ASSESSING SOW PREFERENCE FOR SCRATCHING ENRICHMENT AND EFFECTIVENESS IN FARROWING CRATES

by

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ABSTRACT

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Effective enrichments for farm animals are increasingly important to address public concerns about farm animal welfare and improve the welfare of the animals we raise. The public's concern has increased in recent years as the management and care that farmers give their animals has become more apparent to them. Some of the conditions in which animals are kept are emotionally not appealing to the public. One such condition is farrowing crates for sows and piglets. The sows are confined in a small space with no social contact and cannot perform nesting behaviors. Farrowing crates are widely used though, as they allow farmers to handle piglets without fear of sow aggression, meet individual sow nutritional needs, and personalize care. Piglet mortality due to crushing is also decreased with crate use. Sow welfare in farrowing crates can be improved through environmental enrichments. Enrichments improve welfare by increasing species-specific behaviors, creating a more complex environment, reducing abnormal behaviors, and increasing an animal's ability to cope with stressful situations. For pigs, different enrichments have been shown to decrease stereotypies, like sham chewing and bar biting, decrease harmful redirected behavior towards pen mates, like tail biting and belly nosing, increased exploratory behavior, and increase positive affect. Straw has been found to be the best enrichment for pigs because it allows them to perform motivational behaviors such as rooting, foraging, and nest building. It is also complex, manipulatable, destructible, and ingestible, which are important attributes of effective enrichments. Unfortunately, straw cannot be used in farms that have slurry systems, as the straw will fall through the slats into the pit below and cause drainage issues. This includes farrowing crates. There have been a few studies on alternative enrichments for sows in crates, like cloth tassels, but they are not as effective as straw and are rarely used on farm.

Most enrichments target pigs' motivations to forage, root, graze, or build nests. Pigs perform other behaviors and may have other motivations that enrichments have not targeted yet. One such behavior is scratching. In a semi-natural environment, pigs will rub against trees and bushes. In confinement, pigs rub on fences, walls, and even allow people to scratch them with their hands. There have been no recorded studies done on scratching enrichment for pigs. Many studies have been done in the dairy industry exploring rotating brushes. These brushes have been implemented successfully on commercial farms and are used by cows to groom and scratch themselves. A similar device may allow pigs to also satisfy their itch. Our aim is to provide scratching enrichment to sows in farrowing crates. Since there have been no studies recorded on scratching enrichment or scratching in pigs in general, several steps had to take place before addressing the topic for sows in crates. The first project's aim was to see what materials pigs prefer to scratch on and their willingness to use such an enrichment.

The first project consisted of 2 experiments. Exp. 1 was a pilot study where 5 different materials on scratch posts were presented to a pen of gestating sows. The scratch posts were constructed from polyvinyl chloride (**PVC**) pipes, boards, and a gate post. Five different materials were attached to the boards: white, soft, long-bristled brushes (**White Brush**), red, hard, short-bristled brush (**Red Brush**), black, short-bristled, astro-turf-like mat (**Plastic Mat**), colorful coir, hard, short-bristled mat (**Fiber Mat**), and blue, plastic, large-round-bristled combs (**Plastic Combs**). The 8 sows received all 5 scratch posts in their pen for a habituation day and then 7 d of testing. During testing, video was continuously recorded from which 2 behaviors were collected; scratching and interacting. Sows scratched the most on Plastic Mat followed by Fiber Mat, Plastic Combs, and Red Brush. The White Brush was scratched on the least. The top 3 preferences were chosen to proceed to Exp. 2.

Experiment 2 for sow preference was performed on several pens (N=14) of sows and gilts with Plastic Mat, Fiber Mat, and Plastic Combs to narrow the preference down to 2 materials to proceed to the farrowing crates. The experiment was carried out in repetitions. Each repetition tested 4 pens at a time. The scratch posts were modified from Exp. 1 and each material was placed in a pen. Due to material destruction only 2 repetitions were carried out, both ending a little early (N=8). During the first repetition (**Rep 1**), sows ate and destroyed all the Plastic Combs within 2 d. The Plastic Comb scratch posts were pulled from the study and the second repetition (**Rep 2**) only had the Plastic Mat and Fiber Mat represented. An observation was made that one of the pens in Rep1 had extra feed on their floor and were not destroying their materials as fast as the other pens. So for Rep 2, more modifications to the scratch posts were made and the sows were given a little extra feed. The scratch posts were still destroyed in Rep 2 proving that the sows' hunger and motivation to perform oral manipulations overwhelmed scratching behaviors. However, from the data that was collected sows spent more time and more frequently interacted with the Fiber Mat compared to the Plastic Mat. They more frequently and spent more time interacting than scratching with the enrichments but scratched on both enrichments the same amount of time and frequency (Durations: $F_{1,112.6} = 13.63$, $P = 0.0003$; Frequencies: $F_{1,111.9} = 19.72$, $P < 0.0001$).

The plastic and fiber mats were presented to sows in farrowing crates for the second project by default. Sows (N=18) of parities 2 (**P2**) and 3 (**P3**) were housed for 25 d and assigned no enrichment (**Control**) or to a scratch pad treatment of plastic mats (**Plastic**) or fiber mats (**Fiber**). All were assessed for lesions, abnormal behaviors, eating and scratching behaviors, and time spent in different postures and behaviors. Scratching bouts occurred in short durations and were intermittent throughout the day. Parity 2 Plastic sows scratched for a longer total duration than P2 and P3 Fiber sows, P3 Plastic sows, and P2 Control sows ($F_{2,11} = 11.94$, $P = 0.002$). Parity 2 Plastic sows also displayed scratching bouts more frequently than all except P3 Control sows ($F_{2,11} = 18.46$, $P = 0.0003$). There were no body lesion differences between treatments ($P > 0.05$). Abnormal behaviors ($P > 0.05$) and proportion of time spent in different postures ($F_{2,94} = 0.0003$, $P = 0.999$) did not differ among treatments.

In conclusion, if a sow is experiencing hunger while in gestation pens this motivation may be overwhelming any other behavior needs. Scratch posts were destroyed and eaten. In this sort of environment, focusing on an enrichment that meets the need to forage and root would be more successful. Sows still scratched on the posts, so their preference and scratching use was still recorded to an extent to proceed to the experiment in farrowing crates. In farrowing crates, plastic scratch pads may be a suitable enrichment as they increased the natural behavior of scratching and did not increase abnormal behaviors. More research is needed to refine the scratch pad design and identify additional measures needed to examine the suitability of scratch pads as a form of environmental enrichment for sows in farrowing crates. In addition, the behavioral characteristics and sows' underlying motivation for scratching need to be studied because very little is known about scratching behavior of sows. If sows are motivated to scratch, and scratching helps improve their welfare, then scratching enrichment may be beneficial to sows and farmers.

CHAPTER ONE. LITERATURE REVIEW

Increasing public concern over food animal production and welfare has recently led to public pressures and changes in animal care policies (Tonsor et al., 2009; Lusk et al., 2010). Most people believe that their purchases impact current farm animal lives and they are confident that their concerns about animal welfare will create changes in food markets (Lusk et al., 2010). Sow gestation stalls are a prime example of how consumers influence animal care policy. The United Kingdom banned the use of gestation stalls in 1999; the European Union issued a partial ban in 2013; and since then nine states in the United States have banned them. Farrowing crates are similar to gestation stalls and are still widely used; however, both face issues regarding sow welfare (lack of space and social interaction) (Barnett et al., 2001; Tonsor et al., 2009). Thus, solutions to improve sow welfare in farrowing crates are needed.

1.1 Animal welfare

1.1.1 Animal welfare definition

The term animal welfare has many definitions as it is found in many disciplines and covers complex relationships. Three popular approaches to animal welfare are: 1. an emotional based approach that takes into consideration what the animal is feeling, 2. an approach that looks at what is natural for the animal and the natural behaviors performed for survival, and 3. a homeostasis approach that looks at how well an animal can cope with its environment (Fraser et al., 1997; Barnett et al., 2001). The ability of an animal to cope with the environment as a welfare indicator is popular and can be assessed in two ways: the behavioral and physiological responses and the biological costs of the responses. Animal welfare is a continuum that spans from good to poor as assessed by physical, behavioral, and mental elements (Marchant-Forde, 2009). Animals that have reduced life expectancy, reduced ability to grow or breed, disease, injury, express behavioral or physiological attempts to cope, and/or do not display as many normal or natural behaviors are considered to have poor welfare (Broom, 1991). Animals that display normal behaviors, especially highly motivated behaviors, and indicators of pleasure are considered to have good welfare (Broom, 1991).

1.1.2 Pig welfare

Pigs in intensive farming systems are often considered to have poor welfare (Barnett et al., 2001; Johnson and Marchant-Forde, 2009). This is predominantly due to the barren environments in which they spend their lives. In the United States, these environments usually contain a slatted concrete floor without interactive substrates (van de Weerd and Day, 2009). Barren environments discourage learning and mental well-being: growing pigs in a barren pen took longer to learn an operant task and maze test compared to pigs in an enriched pen containing peat and straw (Sneddon et al., 2000). Barren environments increase the occurrences of negative social interactions: growing pigs in an empty pen had increased instances of tail biting and belly nosing compared to pigs in an enriched pen (Beattie et al., 1996). These bare environments prohibit the expression of normal behaviors, so pigs redirect behaviors towards other pigs (Studnitz et al., 2007). Pigs are less active, show less exploratory and play behaviors, and perform more oral activities directed at pen mates in barren environments compared to pigs in enriched environments (Bolhuis et al., 2005).

1.2 Farrowing Crates

1.2.1 Farrowing crates defined

A farrowing crate is a rectangular box, usually 2.2 m x 1.5 m, with slatted floors and plastic edges that the piglets cannot climb over. The crate is a metal framework running horizontally with bars across the top that prevents escape, about 2.2 m long, 0.6 m wide, and 1.0 m tall. The rear of the crate has a removable frame to let the sows in and out. On either side of the metal framework is open space for the piglets equipped with a heating source (Johnson and Marchant-Forde, 2009). Pregnant sows are placed into farrowing crates a few days before they give birth, or farrow, to a litter of piglets. The sow and her piglets will stay in the crates until the piglets are weaned, between 21 to 28 d of age. Farrowing crates take up little space so more animals can be housed in one barn. The crates restrict sow movement in order to reduce piglet mortality from crushing. The confinement also allows farmers to safely handle the piglets with the sows contained. Housing the sows individually allows the farmers to feed on an individual basis to reduce sow competition and allow for easy health evaluation (Webster, 2011). These systems are indoors which provides protection from the elements and predators, a constant climate with a reduced range of temperatures compared to outside, and can be easily cleaned. Farrowing crates work well for farmers as they try to meet consumer demands efficiently and effectively. However, meeting consumer demands for low-cost meat may be at the expense of the animals' welfare (Marchant-Forde, 2009; Lusk et al., 2010).

1.2.2 Sow and piglet welfare in farrowing crates

The welfare of sows and piglets in farrowing crates is complex due to having animals from 2 different stages of life, with different needs, within the same environment (Barnett et al., 2001; Johnson and Marchant-Forde, 2009). Farrowing crates attempt to compromise sow and piglet needs. They reduce piglet mortality and provide supplemental heat that is essential for piglets to stay warm. The slatted floors allow for better hygiene and being individually crated allows for better management. Piglets are kept together with the sow until weaning and during the first days of life, the small space allows them to find the udder more easily to nurse (Johnson and Marchant-Forde, 2009). However, sows are confined, given no nesting material, restricted from social contact, and have limited ability to display maternal behavior (Barnett et al., 2001). Nesting behaviors are limited to sows as they have no suitable nest substrates and they cannot escape from their litters as the piglets get older (Webster, 2011; Vanheukelom et al., 2012). The crate structure and flooring can cause skin and feet lesions which decreases sow welfare (Bonde et al., 2004). Being confined in a small area limits the interactions between sows and her offspring so possibilities for social learning are decreased (Oostindjer et al., 2011). The sows lack contact with conspecifics, ability to exercise, and have restricted choices (Barnett et al., 2001). Even when sows were given straw in farrowing crates, they performed more frustration and restlessness behaviors compared to sows with straw in pens. Sows in farrowing crates with straw spent more time sitting, chewing on pen fixtures, and executing quick flops when going to lie down after farrowing compared to sows in pens with straw (Andersen et al., 2014). These various details all contribute to the fact that sows have poor welfare in farrowing crates (Johnson and Marchant-Forde, 2009).

1.2.3 Alternatives to farrowing crates

Farrowing crates were created to be efficient. The amount of space an animal has in a crate was decreased as much as possible so that more animals and crates could fit into one barn.

This allows farmers to stock sows at a higher density and make more profit (Fraser and Broom, 1997; Barnett et al., 2001). Customized barns containing farrowing crates discourage eliminating the hard to remove crates or replacing with alternatives that have larger space allowances (Barnett et al., 2001). Alternatives to the standard rectangular farrowing crate include options where the sow is housed individually, in groups, or a combination of the two. Turn around crates allow the sow additional room and movement, such as ellipsoid and circular crates. Sows can also farrow in pens, singularly or in groups, and in outdoor areas. Studies have been carried out to compare the different systems. Pens allow for more piglet-sow interactions compared to crates but sows still spend the majority of their time lying down in both (Chidgey et al., 2016). Long periods of lateral lying can compress blood vessels where the scapula is pressed into the floor and form shoulder ulcers (Rolandsdotter et al., 2009; Rioja-Lang et al., 2018). Group housing the sows allows for sow social contact, however piglet mortality and inter-sow aggression increases (Barnett et al., 2001). When sows are housed outdoors in huts, gilts may not know to farrow in the hut and so they will have their piglets outside exposed to the elements or may farrow in a hut with other sows. Pens and outdoor areas that use straw also can have problems with hygiene and disease (Barnett et al., 2001). Each system has its own set of costs and benefits and differ in how they affect the welfare of the animals. A final consensus for which system is the best has not been determined as many different factors concern the sow, piglets, and the farmer. Conventional farrowing crates are still the most popular system in the United States, but there is great potential to improve them and sow welfare.

1.3 Environmental Enrichments

1.3.1 Environmental enrichment definition

One way to improve sow welfare in farrowing crates is by adding a form of enrichment. Environmental enrichments improve the quality of captive life and biological functions by increasing an animal's physical or psychological health through the addition of stimuli or recurring changes in environment (Newberry, 1995; Shepherdson et al., 1998). The change in environment elicits natural behaviors and is better for overall animal well-being. An enrichment can be anything that increases social interactions, satisfies different behavioral needs of the animal, or encourages complex problem-solving skills. Enrichment's primary goal is to elicit species relevant behaviors and can come from the natural environment or be man-made (Young, 2003). They have been categorized into 5 groups: social, occupational, physical, sensory, and nutritional (Bloomsmith et al., 1991). Pairing animals up with conspecifics in the same environment or giving animals sounds or pictures of conspecifics are considered social enrichments. Providing puzzles, opportunities that allow the animal control, and forms of exercise are occupational enrichments. Physical enrichments include changing the size or complexity of the animals' enclosure or providing permanent or temporary furniture and toys. Sensory enrichments include objects or situations that stimulate animals' visual, auditory, taste, touch, and smell. Nutritional enrichments include changing the frequency or delivery of food and providing novel, varieties, and treat feedstuff.

1.3.2 Goals of environmental enrichment

Environmental enrichments are implemented to keep animals mentally stimulated, increase the range and frequency of natural behaviors, and provide a more complex environment (Shepherdson et al., 1998). Goals of enrichment include increasing the number of normal behaviors the animals display, preventing or reducing abnormal behaviors, increasing use of the environment, and increasing the animals' ability to cope with stress (Young, 2003; Mench et al., 2010). Animals vary in their physical and behavioral needs, which can be due to species, breed, or individual differences. For example, pigs cannot sweat so when they need to thermoregulate they will wallow in mud (Signoret et al., 1975). If the environment allows for it, providing pigs a space to wallow is beneficial for them to express goal directed behaviors. Goats on the other hand prefer to stay dry and avoid getting wet or dirty. So, giving goats a pit of mud to wallow in will most likely go untouched. Chickens will bathe themselves in dust to clean their feathers and prevent pests (Duncan, 1998). Providing chickens with suitable substrates allows them to perform this highly motivated behavior. Animals show strong motivation to perform certain behaviors and when restricted, can show signs of distress, frustration, and develop abnormal behaviors (Poole, 1992; Vanheukelom et al., 2012). Chickens not given substrate to dust bathe will still perform the behavior on wire floors, resulting in feather and claw damage (Duncan, 1998). Providing an enrichment that is appropriate for a species will be more productive and rewarding than an object of little relevance to the animal. If an enrichment meets these goals it is considered successful and meeting any of the goals can be beneficial for the animals.

1.3.3 Benefits from enrichment

Animals can greatly benefit from environmental enrichment. Assessing an enrichment's impact can be done through measures of behavior (ex. number of normal vs abnormal behaviors), physiology (ex. good or poor health), and neurology (ex. enhanced vs normal cognition; Young, 2003). Direct comparisons of enriched and barren environments have shown several benefits of enrichment. First, enrichments can reduce stereotypies (Shepherdson et al., 1998). Stereotypies are repetitive, fixed in form, and serve no obvious function (Mason and Rushen, 2006). For example, mice will spend a large amount of their activity period performing backflips in open space or against the side of the cage. Backflipping appears to have no function and the mouse will repeatedly perform the behavior in the same space and manner (Mason and Rushen, 2006). They can occur for a variety of reasons and may depend on the animal's needs and motivations. They are typically an indicator of poor welfare (Mason and Rushen, 2006). Enrichments create a more stimulating environment and prevent or reduce the instances of stereotypic behaviors by providing the animal with outlets for highly motivated behaviors. They also encourage animals to perform natural and motivating behaviors, adapt quickly to new situations and stimuli, increase their learning ability, and give the animal a sense of control and choice, which are often limited in a captive environment (Mench et al., 2010). All these effects increase the psychological and physiological health of a captive animal. Data has shown that enrichment increases welfare; thus, the public encourages the use of enrichment (Young, 2003).

