch-pads may be a successful enrichment for sows in farrowing crates. For these scratch-pads to become a practical enrichment used in commercial settings, further research is required. These pads were placed only on the sides of the crates and towards the back so that the sows could not eat them. Sows still scratched their face on the bars of the crate even if provided scratch-pads. Creating scratch-pads that the sows could access with their face and back may provide different, more effective results. More testing is needed to test the sows' motivation for scratching material to better understand if this enrichment provides an outlet for the sows' needs in this time of their life and whether increased opportunities to scratch lead to improved sow welfare. Future studies conducted on the level of sow motivation to scratch and on other physical measures that can verify the sows' improved welfare (cortisol, brain-derived neurotrophic factor, etc) will give a clearer picture of what scratching is to a sow. If sows are motivated to scratch, even though they do not scratch for long and often, and their welfare improves with a scratching enrichment, implementing scratch-pads in farrowing crates could be an advantage. Scratch-pads can work in the slurry systems, they target a natural behaviour that sows display, and the sows utilise it consistently over long periods of time making the enrichment a promising solution.

Animal welfare implications

Sows have impaired welfare when housed in farrowing crates due to limited space and no opportunities to perform natural behaviours such as nesting (Barnett *et al* 2001; Johnson & Marchant-Forde 2009). Environmental enrichments can increase natural behaviours and improve health to improve the welfare of confined animals (Newberry 1995; van de Weerd & Day 2009). Scratch-pad enrichments in farrowing crates may increase sow welfare through increasing the natural behaviour of scratching. More studies are recommended to learn what motivates sows to scratch, how sows benefit from scratching, and if scratch-pad enrichments can be designed to optimise their use.

Conclusion

Plastic mat scratch-pad enrichment for sows in farrowing crates increases scratching behaviour; a naturally occurring behaviour. The enrichment did not cause an increase in body lesions. The enrichments themselves withstood use for the duration that the sow was in the farrowing crate suggesting that a simple and inexpensive scratch-pad can be easily implemented and maintained by farm staff. More research is needed to refine the scratch-pad design and to conclude how motivated sows are to scratch.

Declaration of interest

The authors declare no conflict of interest. Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the US Department of Agriculture. The views expressed in this article are solely those of the authors and not the USDA.

Acknowledgements

The authors would like to acknowledge the staff at the Animal Science Research and Education Centre Swine Unit, Purdue University, for husbandry and assistance with this experiment. We thank Victoria Raber, Katie Bachert, Stacey Enneking, Romain Lefèvre, Andrew Smith, Patricha Hartley, Alexis Weldon, Symphony Nguy, Audrey Sjahfiedin, and Taylor Fidler-Jarzyniecki for their much-appreciated help.

References

Barnett JL, Hemsworth PH, Cronin GM, Jongman EC and Hutson GD 2001 A review of the welfare issues for sows and piglets in relation to housing. *Australian Journal of Agricultural Research 52*: 1-28. https://doi.org/10.1071/ar00057

Bautista DM, Wilson SR and Hoon MA 2014 Why we scratch an itch: the molecules, cells and circuits of itch. *Nature Neuroscience 17*: 175-182. https://doi.org/10.1038/nn.3619

Blokuis H, Dalmau A, Velarde A, Scott K, Edwards S, Veissier I, Keeling L and Butterworth A 2009 *Assessment protocol for pigs.* Welfare Quality® Consortium: Lelystad, The Netherlands

Chidgey KL, Morel PCH, Stafford KJ and Barugh IW 2016 Observations of sows and piglets housed in farrowing pens with temporary crating or farrowing crates on a commercial farm. *Applied Animal Behaviour Science 176*: 12-18. https://doi.org/10.1016/j.applanim.2016.01.004

Dellmeier GR and Friend TH 1991 Behavior and extensive management of domestic sows (*Sus scrofa*) and litters. *Applied Animal Behaviour Science 29*: 327-341. https://doi.org/10.1016/0168-1591(91)90258-Y

DeVries TJ, Vankova M, Veira DM and von Keyserlingk MAG 2007 Short communication: Usage of mechanical brushes by lactating dairy cows. *Journal of Dairy Science 90*: 2241-2245. https://doi.org/10.3168/jds.2006-648

Johnson AK and Marchant-Forde JN 2009 Welfare of pigs in the farrowing environment. In: Marchant-Forde JN (ed) *The Welfare of Pigs* pp 141-188. Springer Netherlands: Dordrecht, The Netherlands. https://doi.org/10.1007/978-1-4020-8909-1_5

Loewenstein M, Ludin A and Schuh M 2006 Comparison of scratching behaviour of growing pigs with sarcoptic mange before and after treatment, employing two distinct approaches. *Veterinary Parasitology 140*: 334-343. https://doi.org/10.1016/j.vetpar.2006.04.001