1.3.4 Restrictions to using enrichments

Although enrichments are proven to be beneficial for captive or intensively housed animals, their costs are often more influential for determining rate of use(Shepherdson et al., 1998; Young, 2003). They may be financially costly to buy or make and some enrichments need to be replaced often. They often increase workload for caregivers due to regular maintenance and replacement. It has also been argued that enrichments increase variability in scientific research experiments which discourages use in laboratory settings (Young, 2003). Specifically, in livestock production, enrichments are rarely used. Implementing enrichments in a large-scale production would be challenging. The increased labor, management, and object costs are perceived to greatly outweigh the profits gained from increased productivity (ex. increased reproductive performance and growth rates) as a result of the enrichment (Shepherdson et al., 1998; Young, 2003).

1.3.5 Enrichments created based off animal behavior

Not all “enrichments” are beneficial or target an animal’s species specific needs (Newberry, 1995). When creating an enrichment, the behavior and physiology of the species must be understood (Mench et al., 2010). The enrichment should be relevant to the animal based on their natural behavior and satisfy a motivational need. If the enrichment cannot capture the animal’s interest, is boring or too simple, the animals will disregard it. Similarly, if the enrichment fails to target the proper species sensory specialties or physical attributes then it is not benefiting the animal. For example, pigs are very motivated to root and use their snouts to investigate their surroundings. Providing them straw allows pigs to manipulate the substrate and provides more facets to their environment, creating a more complex space and allowing them to explore (van de Weerd and Day, 2009; Mkwanazi et al., 2019).

1.3.6 Understanding swine

Pigs are omnivores but also considered prey animals. They have a panoramic visual range of about 310°, when not obscured by their ears, and prefer the color blue over red and yellow (Klocek et al., 2016). Whether pigs can distinguish blue from green or have red-green color blindness is debatable (Lomas et al., 1998; Klocek et al., 2016). Even though they can see almost all the way around themselves, they rely more on their sense of smell, touch, and hearing (Webster, 2011; Klocek et al., 2016). Sows will respond very little to visual stimuli (a rod, hanging ball, moving chime, and opening an umbrella) but respond well to auditory (a buzzer and playback of a sow grunt) and tactile stimuli (water dripped on back, clip on ear, and slap; Hutson et al., 1993). Pigs primarily rely on touch and smell because these systems are utilized most while foraging (Webster, 2011).

In a semi-natural environment, domestic pigs spend most of their time exploring their environment through grazing, rooting, and moving about (Stolba and Wood-Gush, 1989). Rooting is considered an exploratory behavior that helps a pig graze and forage in a natural setting. Pigs will use their snout to root, pushing or nudging something repeatedly usually to dig into the ground searching for edible material. Since it is such an important behavior for survival, pigs are highly motivated to root. Exploratory behaviors, like rooting, are best encouraged by substances that are complex, manipulatable, destructible, and malleable (Studnitz et al., 2007). When materials have these qualities, these materials satisfy the pigs' natural urges and motivation. Highly motivated behaviors, such as rooting, will occur even in environments that are not conducive to the behavior. Pigs will chew, sniff, and manipulate any nearby object if rooting is discouraged (Studnitz et al., 2007). In a barren environment, nearby objects may be fellow pen mates, which increases aggression and injuries (Fraser et al., 1991).

All pigs are highly motivated to root, but sows are also motivated to perform several maternal behaviors. Maternal behaviors can be categorized as seeking out a nest site in isolation, building a nest, farrowing, occupying the nest with her litter, introducing her litter to other pigs, and then weaning (Barnett et al., 2001; Johnson and Marchant-Forde, 2009). Sows will create a nest for their coming litter out of different materials (Johnson and Marchant-Forde, 2009). In a semi-natural environment, pigs will use tree branches, bushes, and grasses to create nests (Stolba and Wood-Gush, 1989). The proportion of time sows performed nesting behaviors increased until approximately 4 to 6 h before they farrowed and then declined in the final 3 h before farrowing (Rosvold et al., 2018). Having suitable materials and room to move about are important for the sows to express nesting behaviors (Rosvold et al., 2018). When creating an enrichment for pigs, understanding their behaviors, preferences, and physiology are all important considerations.

1.4 Enrichment for Swine

1.4.1 What makes a successful swine enrichment?

For an enrichment to be successful, it must increase the animal's natural behaviors, prevent or reduce abnormal behaviors, increase the animal's use of the environment, and increase its ability to deal with challenges (Young, 2003; Mkwanazi et al., 2019). When considering the environment of domestic swine, an enrichment should ideally improve the economics of the production system, and be practical to employ (van de Weerd and Day, 2009). The natural behaviors of pigs include exploration, play, foraging, and social interactions. The best materials to increase these behaviors are complex, manipulatable, destructible, and ingestible (van de Weerd and Day, 2009; Mench et al., 2010; Mkwanazi et al., 2019). Ingestible and destructible materials hold pigs' attention for a continued period of time (van de Weerd et al., 2003). Complex, changeable, and destructible materials maintain their interest (Studnitz et al., 2007). Because pigs are usually housed in barren environments, the number one goal is to enhance their living conditions and provide suitable outlets for their behaviors to enhance their welfare. The second is to manage undesirable and damaging behaviors such as tail biting and stereotypies (van de Weerd and Ison, 2019).

1.4.2 Pig enrichment studies

Many studies have explored which enrichments are best for pigs and which the pigs prefer. Scientists have presented pigs with many different and creative enrichment ideas: pig mobiles, chains, lifter bars, swivel wheels, plastic balls, rubber tires, rubber hoses, destructible-nutritious toys, straw, cloth strips, etc. (van de Weerd and Day, 2009). To explore a few, one study targeted grower and finisher pigs' rooting behavior and sense of smell with hemp ropes, sawdust, rubber balls, and herbal compounds: sensory and physical enrichments. The pigs with these enrichments spent less time engaging in stereotypies and problem behaviors directed toward pen mates. Enriched pigs also displayed more exploratory behavior (Casal-Plana et al., 2017). When sows were offered wood shavings, peat, branches, and straw (occupational and physical enrichments), their piglets had reduced fear of novel objects, increased behavioral flexibility, and how they dealt with weaning stress changed; lower levels of belly nosing, more food exploration, and more play behavior postweaning (Oostindjer et al., 2011).When pregnant sows were given these enrichments, their piglets also had increased development of social and foraging behaviors and increased growth before weaning compared to piglets whose mother had no enrichment (Oostindjer et al., 2011). The authors speculate that the piglets with no enrichment may have had a reduced intake or had reduced feed efficiency compared to piglets with enrichment. Enriched growing pigs also had increased growth compared to pigs without enrichment; hemp ropes, sawdust, rubber balls, and herbal compounds (Casal-Plana et al., 2017). The authors speculate that the increase in piglet growth may be due to pigs being more active, which led to more visits to the feeder, or were less stressed; reduced cortisol and catecholamines which have catabolic activity. However, contradictory results of enriched environments on piglet growth have also been found. The piglets born into pens with and without straw did not differ in weight at 21 d or weaning day (specific day not given) (Liu et al., 2018). Many studies with enrichment (peat, straw, and extra space; wood shavings, peat, branches, straw, and more space; hemp ropes, sawdust, rubber balls, and herbal compounds: physical and sensory enrichments) have found increased growth (Beattie et al., 2000; Oostindjer et al., 2011; Casal-Plana et al., 2017) so this one result may be a false negative or the fact that the piglets were in pens, with additional space, and had access to maternal behaviors. Another outcome with contradictory findings is the effect of enrichment on meat quality. One study found that pigs with enrichment had higher average daily food consumption and lower feed conversion ratios, which resulted in higher growth rates and heavier carcass weights compared to pigs in empty pens. The enriched pigs also produced pork products that were more tender and had fewer cooking losses (Beattie et al., 2000). However, another study comparing pigs with and without enrichment (chains, hoses, and positive human contact: physical and social enrichments) found no differences in pig performance or meat quality (Hill et al., 1998). Pigs were seen to be motivated to explore new stimuli even though the stimuli had little biological value, indicating that novelty can be beneficial but perhaps may not be stable across time (Day et al., 1998). Currently, the most effective environmental enrichments for pigs are straw, peat, rubber hoses, and ropes; physical enrichments (Mkwanazi et al., 2019). A pen full of straw was found to be the most successful way to occupy pigs and prevent severe tail biting when compared to different substrate dispensers that provided straw, food, or flavored water (van de Weerd et al., 2006). In particular, straw meets all the requirements of a successful enrichment: increases species-specific behaviors, maintains or improves health, improves economics of the production system, and is practical to employ (van de Weerd and Day, 2009).

1.4.3 Enrichment benefits for pigs

Providing enrichments to pigs’ barren environment can result in many benefits. Adding enrichment increases the number of different behaviors the pigs display (Haskell et al., 1996) such as time spent active, interacting in positive social interactions (ex. play), and in exploratory behaviors (ex. rooting; Beattie et al., 2000). Enrichment reduces the time spent in harmful social and aggressive behaviors, such as belly nosing and tail biting (Beattie et al., 2000; van de Weerd et al., 2006). Pigs also perform less stereotypies, like sham chewing and bar biting, when provided enrichment (Casal-Plana et al., 2017; Rosvold et al., 2018).

Enrichments can increase the positive affective state in pigs. A positive affective state is an indicator of better welfare. Cognitive bias is commonly used to assess positive and negative affective states (Douglas et al., 2012). Pigs were trained to approach a hatch for a food reward when they heard a positive cue or stay away from the hatch and a mildly aversive experience when they heard a negative cue (Douglas et al., 2012). To test a pig's cognitive bias, an ambiguous cue was given to see how the pigs would react, either approach or stay away. Pigs from an enriched environment were more optimistic: they were more likely and faster to approach the hatch with an ambiguous cue. Optimism indicates the pig is in a more positive affective state. If pigs were housed with enrichment and then were housed without, they took longer to approach the hatch with an ambiguous cue, representing a more negative affective state (Douglas et al., 2012). Measures of brain-derived neurotrophic factor (BDNF) also have indicated positive welfare effects from enrichment. Pigs provided with enrichment had higher levels of BDNF than pigs in barren environments, which is associated with better stress resilience (Rault et al., 2018).

1.4.4 Ineffective pig enrichments

Not all enrichments increase the welfare of pigs; some enrichments provided to pigs worked poorly or decreased welfare. Pigs are very intelligent and curious animals. They will spend more time exploring novel objects compared to familiar objects; however, the novelty declines rapidly (Wood-Gush and Vestergaard, 1991). Pigs will lose interest faster if the enrichment is only partially effective or altogether ineffective (Blackshaw et al., 1997; van de Weerd and Day, 2009). If an enrichment is designed to target a specific behavior but the animal cannot express the behavior appropriately, then their frustration increases, and they may redirect their frustration on their pen mates. A study gave a group of growing pigs a liquid dispenser, targeting the pigs' behavior to manipulate and explore. However, the dispenser was broken for most of the experiment so pigs could not interact with it properly. The pigs in this pen displayed higher levels of tail biting than other pens with straw and feed dispensers (van de Weerd et al., 2006). Enrichments can also not be as effective if social hierarchy is not considered. Social status determines which pigs have more access to the enrichment and when (Elmore et al., 2011). Cotton rope, rubber mats, straw, and compost were placed into an enriched pen. Dominant and subordinate sows were similarly motivated to access the enriched pen, however dominant sows were more aggressive so spent more time using the enrichments and prevented subordinates from using it at the same time. Subordinate sows would wait to use the enrichments during times when the dominant sows were inactive (Elmore et al., 2011). If enrichments do not keep the pigs' interest, they are not as effective as those that do and the pigs lose interest. Pigs prefer more deformable and destructible enrichment particularly over chains (van de Weerd and Day, 2009). Chains are not suitable enrichment for pigs (Bracke, 2018). Pigs habituate to chains and then only rarely interact with them (Day et al., 2002).

Enrichments can provide benefits to pigs, but the pig industry has not fully embraced them because of the current waste systems (ex. slurry) and costs outweigh the profits (ex. labor, time, and material cost vs. increased production). Enrichment has rarely been seen on farms in the United States, except when required by higher welfare farm assurance schemes. The European Union has a law that requires farms to give enrichment to their pigs. However, that does not mean the farms follow the law or if they do, the enrichment may be unsuitable or inadequate (van de Weerd and Ison, 2019).

1.4.5 Specific enrichments for sows

Understanding the motivational needs and behaviors of an animal in their environments allows enrichments to target the area and provide benefits. Gestating sows are limit fed so that they do not become overly fat and so are consequently kept in a constant state of hunger. Hunger increases the need for exploratory behaviors so the sows are very motivated to forage to find food to satiate their hunger (Beattie and O'Connellt, 2002; Studnitz et al., 2007). If an enrichment contains parts that are edible it may help satisfy these foraging behaviors (Studnitz et al., 2007). Once sows are placed into farrowing crates, they are given larger quantities of feed. Farrowing and nursing require large amounts of energy, so sows are fed more to meet this need. Since hunger is predominantly satiated, a drive to nest build becomes the primary motivated behavior in farrowing crates. Sows will build a nest for their litter right before they farrow and if not given the suitable substrate to do so, they become frustrated (Rosvold et al., 2018). Straw allows sows to carry out both foraging and nesting behaviors. Straw provides an outlet for rooting and foraging behaviors and provides fiber and stomach fill to the gestating hungry sows. When given straw, peat, or no nesting materials, sows with straw performed more nesting directed behaviors than peat or the control. Sows with straw also spent a longer proportion of their time lying down and displayed less stereotypies (Rosvold et al., 2018). Straw is an ideal enrichment to give to sows in gestation pens and farrowing crates.

However, intensive farming systems usually have slurry systems that discourage the use of straw, so alternative enrichments are necessary. Providing cloth tassels to sows pre-farrowing resulted in the sows pulling, nosing, tearing, and rooting at the material (Widowski and Curtis, 1990). When comparing sows with just cloth tassels or cloth tassels and straw, the sows directed more of their activity towards the straw and less towards the cloth tassels when both enrichments were compared to provision of just the cloth. No matter the material, sows spent the same amount of time in activity. This suggests that cloth tassels may partially satisfy the need to nest (Widowski and Curtis, 1990). In group pens, sows preferred hanging rope over hanging rubber sticks and preferred both of these over fixed wood block enrichments (Horback et al., 2016). Other studies have been carried out, however effective enrichment for gestating sows is rare (van de Weerd and Ison, 2019). Focusing on commercial farms, no tested enrichment is practical to implement on a large scale nor do any provide a productivity increase large enough to justify utilizing it thus far. Consequently, the environments of these pigs continue to be barren.

1.5 Scratching as a potential enrichment for sows

1.5.1 Scratching behavior in pigs

Pig enrichments primarily focus on exploratory and foraging behaviors; however, these are not the only behaviors pigs perform or may be motivated to do. In a semi-natural environment, domestic pigs will rub their bodies against trees and bushes (Stolba and Wood-Gush, 1989). Pigs have been seen to scratch or rub up against the fences and walls of their enclosures (Dellmeier and Friend, 1991). They will even allow people to use their hands to scratch them on their backs and behind their ears. However, overall the literature presents a very limited focus on scratching behavior in pigs. One study examined pig scratching in relation to mange (Loewenstein et al., 2006). Scratching bouts for pigs with mange lasted around 1 to 10 seconds long and occurred mostly between 1000 h and 1500 h. A study exploring the responses of sows to different stimuli noted that sows presented with eucalyptus oil and perfume on a cotton swab placed in their crate rubbed regions of their bodies on the side of the stalls (Hutson et al., 1993). No studies of scratching behavior as a target for environmental enrichment have been published.

1.5.2 Scratching and grooming definition

Currently, it is unknown whether the rubbing behavior that pigs display is considered scratching, part of their grooming, or both. Scratching usually occurs to relieve itchiness of the skin. An itch is a sensation caused by skin cell irritation (Andrews, 2007). Immune response and pain relief chemicals, neuropeptides, neurotransmitters, and prostaglandins can all stimulate nerve endings in the skin to cause itchiness. An itch is a warning system of the skin as it alerts the organism of harmful external stimuli (Andrews, 2007). Scratching helps remove dead cells and clinging materials from the skin. After wallowing in mud, pigs will rub their bodies up against objects in their environment to remove the dried mud.

Pig rubbing has been defined as a self-grooming behavior. Pigs use their hindlegs to rub their own head, neck, belly, and forelegs (Dellmeier and Friend, 1991). This is different from how a lot of other animals groom (social grooming) as pigs do not social groom (Signoret et al., 1975). Social grooming, in which animals clean each other, is a major bonding experience for some species. It can help resolve conflict, establish hierarchies, and develop a bond between a female and offspring. Other species often use their appendages or tongues to groom. Pigs do not lick each other, nor do they use appendages to groom each other. Therefore, scratching may be their primary form of grooming. No study has explored what rubbing exactly is to pigs. For practicality, the behavior of rubbing up against objects will be referred to as scratching.

1.5.3 Cattle brushes success in dairy industry

Even though scratching and grooming have not been explored in pigs, many studies have been done on dairy cattle. Many commercial dairy barns have implemented rotating brush enrichments to encourage cattle to scratch and groom themselves. When brushes were first introduced into a barn, cows increased their time spent scratching by 508% (DeVries et al., 2007). Brushes allowed the cows to groom themselves in hard to reach areas and helped satisfy the natural behavior to groom. The brushes keep the cows cleaner and can increase milk yields (Schukken and Young, 2009). Second lactation cows increased their daily yields by 3.5%. Brush usage decreases during the day when temperature and humidity are high and when the brushes are located farther from food (Mandel et al., 2013). If brush usage is altered by temperature and humidity brush usage could be used as a welfare indicator. When cows had access to brushes before calving, they spent more time grooming their calf in the first hour compared to cows that did not have access to a brush. The cows also increased their auto-grooming (grooming themselves) and scratching when they were eventually separated from their calf which has been suggested to act as a coping mechanism (Newby et al., 2013). The success of brushes in dairy cattle could potentially be replicated to other species if enrichment can target their scratching and grooming behaviors.

1.6 The aims of this project

The rising concern for animal welfare from the public has prompted changes in policy and animal care. In the swine industry, sows in farrowing crates are considered to have poor welfare because of lack of space and no social contact. Banning farrowing crates, like gestation crates have been banned, would not be economical for farmers so improving sow welfare, while keeping these environments may be an alternative solution. Environmental enrichments have documented improvements in animal welfare. Enrichment for sows is scarce, however, as the best enrichments cannot be implemented or are too expensive and implementation in farrowing crates is negligible. The slatted floors of crates prohibit using an ideal enrichment for pigs; straw. Scratching enrichments could be implemented as they are off the floor and target a natural species-specific behavior. Since scratching enrichment has not been implemented before, the preference of what materials pigs will scratch on unknown. The first objective of this project was to explore what materials pigs prefer to scratch on. Then the preferred materials were inserted into farrowing crates to see if scratching enrichments are successful in improving sow welfare.

CHAPTER TWO. DETERMINING SOW PREFERENCE FOR SCRATCHING MATERIAL

2.1 Abstract

Enrichment for farrowing crates to improve sow welfare are scarce. Most enrichment studies for sows focus on their motivation to explore and forage. Sows perform other behaviors while in crates, however. Scratching is one of these behaviors and it has not been tested as an enrichment for sows. Since scratching enrichment has not been tested, preference tests of scratching materials were conducted. It was carried out in 2 experiments. Experiment 1 was a pilot study consisting of 8 sows in an open gestation pen. Five different scratch posts were constructed and placed into the pen for 8 d. The scratch posts were made from a gate post, polyvinyl chloride (**PVC**) pipe, plywood board, and each had a different material on it: white, soft, long-bristled brushes (**White Brush**), red, hard, short-bristled brush (**Red Brush**), black, short-bristled, astro-turf-like mat (**Plastic Mat**), colorful coir, hard, short-bristled mat (**Fiber Mat**), and blue, plastic, large-round-bristled combs (**Plastic Combs**). During testing, video continuously recorded 2 behaviors: scratching and interacting. Sows scratched for the longest time on Plastic Mat followed by Fiber Mat, Plastic Combs, and Red Brush. The White Brush was scratched on the least (Plastic Mat: 12.27 ± 16.46 s; Fiber Mat: 10.44 ± 17.71 s; Plastic Combs: 4.06 ± 6.30 s; Red Brush: 2.64 ± 3.53 s; White Brush: 1.03 ± 1.84 s; mean ± SD). The top 3 preferences were chosen to proceed to Exp. 2.

Experiment 2 was performed on several pens of sows and gilts with Plastic Mat, Fiber Mat, and Plastic Combs to narrow down the materials to 2 for a future experiment in farrowing crates. Experiment 2 was carried out in repetitions. Each repetition tested 4 pens at a time. Scratch posts were modified from Exp. 1 and each material was placed in a pen. A total of 2 repetitions were carried out over 8 and 4 d (N=8). During the first repetition (**Rep 1**), sows ate and destroyed all the Plastic Combs within 2 d. The Plastic Combs were pulled from the study and the second repetition (**Rep 2**) only had the Plastic Mat and Fiber Mat represented. For Rep 2, more modifications to the scratch posts were made and the sows were given a little extra feed to try and alleviate destruction.

There was an interaction effect for duration and frequency of scratching and interacting with the 2 enrichments (Durations: $F_{1,112.6} = 13.63$, $P = 0.0003$; Frequencies: $F_{1,111.9} = 19.72$, $P < 0.0001$). Sows spent more time and more frequently interacted with the Fiber Mat compared to the Plastic Mat and interacted with both enrichments more than compared to scratching according to a post-hoc Tukey test. The scratch posts were destroyed by chewing in Rep 1 and 2 proving that the sows' motivation to perform oral manipulations was greater than scratching behaviors.

Keywords: animal behavior, environmental enrichment, gestation pens, preference, scratching, swine

2.2 Introduction

Enrichment can improve the welfare of animals and in doing so alleviate rising public concern for better animal welfare (Young, 2003; Tonsor et al., 2009). A particular area of concern for animal welfare is the use of farrowing crates. Sows in farrowing crates lack space to move, social contact, and cannot perform many natural behaviors, which decreases their welfare (Johnson and Marchant-Forde, 2009). Providing straw enrichment to sows allows them to perform motivated nesting behaviors and decreases the occurrence of stereotypies, which increases their welfare (Rosvold et al., 2018). Unfortunately, the slurry waste management system, common on intensive commercial farms, prevents the use of straw. Other enrichments for sows are not as effective as straw, and farmers are reluctant to implement an item that increases costs, management, and labor. Consequently, environmental enrichments for sows are uncommon (van de Weerd and Ison, 2019).

Most pig enrichments target exploratory and foraging behaviors since pigs are very motivated to display these behaviors. Pigs display other behaviors that may make for a more practical enrichment target, especially in the limited environment of farrowing crates. In crates, sows will often be observed scratching themselves on the stall bars. In other environments, they will also rub against walls, fences, and allow scratching from handlers (Dellmeier and Friend, 1991). In a semi-natural environment, domestic pigs will rub up against trees and bushes (Stolba and Wood-Gush, 1989). Current literature provides very few definitions and explanations for scratching behavior. Neither the motivation sows have to scratch nor what sort of materials sows enjoy rubbing up against is known. Enrichment items designed to target scratching behavior have not been published.

Our aim was to provide a scratching enrichment to sows in farrowing crates. However, first sow preference for scratching material and willingness to scratch on an enrichment needed to be tested. A pilot study was performed with several different materials to determine sow preference, narrow down the potential materials, and explore enrichment design and destructibility. A more formal experiment was then implemented with the top 3 preferred materials to determine which 2 materials sows preferred, how often sows scratched, and for how long they scratched.

2.3 Materials and Methods

2.3.1 Animals, Housing, and Management

All research was approved by the Purdue University Animal Care and Use Committee (PACUC, 1712001667). Gilts and sows were housed in an open gestating barn at the Purdue University Animal Science Research and Education Center (ASREC, West Lafayette, IN). Each pen contained 5 to 14 gilts or sows. The back half of the pens had solid concrete floors and walls that reached the metal ceiling. A feed dispenser dropped feed (gestation ground corn diet) on the ground every morning around 0800 h. Sows had a heat lamp suspended from the ceiling to give warmth during cold months. The front half of the pen had slatted concrete floors and the concrete walls were about 1 m high. A ceiling tall pole was located between the 2 types of flooring and held a drinker to provide water *ad libitum* (Fig. 2.1). The fronts of the pens were open to provide natural light.

2.3.2 Experimental Design

Because no scratching enrichment experiments had been conducted before, a pilot study (**Exp. 1**) was carried out first to explore potential materials and the best way to present materials to the pigs. The pilot consisted of 1 pen of 8 sows. For the formal experiment (**Exp. 2**), the experimental unit was the pen. The barn only contained a total of 12 pens and pigs were consistently being cycled in and out, to go to the farrowing barns. Pens contained gilts or sows of multiple parities. Pens with sows or gilts in the last third of gestation were excluded from the experiment. The experiment was conducted in 2 repetitions of 4 pens (actual sample size of 8), due to availability and material destruction (**Rep 1** and **Rep 2**).

2.3.3 Experiment 1

2.3.3.1 Enrichments

Five scratch posts, consisting of PVC pipes with boards attached to them, were created (Fig. 2.2). The structure of the post was an upside down ‘L’ and was made from PVC pipe (PVC Schedule 40 Foam Core Pipe, Lisle, IL). This height was selected based on the back height of standing sows used in this experiment. A 76.2 cm length of 3.81 cm diameter pipe was cut, a

33.02 cm lengthwise 1.27 cm wide cut was created in the pipe, and then placed inside a 33.02 cm long 5.08 cm diameter pipe. A 3.81 cm elbow was attached to the inside pipe and a 3.81 cm diameter 45.09 cm long pipe was attached to the other end of the elbow to make the small part of the ‘L’. The elbow and pipes were held together with glue (Regular PVC cement, Oatey, Cleveland, OH). Plywood (treated handi-panel, Menards, Inc., Eau Claire, WI) was cut into a long part (20.32 cm x 45.72 cm) and a short part (11.43 cm x 27.94 cm). The boards were attached to the pipes with hex bolts (0.79 cm shank diameter x 7.62 or 6.35 cm length) that went through the board and pipe and was secured with a nut at the back of the pipe. For the long part of the ‘L’ the bolts also went through the slit in the inside pipe. This allowed the inside pipe to move up and down but not be removed. This upside down ‘L’ of pipe and board was attached using quick links (SecureLine 1/8 inch stainless steel, Lehigh, Allentown, PA) and chains (Tie Out Chain, Large, Meijer Inc., Grand Rapids, MI) to a gate post with a floor plate and t-bolts to allow for attachment to slatted floors (Hog Slat, Newton Grove, NC). Different scratching materials were attached to the boards with hex bolts and nails (Grip Fast #6 x 1-inch Phillips dive zinc flat head sheet metal screws, Menards, Inc., Eau Claire, WI).

Five different scratching materials were used to provide a wide range of options for the pigs to scratch on: from plastic to fiber, short to long bristles, and hard to soft. They included a white, soft, long-bristled brush (**White Brush**; 5.08 cm bleached tampico bristles, Decker Manufacturing Co., Keokuk, IA); red, harder, short-bristled brush (**Red Brush**; 3.18 cm recycled fiber bristles, Libman, Arcola, IL); black, short-bristled, astro-turf-like plastic mat (**Plastic Mat**; 45.72 cm x 76.20 cm, Clean Machine Metro Entrance Mat, Grass Worx, St. Loui, MI); colorful coir, hard, short-bristled coir mat (**Fiber Mat**; 45.72 x 76.20 cm, Meijer, Inc., Grand Rapids, MI); and blue, plastic, large-round-bristled combs (**Plastic Combs**; Oster Equine Care Series, Boca Raton, FL; Fig. 2.2). The materials were cut or placed so that the boards attached to the PVC were mostly covered.

2.3.3.2 Procedures

Sows were given 5 different scratch posts (**White Brush, Plastic Mat, Red Brush, Fiber Mat, Plastic Combs**). They had 1 d to habituate and then data were recorded for the next 7 d before the posts were removed. The enrichments were positioned in the front half of the pen on the slats, so pigs had to move away from the lying and eating site to explore. Enrichment location was randomly allotted and there was enough space between each enrichment so that a sow would not touch 2 at once (Fig. 2.3). One camera (KPC0N502NUB, KT&C, Fairfield, NJ) recorded continuous video using management software (GeoVision Network Video Recorder, Taipei, Taiwan). Video was then observed (EzViewLog500, GeoVision, Taipei, Taiwan) starting at 1200 h on the first data collection day and ended at 1200 h on the day the materials were removed. Continuous sampling was used to document scratching behavior and interacting with the posts since scratching bouts are very rapid (Table 2.1).

2.3.3.3 Data Processing

Durations for Scratching and Interacting were calculated from the difference between start and stop times of the pigs touching the enrichment. The durations were then summed for each enrichment per behavior per day. The frequency of Scratching and Interacting were also counted and totaled for each enrichment per behavior per day.

2.3.3.4 Statistical Methods

The experimental unit was the pen. Since Exp. 1 only had 1 experimental unit, all data are descriptive. Results are presented as averages ± standard deviation.

2.3.4 Experiment 2

2.3.4.1 Enrichments

The scratch posts for the full experiment were modified from the pilot. The posts in the pilot could swing back and forth since they were attached to the gate post with chains. Since the gate posts were open on one side (Fig. 2.4), the 5.08 cm diameter outside pipe was discarded and the 3.81 cm diameter inside pipe was placed inside the gate post. The hex bolts would then go through the board, the slit in the 3.81 cm diameter pipe, and then through holes in the gate post. This kept the pipes from swinging back and forth since the main part of the structure was now the gate post and not the 5.08 cm pipe. The upside down ‘L’ was also too tall for some of the shorter sows, so the 3.81 cm pipe was cut shorter (73.66 cm in length).

For Rep 1, 3 scratch posts were used; Plastic Mat, Fiber Mat, and Plastic Combs. The mats were cut and placed onto the bigger board so that the material wrapped around to the back.

A metal edge piece (1 ¼ inch x 1 ¼ inch slotted steal angle, Hillman, Cincinnati, OH) was also cut and placed on the bottom edge of the board (Fig. 2.4). This was done to discourage the sows from pulling the material off. A bolt and cable tie (20.32 cm black cable tie, Gardner Bender, New Berlin, WI) were placed through the elbow and attached pipes so that the short end of the 'L' could not be torn off. In addition to screws to attach the mats, staples (1.43 cm Arrow t50, Arrow Fastener Co., Saddle Brook, NJ) and glue (E6000, Eclectic Products, Eugene, OR) were also added for double reinforcement.

For Rep 2, only 2 scratch posts were used (Plastic Mat and Fiber Mat) because Plastic Combs were found not to be durable since the sows ate and tore them apart in Rep 1 so were not practical for implementation. The metal edge pieces were added all around the mat on the bigger board (Fig. 2.5). Pigs can taste bitterness and tend to avoid bitter tasting substances (Nelson and Sanregret, 1997; Danilova et al., 1999). Thus, bitter spray (ultra-bitter training aid spray, Fooey, Fort Lauderdale, FL and bitter apple spray, Grannick's, Greenwich, CT) was also sprayed onto the materials to discourage the pigs from eating and chewing the mats. To attract attention away from eating the scratch posts, two chains were added to the gate as oral enrichments. The sows would hopefully perform more biting and chewing behaviors on the chains rather than the mats.

2.3.4.2 Procedures

Procedures were the same for the pilot with some exceptions. For Rep 1, each pen only contained 3 scratch posts (Plastic Mat, Fiber Mat, and Plastic Combs). All the posts were located toward the front of the pen where the floor was slatted. The posts were on the left, right, or center of the slatted area (Fig. 2.6). Left, right, or center spot for each scratch post was randomly balanced across pens to account for potential location bias. They had 1 d to habituate before data were video recorded for 2 wk. For Rep 1, Plastic Combs were pulled from the study after 2 d since most had been eaten or destroyed. Seven days after habituation a new enrichment design with all metal edges and bitter spray was created as the sows were destroying the materials so fast. After 12 d, the posts were pulled out and bitter sprays and chains were experimented with for a few days to see if destruction could be mitigated. For Rep 2, they were given 1 d to habituate with the new design and chains. Due to continued destruction, video was recorded for only 4 d.

Video was recorded in the same way as the pilot to document Interacting and Scratching behaviors on the Plastic Mat and Fiber Mat. Continuous sampling was used to record behaviors, what part of the enrichment was touched, and what region of the pig's body touched the enrichment (Table 2.2). The pig had to be touching the scratching materials, not the back of the post or back of the materials, to be counted as a bout of behavior. Two behavior bouts by the same pig were counted as separate durations if there were greater than 2 s in between the pig touching the materials. The pigs had to be actively touching the material and not be stationary to be counted as a bout of behavior. Since the pigs destroyed some of the enrichments, data were only recorded if both scratching posts were intact. This way the data would not be biased if material was gone mostly on one enrichment and the pigs switched their attention to destroying the other enrichment. When people and the boar were in the pen, data were not recorded as the sows' behavior was heavily influenced by their presence.

A data logger (HOBO U12-112, Onset, Bourne, MA) was placed in the middle of the barn to record temperature (Rep 1: 23.99 ± 1.59°C, Rep 2: 24.82 ± 1.33°C; average ± standard deviation). Body lesion scores were recorded for each sow the day the enrichments were put in and when they were taken out (Table 2.3). Wounds could potentially occur due to improper use of the enrichment or aggression between pen mates for access to enrichment, neither being desirable (Elmore et al., 2011). For each pen, the farm personnel provided the parities of each sow. Each pen was then considered to contain gilts or sows. The number of pigs in each pen was also recorded (Table 2.4).

During Rep 1, 1 of the pens had extra feed on the floor for most of the week as their feed had not been adjusted after some pigs had been removed from the pen. It was observed that this pen did not tear apart their scratch posts. For Rep 2, the feed was increased by 0.45 kg per pig for all 4 pens. This was done to try and mitigate the pigs' hunger and see if it influenced how they interacted with the scratch posts.

2.3.4.3 Data Processing

Durations for the 2 behaviors were calculated by finding the difference between the start and end times for a single occurrence. The durations were totaled per enrichment per pen per day. Frequencies of the 2 behaviors were calculated and also totaled per enrichment per pen per day.

The differences between body lesion scores were calculated by taking the score at the end of the repetition and subtracting it from the score taken when the enrichment was put in. The lesion score difference for each sow was then averaged per pen.

A data logger recorded temperature every h from the days of habituation to the end of the experiments. The maximum temperatures for each day were found.

2.3.4.4 Statistical Methods

Data were analyzed in JMP statistical software (version 13.2.0, SAS Institute Inc., Cary, NC) using general linear mixed models. The experimental unit was the pen. Independent variables included the pen, extra feed, parity, repetition, day, maximum ambient temperatures, the 5 enrichments, and the 2 behaviors. Pen was nested within repetition. The total durations and frequencies for both behaviors were transformed using Log10+1. Threshold for significance was set at $P < 0.05$. Models were reduced when appropriate and significant main effects and two-way interactions were analyzed using Tukey post-hoc tests. Results are presented as least square means ± standard error of the mean (LSM ± SEM).

Since the experiment ended early, there was not sufficient power to analyze all the measures. The repetition, number of sows per pen, extra feed, and parity are represented in Table 2.4. Lesion score differences, pig body region, enrichment area, behaviors during different times of day, and enrichment destruction are described in the descriptive results section. The maximum ambient temperatures were dropped from the duration and frequency models as they were not significant. Day was dropped from the duration model as it was not significant.