Mandel R, Whay HR, Nicol CJ and Klement E 2013 The effect of food location, heat load, and intrusive medical procedures on brushing activity in dairy cows. *Journal of Dairy Science 96*: 6506-6513. https://doi.org/10.3168/jds.2013-6941

Mason G and Rushen J 2006 *Stereotypic Animal Behaviour: Fundamentals and Applications to Welfare, Second Edition.* CABI: Wallingford, UK. https://doi.org/10.1079/9780851990040.0000

McHugh ML 2012 Interrater reliability: the kappa statistic. *Biochemia Medica 22*: 276-282. https://doi.org/10.11613/BM.2012.031

Mead R 1990 *The Design of Experiments: Statistical Principles for Practical Applications.* Cambridge University Press: Cambridge, UK

Mench J, Newberry R, Millman S, Tucker C and Katz L 2010 *Guide for the Care and Use of Agricultural Animals in Research and Teaching, Third Edition.* Federation of Animal Science Societies: Champaign, IL, USA

Mkwanazi MV, Ncobela CN, Kanengoni AT and Chimonyo M 2019 Effects of environmental enrichment on behaviour, physiology and performance of pigs — A review. *Asian-Australasian Journal of Animal Sciences 32*: 1-13. https://doi.org/10.5713/ajas.17.0138

Newberry RC 1995 Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science 44*: 229-243. https://doi.org/10.1016/0168-1591(95)00616-Z

Parois SP, Cabezón FA, Schinckel AP, Johnson JS, Stwalley RM and Marchant-Forde JN 2018 Effect of floor cooling on behavior and heart rate of late lactation sows under acute heat stress. *Frontiers in Veterinary Science 5*. https://doi.org/10.3389/fvets.2018.00223

Pork Checkoff 2016 *Shoulder lesions in sows: Identification, treatment and prevention.* National Pork Board: Des Moines, IA, USA

Rioja-Lang FC, Seddon YM and Brown JA 2018 Shoulder lesions in sows: A review of their causes, prevention, and treatment. *Journal of Swine Health and Production 26*: 7

Rolandsdotter E, Westin R and Algers B 2009 Maximum lying bout duration affects the occurrence of shoulder lesions in sows. *Acta Veterinaria Scandinavica 51*: 44. https://doi.org/10.1186/1751-0147-51-44

Rosvold EM, Newberry RC, Framstad T and Andersen I-L 2018 Nest-building behaviour and activity budgets of sows provided with different materials. *Applied Animal Behaviour Science 200*: 36-44. https://doi.org/10.1016/j.applanim.2017.12.003

Rushen JP 1985 Stereotypies, aggression and the feeding schedules of tethered sows. *Applied Animal Behaviour Science 14*: 137-147. https://doi.org/10.1016/0168-1591(85)90025-5

Smith RK, Rault J-L, Gates RS and Lay DC 2018 A two-step process of nitrous oxide before carbon dioxide for humanely euthanizing piglets: On-farm trials. *Animals 8*: 52. https://doi.org/10.3390/ani8040052

Stolba A and Wood-Gush DGM 1989 The behaviour of pigs in a semi-natural environment. *Animal Science 48*: 419-425. https://doi.org/10.1017/S0003356100040411

Tanaka Y and Koketsu Y 2007 A field study of the associations between behaviors and reproductive performance in lactating sows. *Journal of Veterinary Medical Science 69*: 1229-1233. https://doi.org/10.1292/jvms.69.1229

Thodberg K, Jensen KH and Herskin MS 2002 Nest building and farrowing in sows: relation to the reaction pattern during stress, farrowing environment and experience. *Applied Animal Behaviour Science 77*: 21-42. https://doi.org/10.1016/S0168-1591(02)00026-6

Webster J 2011 *Managment and Welfare of Farm Animals: The UFAW Farm Handbook, Fifth Edition.* Wiley-Blackwell: London, UK

van de Weerd HA and Day JEL 2009 A review of environmental enrichment for pigs housed in intensive housing systems. *Applied Animal Behaviour Science 116*: 1-20. https://doi.org/10.1016/j.applanim.2008.08.001

Westin R and Rydberg A 2010 Thermal imaging for early detection of shoulder lesion development in sows. *International Conference on Agricultural Engineering - AgEng 2010: Towards Environmental Technologies.* 6-8 September 2010, Clermont-Ferrand, France

Young R 2003 *Environmental Enrichment for Captive Animals, First Edition.* Blackwell Publishing: Oxford, UK. https://doi.org/10.1002/9780470751046

Zurbrigg K 2006 Sow shoulder lesions: risk factors and treatment effects on an Ontario farm. *Journal of Animal Science 84*: 2509-2514. https://doi.org/10.2527/jas.2005-713