2.4 Results

2.4.1 Experiment 1

2.4.1.1 Durations of Behaviors

The total durations the sows spent Scratching and Interacting appeared to be different among the 5 enrichments. The sows spent the most time with Plastic Mat and then decreased their time spent with Fiber Mat, then Plastic Combs, then Red Brush, and the least amount of time with White Brush (Fig. 2.7). The sows spent more time Interacting than Scratching on the enrichments (Interacting: 692.37 ± 896.97 total s per enrich per day; Scratching: 37.97 ± 45.53

total s per enrich per day). The sows spent less time performing behaviors with the enrichments over time (Day 1: 14.04 ± 23.19 total min per behavior per enrichment; Day 7: 6.51 ± 8.85 total min per behavior per enrichment; Fig. 2.8).

2.4.1.2 Frequencies of Behaviors

The total amount of times the sows spent Scratching and Interacting appeared to be different between the 5 enrichments. The sows performed behaviors most frequently with Plastic Mat and declined in frequency for Fiber Mat, then Plastic Combs, then Red Brush, and least frequently with White Brush (Fig. 2.9). The sows also appeared to perform Interacting more frequently than Scratching (Interacting: 20.77 ± 20.99 total counts per enrichment per day; Scratching: 3.4 ± 3.12 total counts per enrichment per day). The frequency that the sows performed behaviors on the enrichments declined as the experiment progressed (Day 1: 25.00 ± 32.85 total counts per behavior per enrichment; Day 7: 14.10 ± 14.64 total counts per behavior per enrichment; Fig. 2.10).

All 8 sows performed Interacting with an enrichment. Over all 7 d, pig 1 had a total count of 39, pig 2 had a total count of 6, pig 3 had a total count of 116, pig 4 had a total count of 144, pig 5 had a total count of 14, pig 6 had a total count of 30, pig 7 had a total count of 12, and pig 8 had a total count of 5 Interacting behaviors. All 8 sows also performed Scratching on an enrichment. Over the course of 7 d the number of times the pigs scratched differed: pig 1 had a total count of 5, pig 2 had a total count of 2, pig 3 had a total count of 13, pig 4 had a total count of 31, pig 5 had a total count of 3, pig 6 had a total count of 2, pig 7 and 8 each had a total count of 1. There was a total of 361 Interacting and 61 Scratching bouts that were categorized under ‘other’ because the pig number could not be identified because of camera angle and shadow. While watching video, sows were also seen scratching on the cement walls, gates, and drinking pole.

2.4.1.3 Additional Findings

The sows performed Interacting bouts most often between 0700 to 0900 and 1500 to 1600 (Fig. 2.11a). The sows seemed to perform Scratching bouts most often between 0600 to 0800 and 1500 to 1600 (Fig. 2.11b). Sows performed relatively few Interacting and Scratching bouts on the scratch posts between 1700 to 0600.

When the scratch posts were pulled from the pen at the end of the experiment, most of the materials were intact (Fig. 2.12). The pigs chewed and rubbed dirt on the scratch posts. None of the scratch posts had to be repaired during the wk.

2.4.2 Experiment 2

2.4.2.1 Total Durations of Behaviors

The total durations of behaviors showed an interaction effect between the 2 enrichments and what behavior was being performed ($F_{1,112.6} = 13.63$, $P = 0.0003$). Post-hoc Tukey tests showed that sows performed Interacting with the Fiber Mat for a longer duration than Interacting with the Plastic Mat and they spent more time Interacting than Scratching with both enrichments (Fig. 2.13). The total durations spent performing behaviors were not influenced by repetition (Rep 1: 1.78 ± 0.24 Log10 +1 s; Rep 2: 2.27 ± 0.24 Log10 + 1 s; $F_{1,5.66} = 2.08$, $P = 0.20$).

2.4.2.2 Total Frequencies of Behaviors

The total frequencies of behaviors interacted between the 2 enrichments and what behavior was being performed ($F_{1,111.9} = 19.71$, $P < 0.0001$). Post-hoc Tukey tests showed that sows performed Interacting with the Fiber Mat more often than Interacting with the Plastic Mat and they performed Interacting with the enrichments more than Scratching (Fig. 2.14). The frequencies decreased as the experiment progressed ($F_{1,112.5} = 3.97$, $P = 0.049$, Fig. 2.15). The total frequencies were not influenced by repetition (Rep 1: 0.98 ± 0.21 Log10 + 1 total counts; Rep 2: 1.44 ± 0.22 Log10 + 1 total counts; $F_{1,5.94} = 2.35$, $P = 0.177$).

2.4.2.3 Descriptive Results

The average lesion score differences per pen were all close to 0, less than 0.5 or greater than -0.5 (Fig. 2.16). The pigs interacted with the top or the main part of the enrichments more often than both parts of the enrichment at a time (Fig. 2.17). The pigs seemed to use their head and back more often than other body areas to touch the enrichment (Table 2.5). Over the course of the day, pigs Interacted with the enrichments most often between 0600 to 0800 and 0900 to 1200. They Scratched with the enrichments most often between 0600 to 0700 and 1700 to 1800, with quite a bit of activity between these time points (Fig. 2.18). Some of the sows quickly destroyed the enrichment, tearing off the mat. The time from when the enrichment was fastened and the person walked out of the pen to most of the mat being no longer attached to the board, the fastest 3 times recorded were 2 min 32 s, 5 min 36 s, and 12 min 4 s. All were done in the same pen. The fastest times to destroy, in two other pens, were 18 min 43 s and 18 min 50 s. All these mats were Fiber Mats except for 1 Plastic Mat. One of these Fiber Mats was from Rep. 2, but all the others were from Rep. 1. During Rep 1 and 2, materials were replaced when destroyed but the rate of destruction was faster than expected so some days the posts could not be repaired because more materials needed to be bought. The sows destroyed a total of 21 Fiber Mats and 7 Plastic Mats. All 7 Plastic Mats were from Rep. 1.

2.5 Discussion

This study, for the first time, evaluated substrates to promote scratching behavior in gestating sows. Almost nothing is known about scratching as a general pig behavior. In this study, sows were given a choice between many different materials to determine which substrates they prefer to scratch on. Preference tests are good indicators of what animals prefer as they are able to choose (Duncan, 1992). To provide sows with many options to choose from, the materials were made of a few different materials (coir, plastic, bristles) and had different properties (hard or soft). Preference tests cannot contain every possible choice and that was true for this test. The variety of scratching materials attempted to encompass a wide spectrum but there are many more scratching substrate options. For these experiments, we can only conclude that the sows preferred certain materials over others but cannot say that the sows favor one choice over everything. Other studies will need to be done with other objects and the top choices from these studies to gain a better knowledge of what sows prefer overall.

For Exp. 1, the sows performed Scratching the least on bristled items (White Brush and Red Brush) suggesting that sows prefer to scratch on harder surfaces that have more resistance. In semi-natural environments, sows rub against trees and brush while in confinement they rub against concrete walls and fences (Stolba and Wood-Gush, 1989; Dellmeier and Friend, 1991). These surfaces are hard and unyielding and what the sows are used to utilizing. Softer brushes may not satisfy the sows’ itch or they may feel the most foreign to them, so they used these materials less. Over the course of the experiment, the sows spent less time Interacting and Scratching with the enrichments. This may be due to the sows losing interest in the enrichment.

An enrichment can lose its novelty causing the pigs to explore the items less, which has happened in other studies (van de Weerd and Day, 2009). Further studies would need to be conducted that go for a longer duration to see if the sows would lose interest entirely or it would level out and the sows would continue to scratch on the enrichments. The sows spent more time Interacting with the enrichments compared to Scratching. Gestating sows are limit fed so they become hungry and motivated to forage (Mason and Rushen, 2006; Webster, 2011). Chewing and nudging the enrichment may have been motivated by their hunger which then increased their time Interacting. From Exp. 1, the top 3 preferred enrichments moved on to Exp. 2 to be tested for a longer duration (to see if sows would continue to use them) and in multiple pens so statistical analyses could be performed.

For Exp. 2, the sows destroyed many of the materials, which came at a surprise as they did not perform this level of destruction in Exp. 1. Between Rep 1 and 2 many changes had to be made, however all the changes did not discourage the sows from destroying the enrichment. The level of destruction caused the experiment to be ended sooner than expected, however the results did not discourage us moving forward to evaluate its effectiveness in farrowing crates, since it is a more confined environment. Even though the sows destroyed the scratch post enrichments and Exp. 2 ended early, a lot can still be learned about sows' preference. The sows interacted with the Fiber Mat more often and for longer durations than the Plastic Mat. This may be due to the composition of the Fiber Mats. The Fiber Mats were made of coir, or coconut fibers, which may have been appetizing to the sows. The Fiber Mats appeared to be easier to tear apart as there were 3 times as many Fiber Mats replaced as Plastic Mats. Also, once Rep 2 had metal all around the edges of the materials, the sows did not destroy any more Plastic Mats, but they still destroyed Fiber Mats. However, the sows would still scratch on the enrichments even though they were also destroying them. There was no preference between scratching on the Plastic Mats and Fiber Mats, so it is suggested that if more studies are performed the Fiber Mats are not used because of destruction and a material similar to Plastic Mats is used that would be less likely to injure the sows.

The repetition did not affect the total durations or frequencies of Interacting or Scratching even though there were several differences between Rep 1 and 2. There were a lot of changes that occurred between the 2 repetitions and a lot of lost data from the sows destroying the enrichment. If this experiment were to be reran with other materials that are not as destructible the results may be a lot different. In this gestation pen environment, scratching may not be a high priority and putting scratching enrichments in with younger pigs that are fed full feed, there may be more differences seen and less destruction.

For Exp. 1 and 2, statistical analyses could not be run on some of the data because of low numbers. However, the data still provide an idea of how sows interacted and scratched on these enrichments. For both experiments, sows scratched and interacted with the enrichments mostly during the day. There was increased activity before and after 0800 to 0900 h, when the sows usually got fed. The sows most likely were up and about waiting on their food, and then still active right after they were done.

Stereotypies are behaviors that are repetitive, fixed in form, and serve no obvious function. They are considered abnormal behaviors and are indicators of poor welfare. Pigs perform bar biting and sham chewing stereotypies that usually occur around feeding time (Rushen, 1985; Mason and Rushen, 2006). The interactions with the enrichments around these same times might be related to the stereotypies. Chewing and nudging on the enrichments may have allowed the sows to cope by providing an outlet for oral manipulations while they waited for feed, instead of coping through performing bar biting and sham chewing. For Rep 1, there's a peak of activity around 1500 to 1600 h for scratching while Rep 2 has a peak around 1700 to 1800 h for scratching. When these 2 experiments occurred, sunset was about 2 h apart: Rep 1 around 1815 h and Rep 2 around 2015 h. The extra daylight may have impacted the sows' activity. Since statistics were not done on time of day and behaviors, this is just speculation. Future studies with more replications may tell us more.

Experiment 2 also looked at lesion scores and how the sows used the enrichments but was not analyzed. Average lesion score differences were similar between pens. Averages did not range farther than 0.5 to -0.5. All are close to 0, which may indicate that the enrichments did not cause the sows to fight more or injure themselves on the posts. It has been found that dominant and subordinate sows utilize enrichments differently and can cause some aggression over enrichment use (Elmore et al., 2011). The sows used both parts of the enrichment and rubbed all parts of their body against the enrichment. The top part of the enrichment allowed the sows to scratch the top of their back which is a spot the sows are not usually able to reach with walls or fences.

Overall, sows prefer Interacting and Scratching on Plastic Mats and Fiber Mats compared to Plastic Combs, Red Brushes, and White Brushes. However, Exp. 2 faced many challenges that consequently limited the sows' choices. From these experiments, scientists can learn and better prepare for experiments that take place in gestation pens and that work with pig scratching. There are still many unanswered questions concerning pig scratching and how it may play a role in pig enrichment and welfare, such as how motivated pigs are to scratch and what purpose scratching serves.

2.6 Tables and Figures

Table 2.1. Ethogram used when watching Exp. 1, pilot video.

Behavior	Definition
Scratching	Pig moves back and forth or up and down against the mats.
Interacting	Chewing, nudging, or walking under. Pig is touching the enrichment but not scratching.

Table 2.2. Experiment 2 ethogram. Data were recorded based on behavior, pig body region touching the enrichment, and enrichment area being interacted with by the sow.

Category	Term	Definition
Behavior[1]	Scratching	Pig moves back and forth or up and down against the mats.
	Interacting	Pig touching the enrichment but not scratching; chewing, nudging, or walking under.
Pig Body Region	Head	Forward of the pig's shoulders. Includes neck, jowl, ears, snout, and side of face.
	Side	Side of the pig. Surface perpendicular to the ground when sow is standing.
	Back	Loin area of the pig. Dorsal plane.
	Head & Side	Head and side both touch the enrichment in 1 bout.
	Side & Back	Side and back both touch the enrichment in 1 bout.
	Head, Side, & Back	Head, side, and back all touch the enrichment in 1 bout.
Enrichment Area	Top	Board of materials on the part of the post that made the small length of an upside down 'L'. Arm that extended parallel to the ground. Pig could manipulate up and down.
	Main	Board of materials on the part of the post that made the long length of an upside down 'L'. Vertical rectangular piece of board with materials. Stationary.
	Both	Touched both the top and main parts of the enrichment during one bout of behavior.

[1]The pig had to be touching the scratching materials, not the back of the post or back of the boards, to be counted as a bout of behavior. Two behavior bouts by the same pig were counted as separate durations if there was greater than 2 s in between the pig touching the materials. The pigs had to be actively touching the materials and not stationary to be counted as a bout.

Table 2.3. Body lesions were scored 0 to 2 depending on how many scratches or wounds were on the different body regions (Bolkuis et al., 2009).[1]

Steps	Categorization
Sow body regions	Front: head region; forward of the forerib
	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 score ‘c’
	2 - 2 or more regions with score ‘c’

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

Table 2.4. Data provided by farm personnel for Exp. 2 pens.

Pen No.	Repetition	No. Sows	Extra Feed	Parity
3	1	14	No	Sow
7	1	7	No	Gilt
8	1	10	No	Sow
9	1	5	Yes	Gilt
1	2	14	Yes	Gilt
2	2	13	Yes	Gilt
5	2	11	Yes	Sow
12	2	5	Yes	Gilt

Table 2.5. Average behavior frequencies per pen per pig displayed with the pig's different body regions.

Pig Body Region	Mean Frequency
Head	449.38
Side	5.00
Back	128.38
Head & Side	0.25
Side & Back	21.88
Head, Side, & Back	1.63

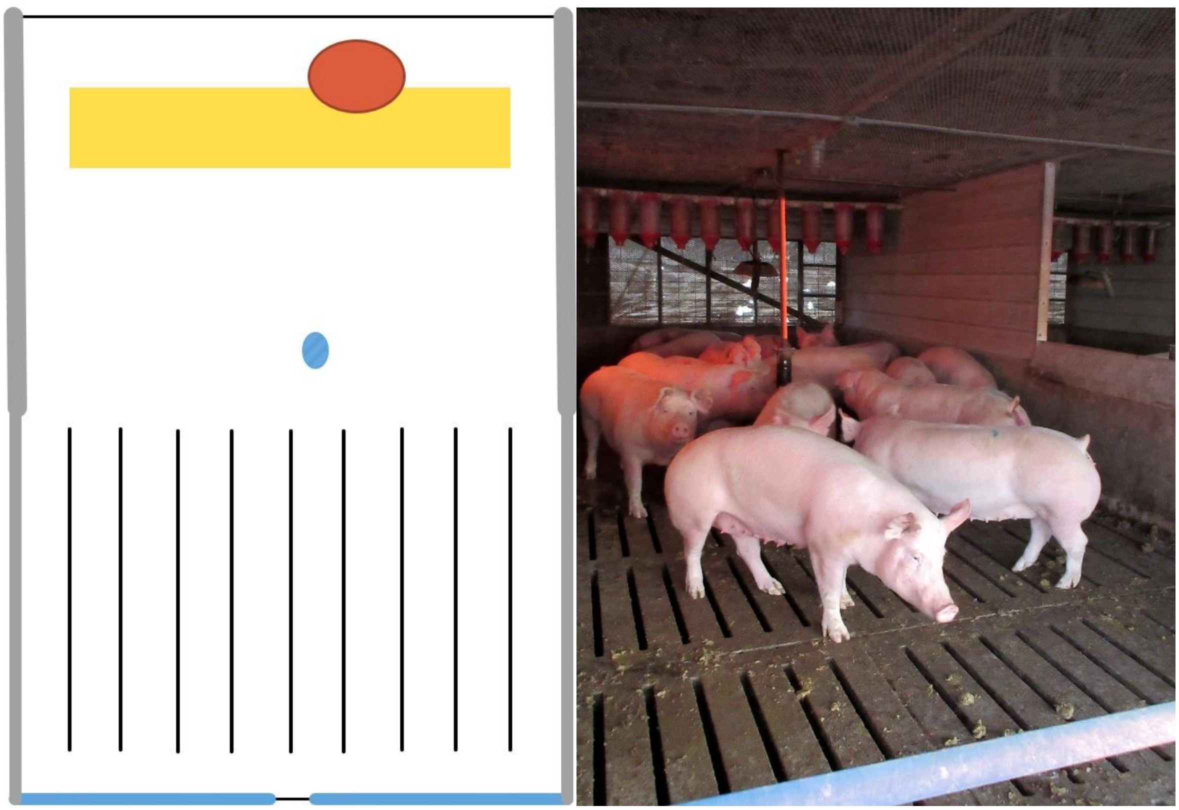


Figure 2.1. Aerial view of the gestation group pen (left) and picture of the pen (right) from the front where the gate is located. Left figure: red circle represents the heat lamp suspended from the ceiling, yellow square is where the feed would fall on the concrete floor in the back half of the pen, small blue dot in the center represents where the post with drinker was situated, blue bars in front are the gate, thicker grey lines represent the walls going all the way up to the ceiling, thinner grey lines are where the walls only go up part way, and black lines represent the half of the floor that was slatted.

Figure 2.2. Five scratch post enrichments were created using polyvinyl chloride pipe (**PVC**), nuts, bolts, chain, screws, and different scratching materials for Exp. 1. Left to right, materials used were: 1) white, soft, long-bristled brushes (5.08 cm bleached tampico, Decker Manufacturing Co., Keokuk, IA); 2) black, short-bristled, astro-turf-like mat (45.72 cm x 76.20 cm, Clean Machine Metro Entrance Mat, Grass Worx, St. Loui, MI); 3) red, hard, short-bristled brush (3.18 cm recycled fiber bristles, Libman, Arcola, IL); 4) coir, hard, short-bristled mat (45.72 cm x 72.20 cm, Meijer, Inc., Grand Rapids, MI); and 5) blue, plastic, large-round-bristled combs (Oster Equine Care Series, Boca Raton). They were made in an L shape so that the top arm of the post could move up and down.

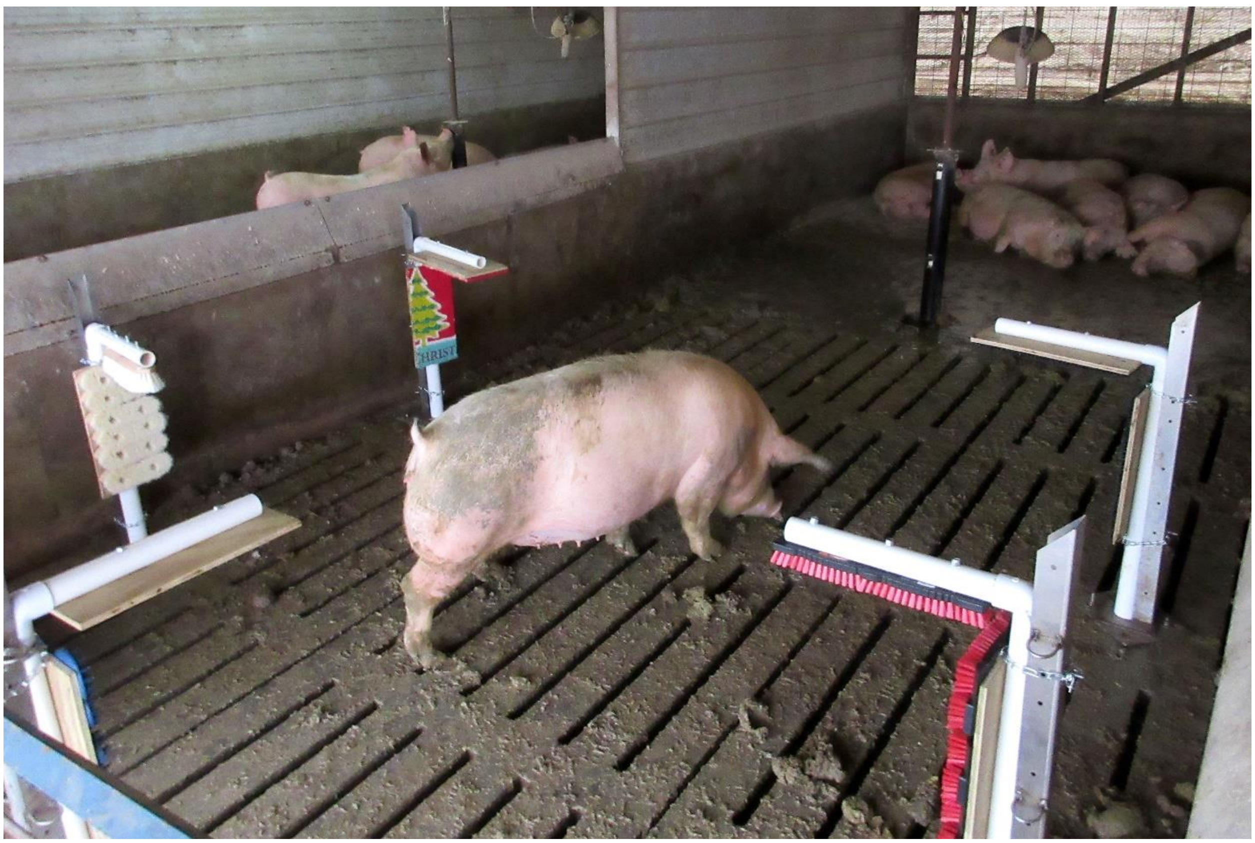


Figure 2.3. The 5 enrichments were placed on the slatted floor so that pigs had to move out of the lying and feeding space in the back to explore. Enrichment location was randomly assigned and there was space in between each enrichment so that a sow could not be touching 2 at once.

Figure 2.4. Experiment 2, Rep 1 scratch post. The inside pipe was placed into the gate post so that the pigs could not swing it back and forth as much. Mats were wrapped around the board and a metal edge was attached to the bottom to discourage the sows from taking the material off. Bolts and cable ties were placed through the elbow where the two pipes attached to keep the sows from popping the top off.

Figure 2.5. Experiment 2, Rep 2 scratch posts. Metal angles were placed all around the mat on the bigger board and bitter sprays were used to try and discourage the sows from eating and tearing the mat off.

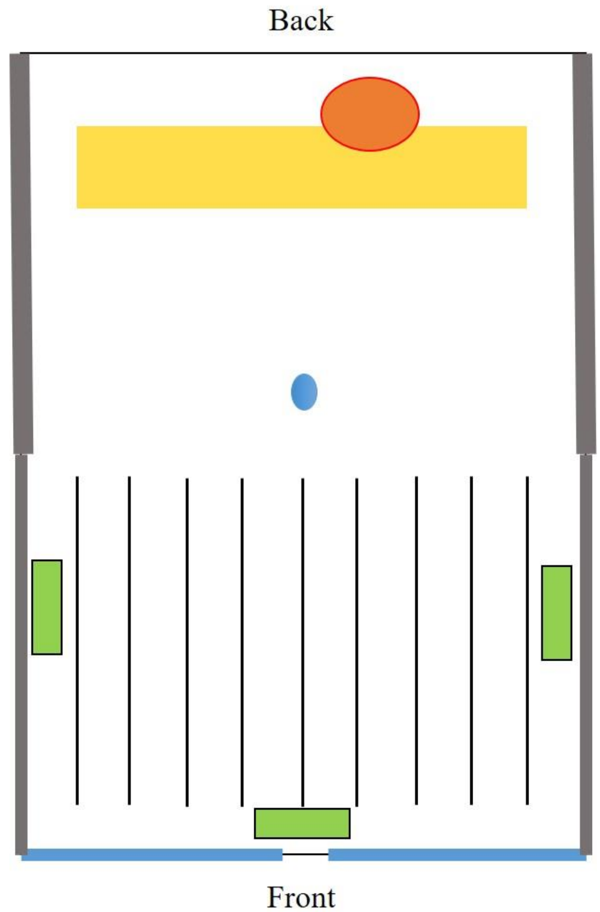


Figure 2.6. Diagram of the pen with three scratch posts (green squares). Scratch posts were positioned left, center, or right, when looking at the pen while standing in the front. So, the center post was located in the middle of the front gates (blue lines). The diagram also portrays a red circle which represents the heat lamp suspended from the ceiling, yellow square where the feed would fall on the concrete floor in the back half of the pen, small blue dot in the center for the post with drinker, thicker grey lines represent the walls going all the way up to the ceiling, thinner grey lines are where the walls only go up part way, and black lines represent the half of the floor that was slatted.

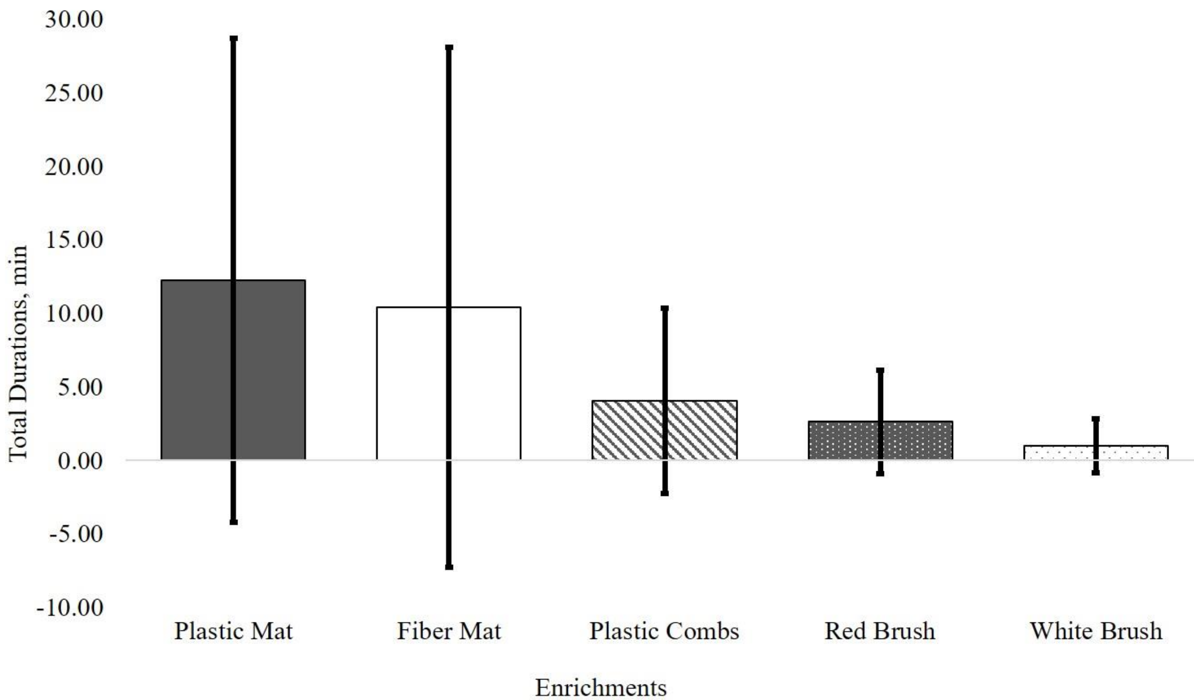


Figure 2.7. Mean total durations in min of both behaviors, scratching and interacting, during all days (mean ± SD) for the 5 enrichments (Plastic Mat, Fiber Mat, Plastic Combs, Red Brush, White Brush).

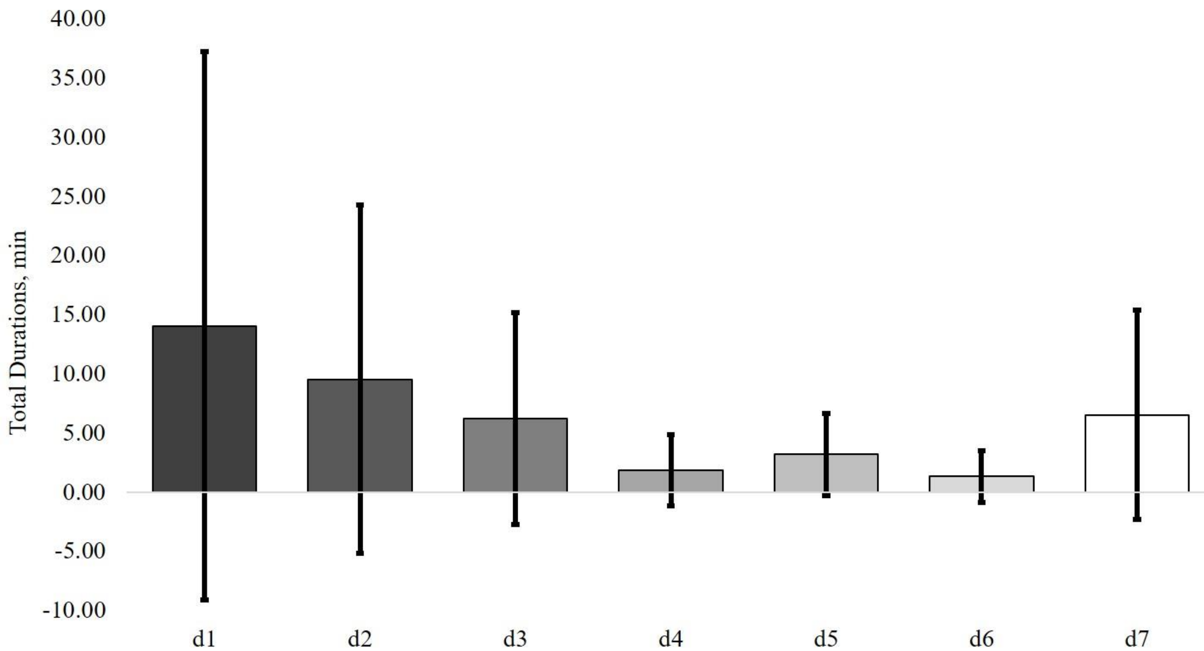


Figure 2.8. Mean total durations in min of both behaviors, scratching and interacting, for all enrichments (mean ± SD) over the days of the experiment (d1-d7).

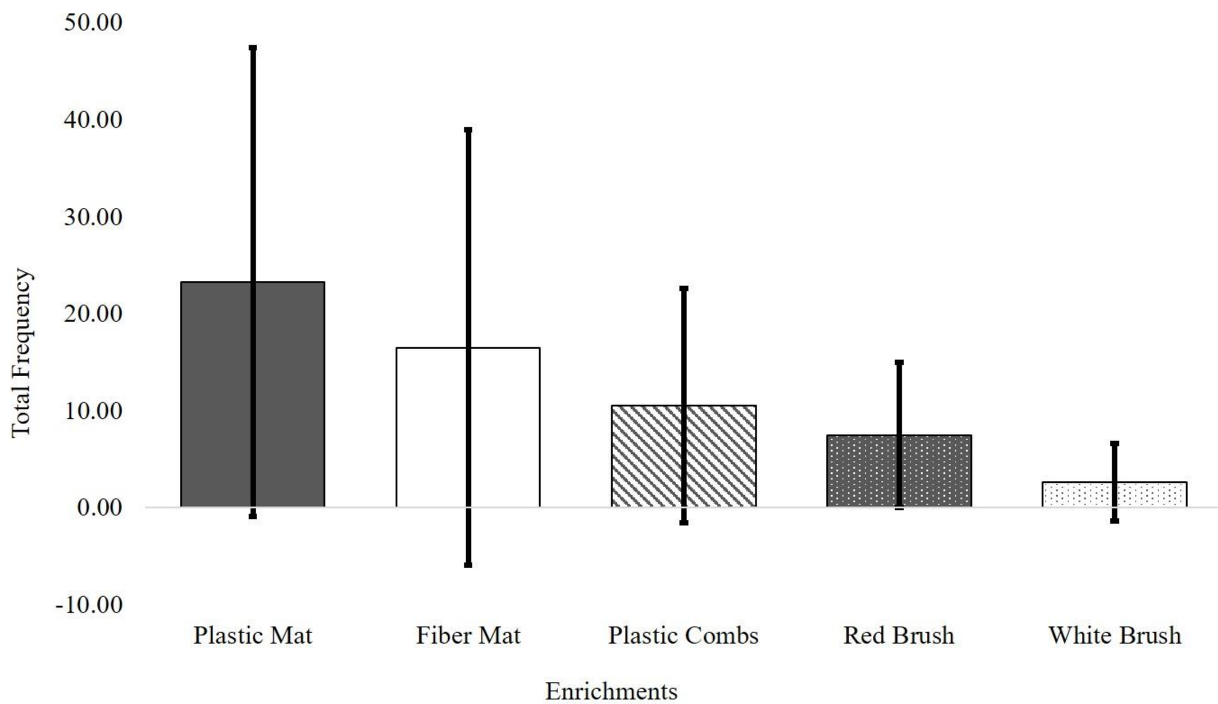


Figure 2.9. Mean total frequencies of both behaviors, scratching and interacting, during all days (mean ± SD) for the 5 enrichments (Plastic Mat, Fiber Mat, Plastic Combs, Red Brush, White Brush).

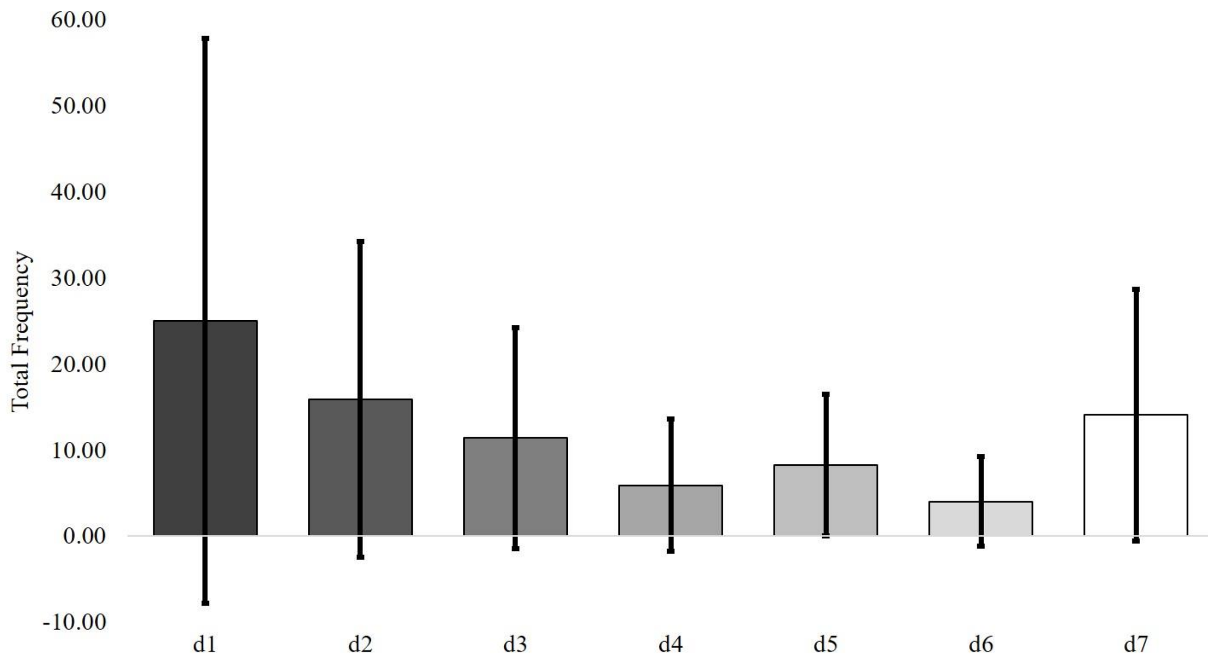
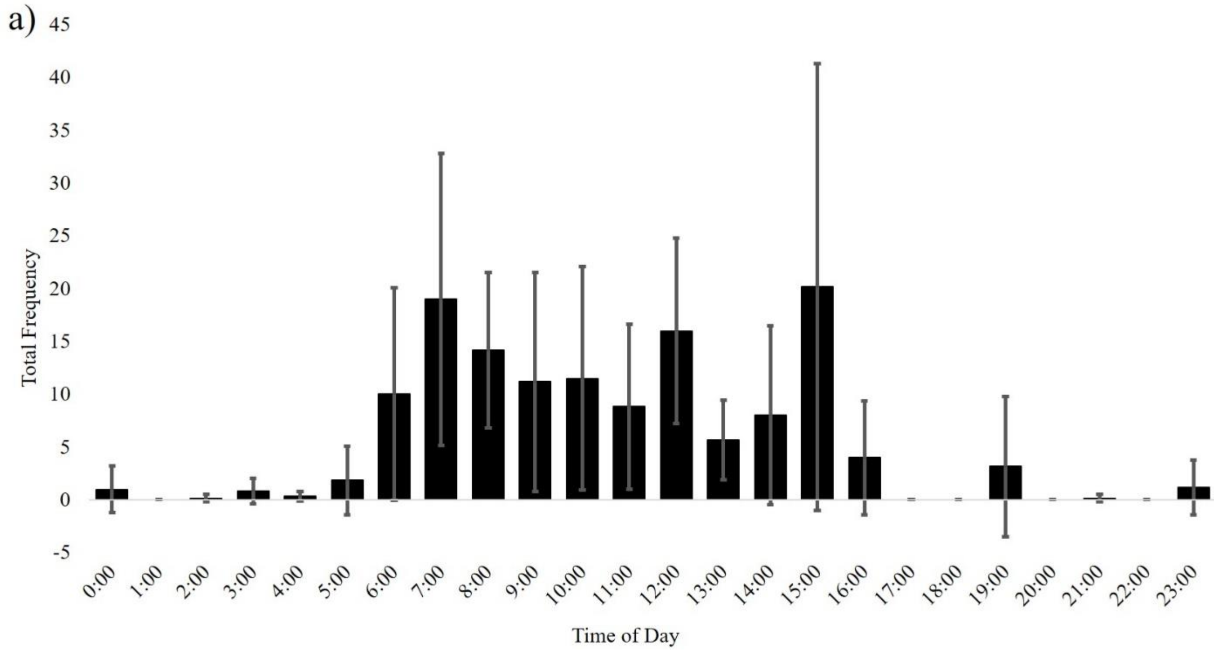


Figure 2.10. Mean total frequencies of both behaviors, scratching and interacting, for all enrichments (mean ± SD) over the days of the experiment.



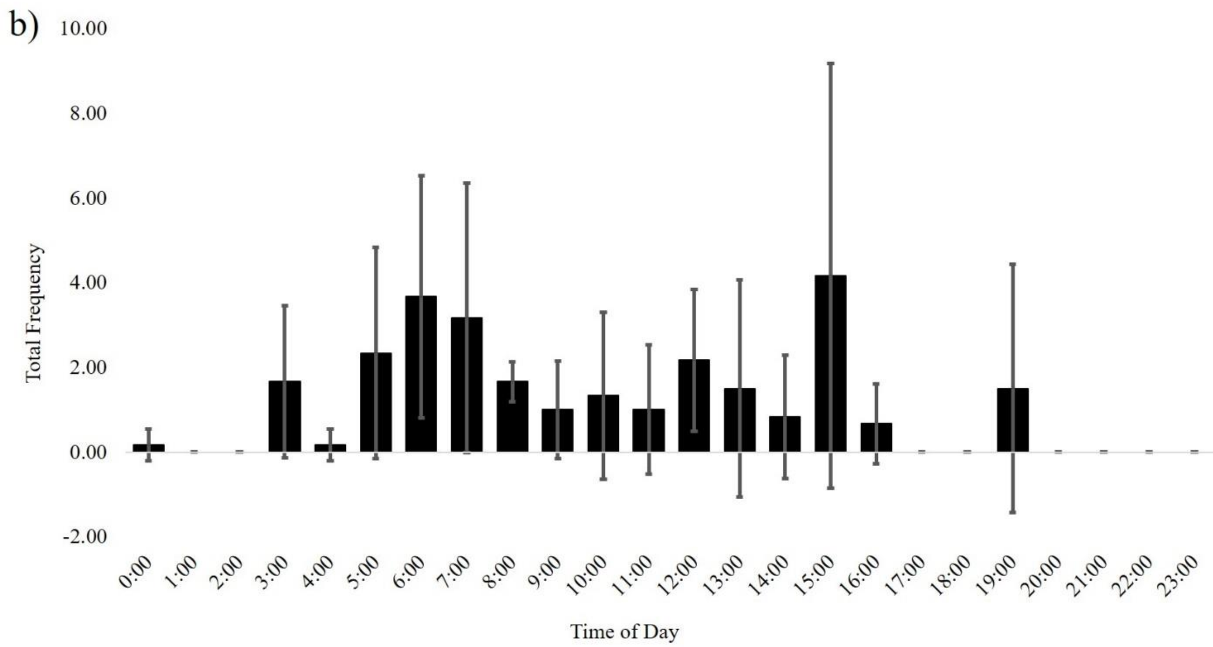


Figure 2.11. The (a) average total Interacting and (b) Scratching frequency on all 5 enrichments (mean ± SD) during different times of day. Each bar represents the average number of bouts per day for that whole hour (For example, bar over 0:00 is for the average counts between 0:00 to 0:59 for all 7 d).

Figure 2.12. Pictures of the scratch posts after they were pulled from the pens at the end of the experiment. From left to right, post and damage done: 1) the white brushes at the bottom of the post were dirty, 2) the plastic mat was mostly unattached from the board at the bottom, 3) the red brushes had a little wear at the bottom, the bottom brush's bristles had been chewed on, 4) blue plastic combs were a little dirty, and 5) the colorful coir fiber mat was a little dirty and was missing a small chunk at the bottom.

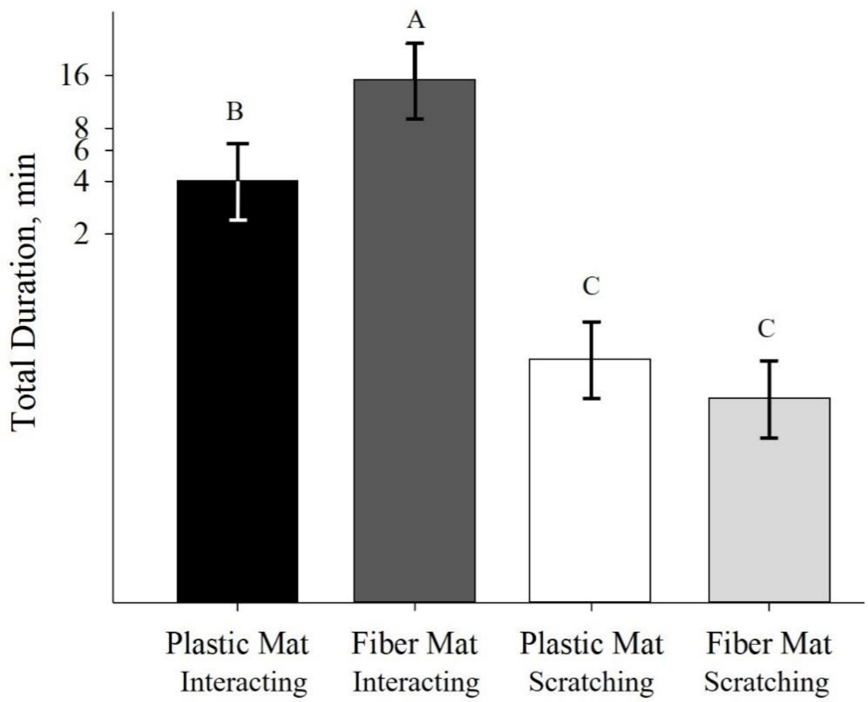


Figure 2.13. Average total duration of behaviors per pen over all 7 d (LSM ± SEM) according to enrichments (Plastic Mat and Fiber Mat) and behaviors (Interacting and Scratching). Total durations were transformed using Log10+1. Y axis values have been back transformed to represent real world values. Different letters represent a significant difference. Significance was set at $P < 0.05$.

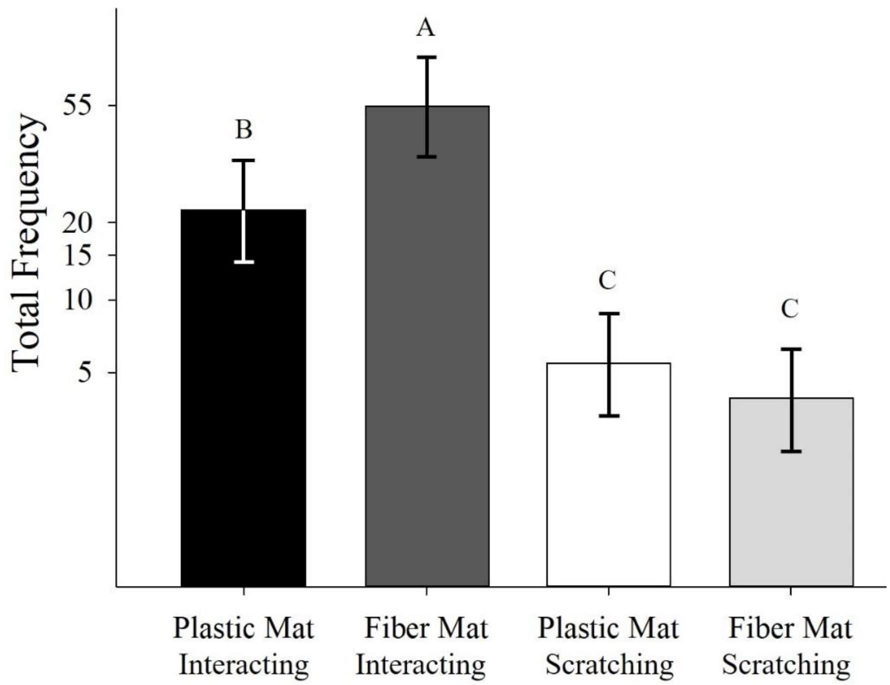


Figure 2.14. Average total frequencies per pen over all 7 days (LSM ± SEM) according to enrichment (Plastic Mat and Fiber Mat) and behavior (Interacting and Scratching). Total frequencies were transformed using Log10+1. Y axis values have been back transformed to represent real world values. Different letters represent a significant difference. Significance was set at *P* < 0.05.

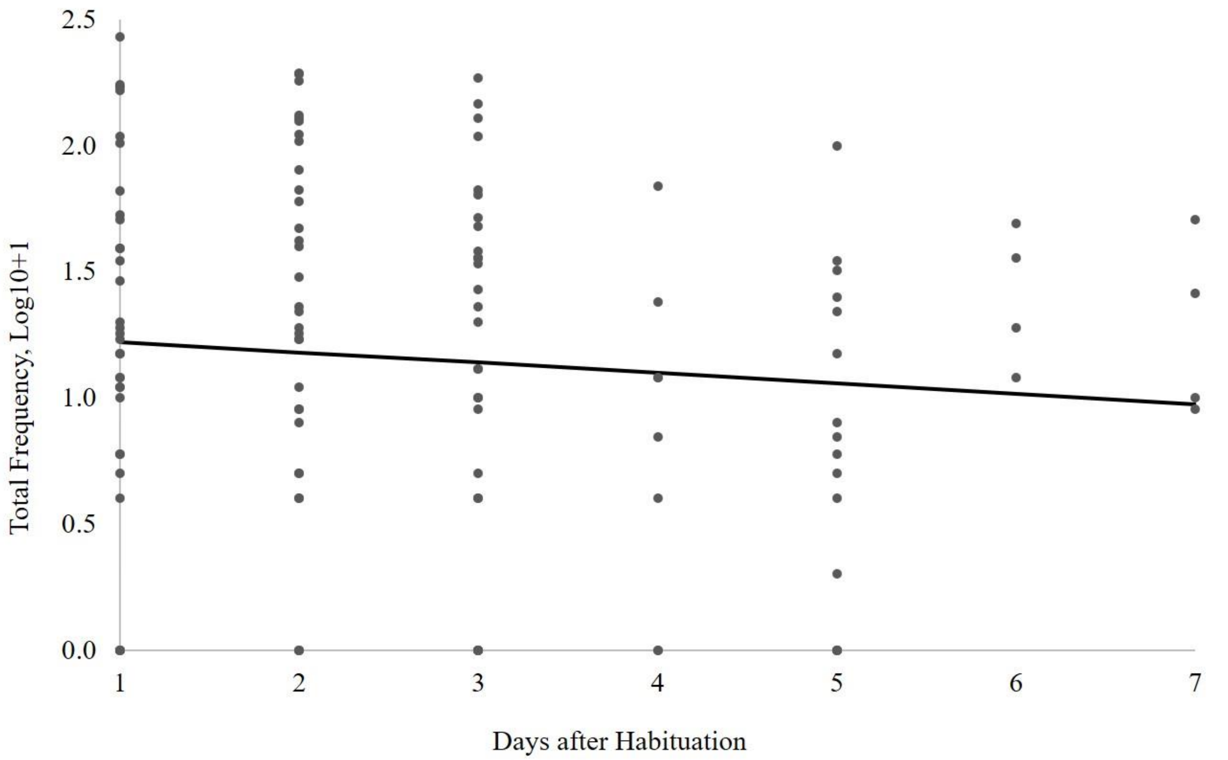


Figure 2.15. Predicted mean total frequencies of both behaviors, scratching and interacting, for all enrichments (predicted LSM = black line) over the days of the experiment ($F_{1,112.5} = 3.97$, $P = 0.049$). Mean total frequencies were transformed with Log10+1. Grey scatter plot dots are the total frequency of both behaviors per pen per enrichment over all 7 d.

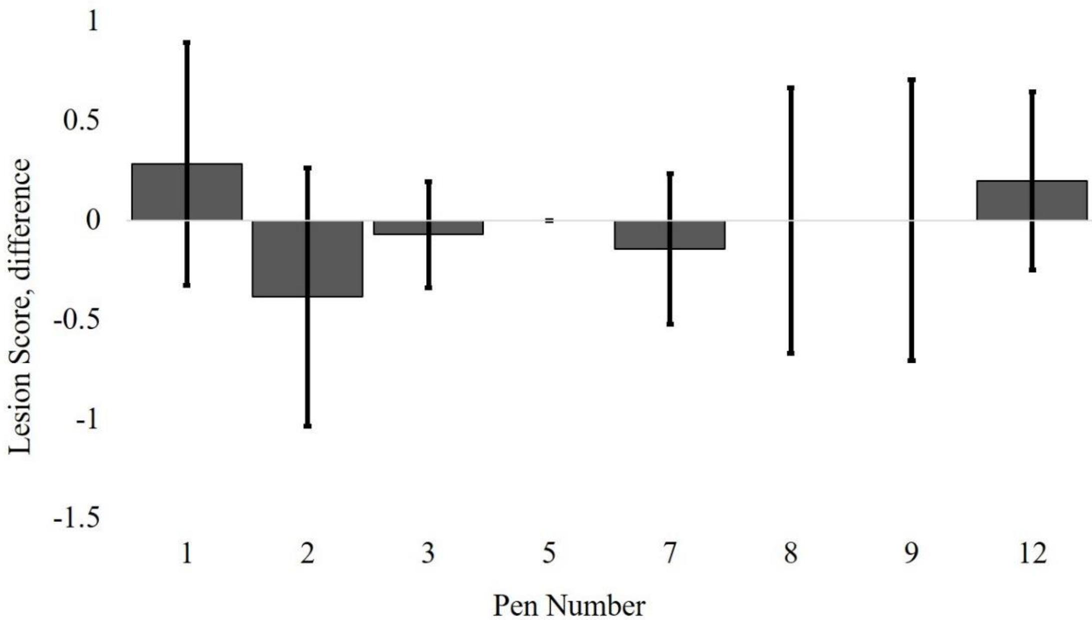


Figure 2.16. Average lesion score differences per pen from all the sows (mean ± SD). Scores ranged from 0 to 2. Negative values represent more lesions appearing on the sows at the end of the experiment (d7) compared to the start (d1).

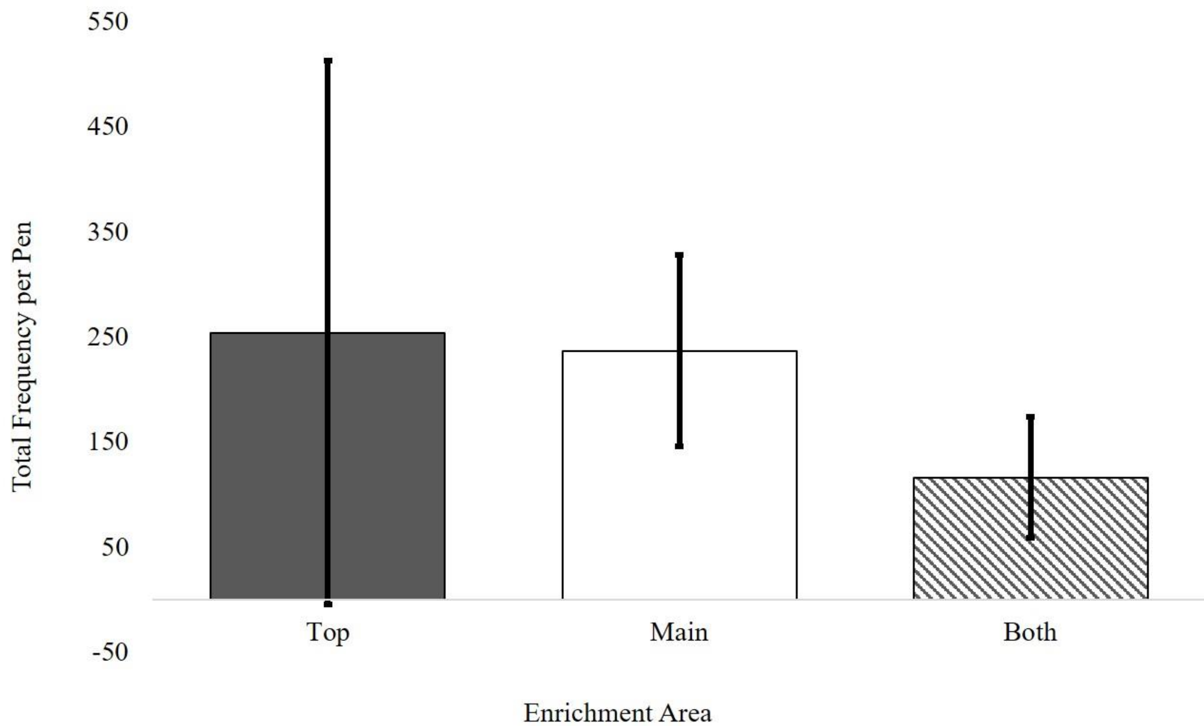


Figure 2.17. Average total frequencies of both behaviors in all pens (mean ± SD) on different enrichment areas. Frequencies of both behaviors were totaled per pen. The frequencies were then averaged per enrichment area.

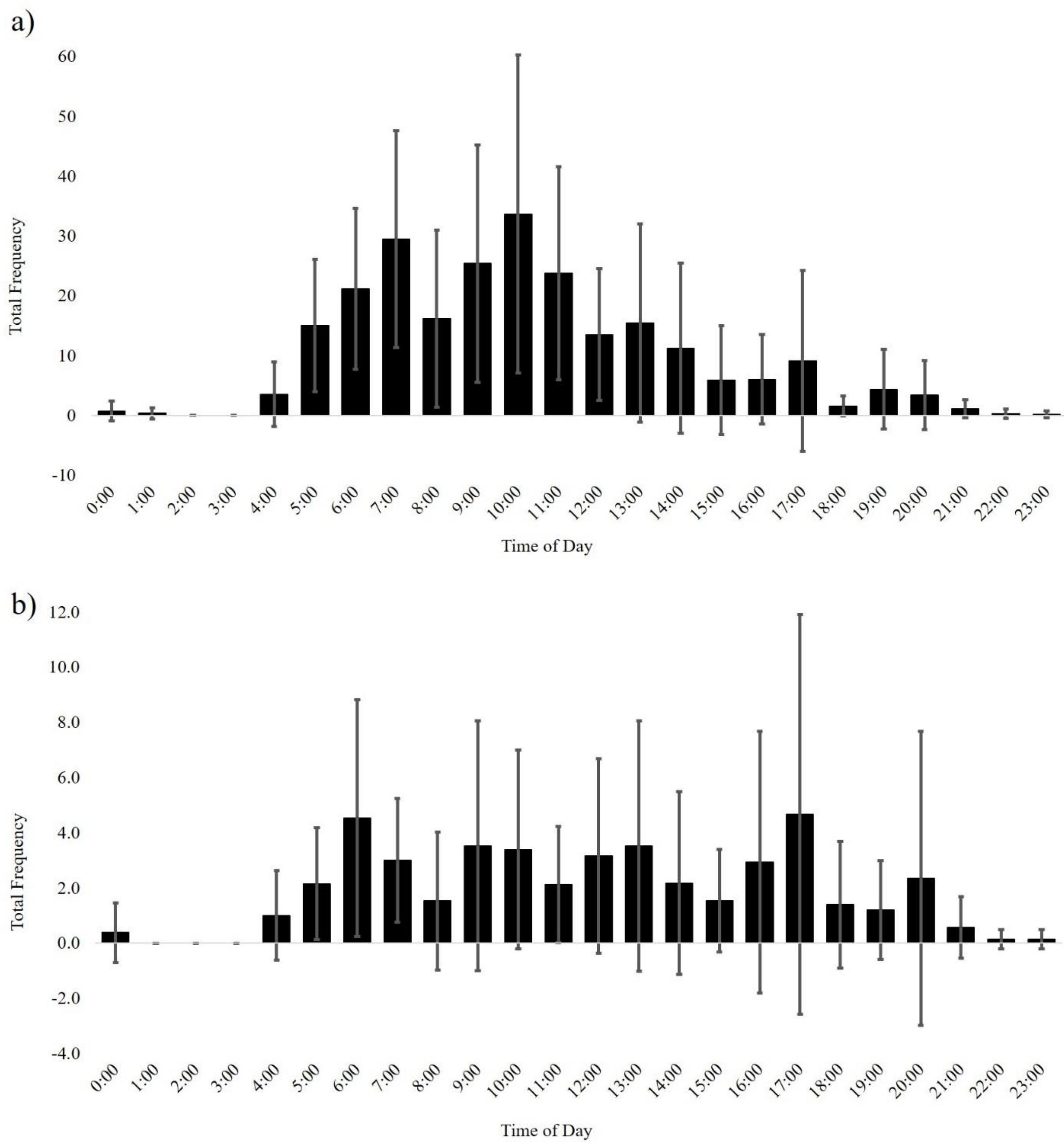


Figure 2.18. The (a) average total Interacting and (b) Scratching frequencies per day during different times of day. Each bar represents the average number of bouts per day for that whole hour (For example, bar over 0:00 is for the average counts between 0:00 to 0:59 for all 7 d).

CHAPTER THREE. SCRATCH THAT ITCH: FARROWING CRATE SCRATCHING ENRICHMENT FOR SOWS

3.1 Abstract

Developing effective enrichments is important for improving pig welfare as it increases species-specific behaviors, decreases abnormal behaviors, and increases time active. However, few enrichments are available for sows in farrowing crates. We examined the behavior and welfare of sows in farrowing crates presented 2 types of scratch pad enrichment. Sows (N=18) of parities 2 (**P2**) and 3 (**P3**) were housed for 25 d and assigned no enrichment (**Control**) or a scratch pad made of plastic mats (**Plastic**) or coir fiber mats (**Fiber**). All were assessed for lesions, abnormal behavior, eating and scratching behaviors, and time spent in different postures and behaviors. Scratching bouts occurred in short durations and were intermittent throughout the day. Parity 2 Plastic sows scratched for a longer total duration than P2 and P3 Fiber sows, P3 Plastic sows, and P2 Control sows ($F_{2,11}$ = 11.94, P = 0.002). Parity 2 Plastic sows also displayed scratching bouts more frequently than all except P3 Control sows ($F_{2,11}$ = 18.46, P = 0.0003). There were no body lesion differences between treatments according to post-hoc Tukey tests (P > 0.05). Abnormal behavior (P > 0.05) and proportion of time spent in different postures ($F_{2,94}$ = 0.0003, P = 0.999) did not differ among treatments. Plastic scratch pads may be a suitable enrichment for farrowing crates as they increased the natural behavior of scratching and did not increase abnormal behavior. More research is needed to refine the scratch pad design and measure motivation, to conclude that scratch pads are a successful enrichment that should be implemented on farm.

Keywords: animal behavior, environmental enrichment, farrowing crate, scratching, swine, welfare

3.2 Introduction

Increased public awareness of livestock care and handling has made welfare a growing priority. The barren commercial environment pigs live in is a significant concern, particularly farrowing crates. Farrowing crates do not allow sows to perform natural behaviors and confine them to a small space, decreasing their welfare (Barnett et al., 2001; Johnson and Marchant-Forde, 2009). Providing environmental enrichment may remedy these concerns.

Enrichments increase species-specific behaviors, maintain or improve health, and improve welfare (Newberry, 1995; van de Weerd and Day, 2009). Many studies exploring pig enrichment have found straw to be the best so far, especially for sows, as it allows them to perform highly motivated nesting behaviors (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). There is currently no feasible enrichment for sows in farrowing crates. One of the few natural behaviors sows in crates can perform is scratching, which may be a good enrichment target.

In a semi-natural environment, pigs rub against trees and bushes (Stolba and Wood-Gush, 1989). In a commercial setting, pigs rub against concrete walls, fences, and even allow their handlers to rub and scratch them. Targeting this natural scratching behavior with an enrichment has not been explored through scientific methods. Our objective was to provide scratch pads to facilitate natural scratching behavior. We hypothesized that providing scratch pads to sows in farrowing crates will allow for the expression of natural behaviors like scratching and improve sow welfare. We predicted that sows would scratch more on the scratch pads, display more natural behaviors, and have improved welfare as indicated by fewer lesions, more time active, and fewer abnormal behaviors compared to sows with no scratch pads.

3.3 Materials and Methods

3.3.1 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 Center (**ASREC**, West Lafayette, IN), approximately 3 d before they were due to farrow. They remained in their respective conventional farrowing crates (Advantage Farrowing Crate, Hog Slat, Newton Grove, NC) until weaning; a total of 25 d. 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. Two data loggers (HOBO U12-112, Onset, Bourne, MA) were placed at opposite ends of the barn to record temperature and relative humidity (28.6 ± 3.6°C; average ± SE).

3.3.2 Experimental Design

Sample size was calculated before the experiment using Mead's resource equation (Mead, 1990). Eighteen sows were balanced by parity 2 and 3 (**P2 and P3**) and assigned to 1 of 3 scratch pad treatments: plastic mats (**Plastic**), coir fiber mats (**Fiber**), or no mat (**Control**; Fig. 3.1). The 3 treatments were balanced across crates, so no sow was next to an identical treatment or 2 of the same treatments.

Scratch pads were constructed of plywood (treated handi-panel, 1.27 cm x 38.1 cm x 54.61 cm, Menards Inc., Eau Claire, WI) and covered with either black plastic mats (45.72 cm x 76.2 cm, Clean Machine Metro Entrance Mat, GrassWorx, St. Louis, MO) or coir fiber mats (45.72 cm x 76.2 cm doormat, Meijer, Inc., Grand Rapids, MI) trimmed to fit the plywood dimensions. Mats were secured with glue (E6000, Eclectic Products, Eugene, OR) and screwed (Grip Fast #6 x 1 inch Phillips drive zinc flat head sheet metal screw, Menards Inc., Eau Claire, WI) and stapled (9/16 inch Arrow T50, Arrow Fastener Co., Saddle Brook, NJ) into place. Holes were drilled into the 4 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). The scratch pads were placed into the crates before sows arrived and taken out 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 (Fig. 3.2).

3.3.3 Procedures

The postures and behaviors, visual body lesion score, visual shoulder lesion score, and thermal images were recorded on all sows 1 and 2 d after sows were in the farrowing crate. After sows farrowed, they were given 2 d to acclimate and then data were collected on d 2 and then every third day after (5, 8, 11, 14 d, and at weaning); data included direct observation of postures and behaviors, visual body lesion score, visual shoulder lesion score, maximum and average temperatures from thermal images, proportions of postures and behaviors, and durations of time spent scratching and eating. A final collection for all sows was made at weaning. Recording data on d 2 and then every third day allowed the data to be compared amongst sows.

3.3.3.1 Continuous and Instantaneous Sampling

Nine cameras (KPC-N502NUB, KT&C, Fairfield, NJ) continuously recorded video using management software (GeoVision Network Video Recorder, Taipei, Taiwan); 1 camera per 2 farrowing crates (Fig. 3.1). 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 0000 h on data collection days (exactly which days is explained after 3.3.3.4 Thermal Images). Two behavioral sampling methods were used when watching video. Continuous, focal sampling was used to observe scratching and eating behaviors (Table 3.1). Instantaneous, scan sampling was used every 10 min to record posture (stand, sit, kneel, sternal lying, left lateral lying, and right lateral lying) and behavior (inactive, nurse, and other). Inter-rater reliability, using Cohen's Kappa coefficient, for instantaneous, scan sampling was almost perfect among the 3 observers for sow posture (Kappa = 0.96) and acceptable for sow behavior (Kappa = 0.77; McHugh, 2012). Video segments for each sow over the duration of the study were randomly ordered to reduce observer bias.

3.3.3.2 Direct Observations

On select days, direct observations using focal, one-zero sampling were made to collect data on abnormal and normal behaviors. Abnormal behaviors occur most frequently after feed consumption (Rushen, 1985; Mason and Rushen, 2006). Sows were fed at 0800 h and after a half hour, each sow was observed 3 times, for 5 min with 20 min intervals (Table 3.2). Besides abnormal behaviors, normal behaviors were recorded to see if they increased due to the scratch pads; rooting and nosing piglets.

3.3.3.3 Lesions

Body lesions 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 are any scratch or wound found anywhere on the sow's body that are a result of altercations with other pigs or damage done from the environment. They were visually scored on a 0 (<4 lesions in an area) to 2 scale (11+ lesions in an area; Table 3.3; Bolkuis 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 0 (no lesion) to 3 scale (>2.3 cm broken skin over scapula; Table 3.4; revised from Zurbrigg, 2006).

3.3.3.4 Thermal Images

Before forming an ulcer, 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 and Rydberg, 2010). An infrared camera (FLIR-T62101, FLIR Systems Inc., Wilsonville, OR) was held above the edge of the farrowing crate, to standardize the distance to the sow, and in line with the scapula while taking pictures. Images were analyzed to determine if skin temperature correlated with shoulder lesion scores and could detect an ulcer before they formed (FLIR Tools+, version 6.4, FLIR Systems, Wilsonville, OR). 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.

3.3.3.5 Scratch Pad Durability

Environmental enrichment durability was calculated on a scale system specifically made for this project. The scale went from 0 to 4 (0 being like new and 4 being greater than 2/3 of the mat missing or not attached) and was taken at weaning to determine how practical the scratch pads held up during the farrowing duration (Table 3.5). The 2 scratch pads in each crate were each given a score and then added together for a combined score for each crate.

3.3.3.6 Piglet Information

Each sows' previous piglet crushing records were obtained from the farm and subtracted from the current crushing records, recorded at the end of the experiment. This information was collected and analyzed to see if sows' performance was changed due to enrichments. The previous crushing records from the last litter were not balanced across the treatments (Control: 1 sow, Fiber: 2 sows, Plastic: 2 sows had crushed piglets). Out of these 5 sows, all had only crushed 1 piglet in their previous litter, except 1 Plastic sow that crushed 3. Only 3 of the sows that had crushed piglets in their previous litter, crushed piglets in this litter.

Piglets were weighed as a group 2 d after farrowing (during processing) and at weaning. An estimated ADG per piglet was calculated by subtracting the group weight at 2 d of age from the group wean weight divided by the number of days between the 2 weighing days divided by the number of piglets. The number of piglets that the sow had at weaning was also recorded.

3.3.4 Data Processing

3.3.4.1 Continuous, Focal Sampling

The durations for eating and scratching behaviors were calculated from the difference between end and start time points collected during continuous, focal sampling. For scratching, all the durations for all the days were totaled per sow. Scratching bouts were infrequent and did not occur on all days resulting in few data so was totaled per sow. For eating, durations were totaled for each sow per day because eating happened every day and in longer durations. Frequency of scratching per sow and eating per day per sow were also recorded.

3.3.4.2 Instantaneous, Scan Sampling

Occurrence of each posture and behavior were counted per sow and divided by the total number of observations to calculate proportions.

3.3.4.3 Direct Observations

The frequency for each posture and behavior were summed per sow to get a total count of how often the behaviors occurred during focal, one-zero sampling for all days.

3.3.4.4 Lesions

The visual body lesion and shoulder lesion scores taken at the beginning of the experiment created a baseline measurement. Baseline scores were subtracted from scores recorded on proceeding 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.

3.3.4.5 Weather

The temperature was recorded every 30 min by 2 data loggers from the time when the sows were moved into the crates until weaning. The average was calculated for each day.

3.3.5 Statistical Methods

Data were analyzed in JMP statistical software (version 13.2.0, SAS Institute Inc., Cary, NC) using general linear mixed models. The experimental unit was the sow. Assumptions were confirmed through visualization of normal quantile and residual plots. For continuous eating, shoulder lesion scores, body lesion scores, thermal image data, and instantaneous behavior 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 summarized over the whole experiment per sow, nesting and treating sow as random was not necessary. For instantaneous, scan sampling, Other was removed from the behavior 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 are 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 analyzed using Tukey tests. Significant effects for the continuous independent variable day were analyzed using SAS (version 9.4, SAS Institute Inc., Cary, NC). Results are presented as least square means ± standard error of the mean (LSM ± SEM).

3.4 Results

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

3.4.1 Scratching & Eating Behaviors

Out of the 18 sows, 3 were not seen scratching (1 from each of the 3 treatments). Not all the scratching bouts performed by the sows with the scratch pads were done on the enrichment. The sows scratched their heads on the available bars as the scratch pads were situated farther back in the crate so they would not eat them. Out of the 6 Plastic sows, 5 were seen scratching on the plastic mats on the observation days and 1 did not scratch at all. Out of the 6 Fiber sows, 3 scratched on the fiber mats, 2 only scratched their heads on the crate, and 1 did not scratch. The Plastic sows spent an average of 40.2 s scratching while Fiber 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, Fig. 3.3). Post-hoc Tukey tests show that Parity 2 Plastic sows scratched for a longer total duration than P2 and P3 Fiber 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, Fig. 3.4). Post-hoc Tukey tests show that Parity 2 Plastic sows had more scratching bouts compared to all except P3 Control sows. 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, Fiber: 73.77 ± 6.03 min; $F_{2,12}$ = 1.76, P = 0.215). The frequency of each sow per day to eat did not differ among treatments (Control: 17.73 ± 4.88, Plastic: 24.80 ± 4.88, Fiber: 25.33 ± 4.88; $F_{2,12}$ = 0.75, P =

0.491). Sows spent progressively more time eating each day ($F_{1,71} = 52.80$, $P < 0.0001$, Fig. 3.5a) and with increased frequency ($F_{1,71} = 21.27$, $P < 0.0001$, Fig. 3.5b).

3.4.2 Posture & Behavior Proportions

The proportion of time sows spent Inactive and Nursing did not differ among treatments ($F_{2,12} = 2.09$, $P = 0.167$). Sows spent a larger proportion of their time 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 did not differ among treatment ($F_{2,12} = 0.04$, $P = 0.966$). For data from all treatments, the proportion of time sows spent in each different posture did differ ($F_{5,85} = 319.56$, $P < 0.0001$, Table 3.6). Sows spent most of their time lying laterally and sternally according to a post-hoc Tukey test.

3.4.3 Normal & Abnormal Behaviors

All behaviors were not different among enrichments ($P > 0.05$). This includes sham chewing (Control: 8.33 ± 0.998, Plastic: 5.17 ± 0.998, Fiber: 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, Fiber: 0.50 ± 0.53; $F_{2,14} = 0.54$, $P = 0.595$). Parity 2 sows nosed their piglets more frequently than P3 sows (P2: 4.22 ± 0.43 nosing events, P3: 2.56 ± 0.43 nosing events, $F_{1,14} = 7.61$, $P = 0.015$).

3.4.4 Lesions

Treatment had an interaction with day when analyzing body lesions ($F_{2,87} = 5.93$, $P = 0.004$). However, when post-hoc Tukey tests were conducted in SAS, there were no differences between treatments (Bonferroni corrected alpha, $P > 0.008$; Fig. 3.6).

Control sows' right side scapulas had worse lesions compared to left and right sides of Fiber sows and left side of the Control sows ($F_{2,194} = 11.31$, $P < 0.0001$, Fig. 3.7). Lesion severity increased as days went by during the experiment ($F_{1,194} = 13.81$, $P = 0.0003$). The proportion of time spent lateral lying on the right and left side did not affect the shoulder lesions ($F_{1,159} = 0.29$, $P = 0.589$).

3.4.5 Shoulder Skin Temperatures

The average temperature taken from the thermal images of the sows' scapulas did not differ among treatment (Control: 35.10 ± 0.45°C, Plastic: 34.24 ± 0.45°C, Fiber: 34.67 ± 0.45°C; $F_{2,12}$ = 0.90, P = 0.432). The average skin temperature increased as the experiment progressed ($F_{1,197}$ = 54.76, P < 0.0001, Fig. 3.8a).

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, Fiber: 36.57. ± 0.35°C; $F_{2,12}$ = 0.93, P = 0.419). The maximum temperature increased as the experiment progressed ($F_{1,197}$ = 40.91, P < 0.0001, Fig. 3.8b).

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

3.4.6 Scratch Pad Durability

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

3.4.7 Piglet Information

The difference in crushing rate from previous litter to current litter was not affected by treatment (Control: 0.50 ± 0.34, Plastic: 0.00 ± 0.34, Fiber: 0.17 ± 0.34 crushed piglet difference; $F_{2,15}$ = 0.57, P = 0.580). The estimated ADG per piglet was different among treatments (Control: 247.25 ± 11.39 g•d•piglet, Plastic: 231.98 ± 11.39 g•d•piglet, Fiber: 283.01 ± 11.39 g•d•piglet,

$F_{2,15} = 5.29$, $P = 0.018$). Fiber sows' litters gained more weight per day than Plastic sows' litters according to post-hoc Tukey tests.

3.5 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 Fiber 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 behavior over a wider range of 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 behavior or find pleasure in performing the behavior. Sows in this experiment scratched an average of 40 s on plastic mats and 20 s on fiber mats, which is longer than the 1 to 10 s range recorded for pigs with mange (Loewenstein et al., 2006). Not much is known about scratching as a behavior or the sows' motivation to scratch. To speculate, scratching may be a luxury behavior. The sows' basic needs have been met and now they will perform behaviors that take up time (Young, 2003). Luxury behaviors 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 cope with stress. Sows are confined and go through labor when in farrowing crates. Scratching may allow sows to cope with the stress by scratching and eliciting pleasurable feelings. Further studies are 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 and Koketsu, 2007). Sows spent more time eating and ate more frequently as the experiment progressed. This reflects the lactation demands on the sows as they need more nutrients as their piglets get larger and demand more milk. The amount 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 percent 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' behavior.

Enrichments are used to decrease abnormal behaviors or prevent them from increasing. Abnormal behaviors did not differ among treatments and the constant level may have been due to the effectiveness of the enrichment. In contrast, farrowing time is stressful on the sow. She is confined for a long duration with no nesting materials. She cannot perform natural nesting behaviors which results in frustration and stress and then undergoes painful labor (Thodberg et al., 2002). The scratch pads may not have been motivating enough to influence abnormal behaviors, have satiated the motivation driving the stereotypy, the sows were already set into these patterns, or the abnormal behavior could be occurring to other motivations that cannot be satisfied by scratching. Stereotypies are abnormal behaviors that are repetitive, have no function, and are fixed in form (Mason and Rushen, 2006). According to this definition, all abnormal behaviors seen during this study would not be considered stereotypies.

The body lesions were not different among treatments indicating that the enrichments did not cause any additional injury to the sows. All of the body lesion scores were close to zero indicating that all of the sows did not sustain many injuries while in the crates. Shoulder lesions were scored on a 0 to 3 scale and the highest average score was a 1 for the right side of Control sows. Even with significant differences, the averages were between 0 (no redness or lesion) and 1 (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 2 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 Check Off, 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 and Rydberg, 2010). The null correlation between the average and maximum skin temperatures and shoulder lesion scores suggests that the two methods 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 previous study that has compared thermal imaging and visual scores (Westin and Rydberg, 2010).

Increasing species-specific behaviors, decreasing or keeping constant abnormal behaviors, 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 behavior for P2 Plastic sows. Therefore, plastic scratch pads may be a successful enrichment for sows in farrowing crates

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 held up during the whole experiment. So, scratch pads would require minimal handling and fixing after implementation. The pads also did not affect the performance of the piglets; piglet crushing did not increase. There was an increase of ADG per piglet in Fiber sows, however the weight differences were small and if a similar study was performed the same result may not occur. 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 her 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 behavior that sows display, and the sows utilize it consistently over long periods of time making the enrichment a promising solution.

3.6 Tables and Figures

Table 3.1. Ethogram for instantaneous scan sampling, Postures (revised definitions from Smith et al., 2018) and Behaviors; 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 into 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 the floor
	Right Lateral Lying	Lying down with right side in contact with the floor
Behaviors	Inactive	Eyes open or closed, animal not moving
	Nurse	At least three piglets actively nosing/nursing, sow must be laterally lying (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 3.2. Ethogram of behaviors observed using direct observations for focal, one-zero sampling.

Behavior	Definition
Sham Chew	Repeated chewing with no food in the mouth
Bar Bite	Biting the bars of the crate
Bite/Push Trough	Forceful pushing or biting of the feed trough
Press Drinker	Press down on the drinker so water is flowing out
Inactive	Eyes open or closed, animals not moving
Eliminate	Defecating 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

Table 3.3. Body lesions are scored 0 to 2 depending on how many scratches or wounds are in the different body regions (Bolkuis et al., 2009).[1]

Steps	Categorization
Sow body regions	Front: head region; forward of the forerib
	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 score ‘c’
	2 - 2 or more regions with score ‘c’

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

Table 3.4. 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

Table 3.5. Scratch pad durability score.

Score	Definition
0	Like new, no wear
1	A little bit of wear, off colored/dirty, whole mat attached
2	< 1/3 of the mat missing or not attached
3	1/3 to 2/3 of the mat missing or not attached
4	> 2/3 of the mat missing or not attached

Table 3.6. Average proportion of time sows spent in different positions each day

	Proportions[1]	
Posture	LSM[2]	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

[1]Proportions were transformed with an angular transformation.
[2]LSM = least square means
[a-d] Values with different superscripts differ ($P < 0.05$)

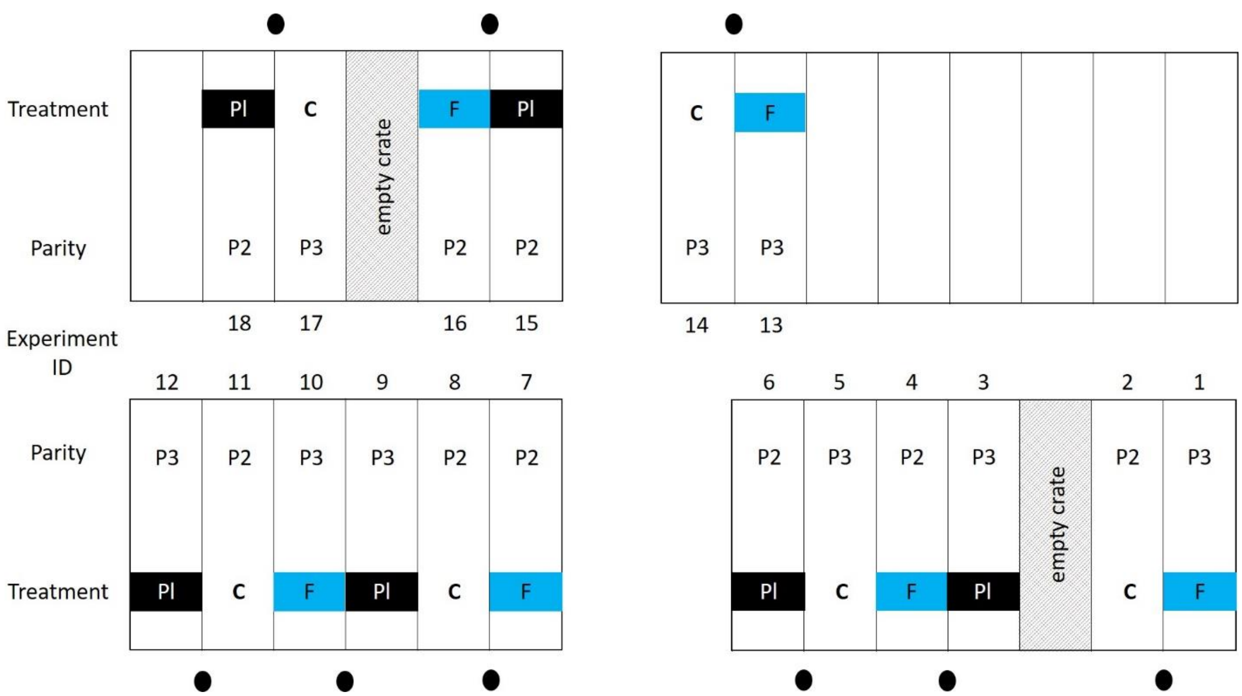


Figure 3.1. Aerial view of barn layout with experimental design. Each crate with a sow in the project was assigned an experimental ID. Over these 18 crates, treatment was randomly ordered and then repeated so that no treatment was next to the same treatment or 2 of the same treatments: plastic mat (**Pl**), fiber 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 1 camera could capture 2 crates at a time.

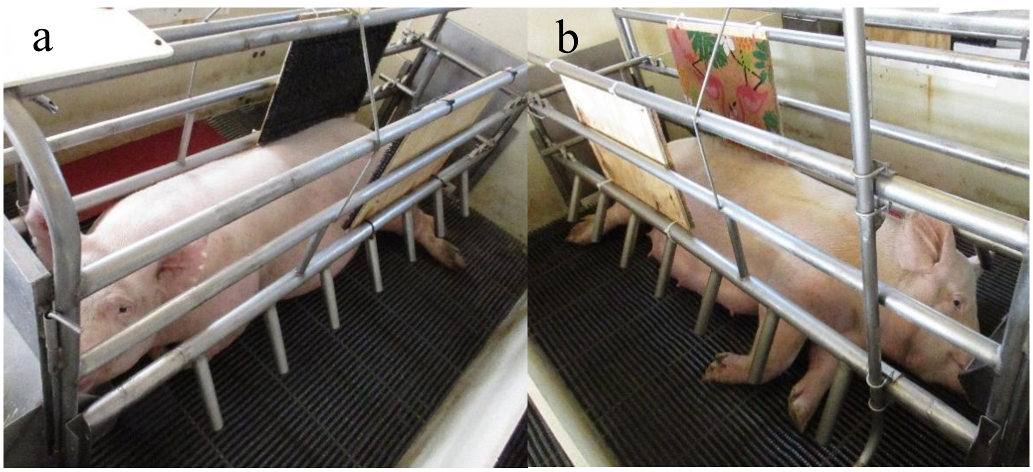


Figure 3.2. Sows in conventional farrowing crates with scratch pads as environmental enrichment. One treatment consisted of a black plastic scratch pad (a), another treatment a colorful fiber/coir scratch pad (b), and the last no scratch pad to serve as the control (not pictured).

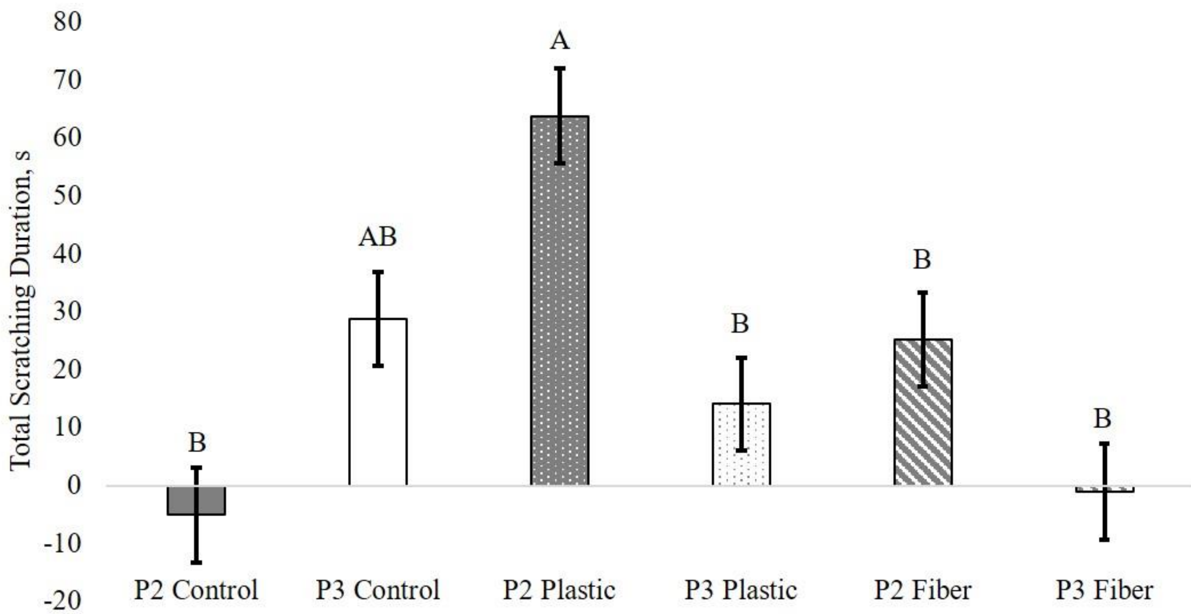


Figure 3.3. Total duration of scratching per sow averaged according to parity 2 and 3 (**P2 and P3**) and treatments (Control, Plastic, Fiber; LSM ± SEM). Negative values indicate unlikeliness to scratch compared to the other groups. Different letters represent a significant difference. Significance was set at $P < 0.05$.

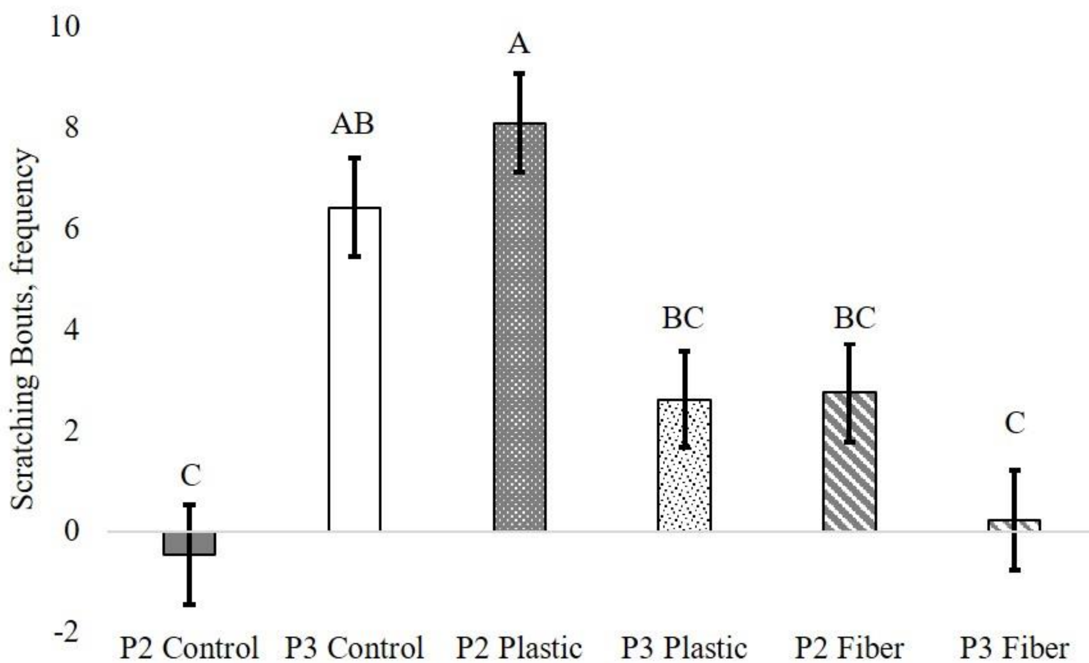


Figure 3.4. Frequency of scratching bouts per sow averaged according to parity 2 and 3 (**P2 and P3**) and treatments (Control, Plastic, Fiber; LSM ± SEM). Negative values indicate unlikeliness to scratch compared to the other groups. Different letters represent a significant difference. Significance was set at $P < 0.05$.

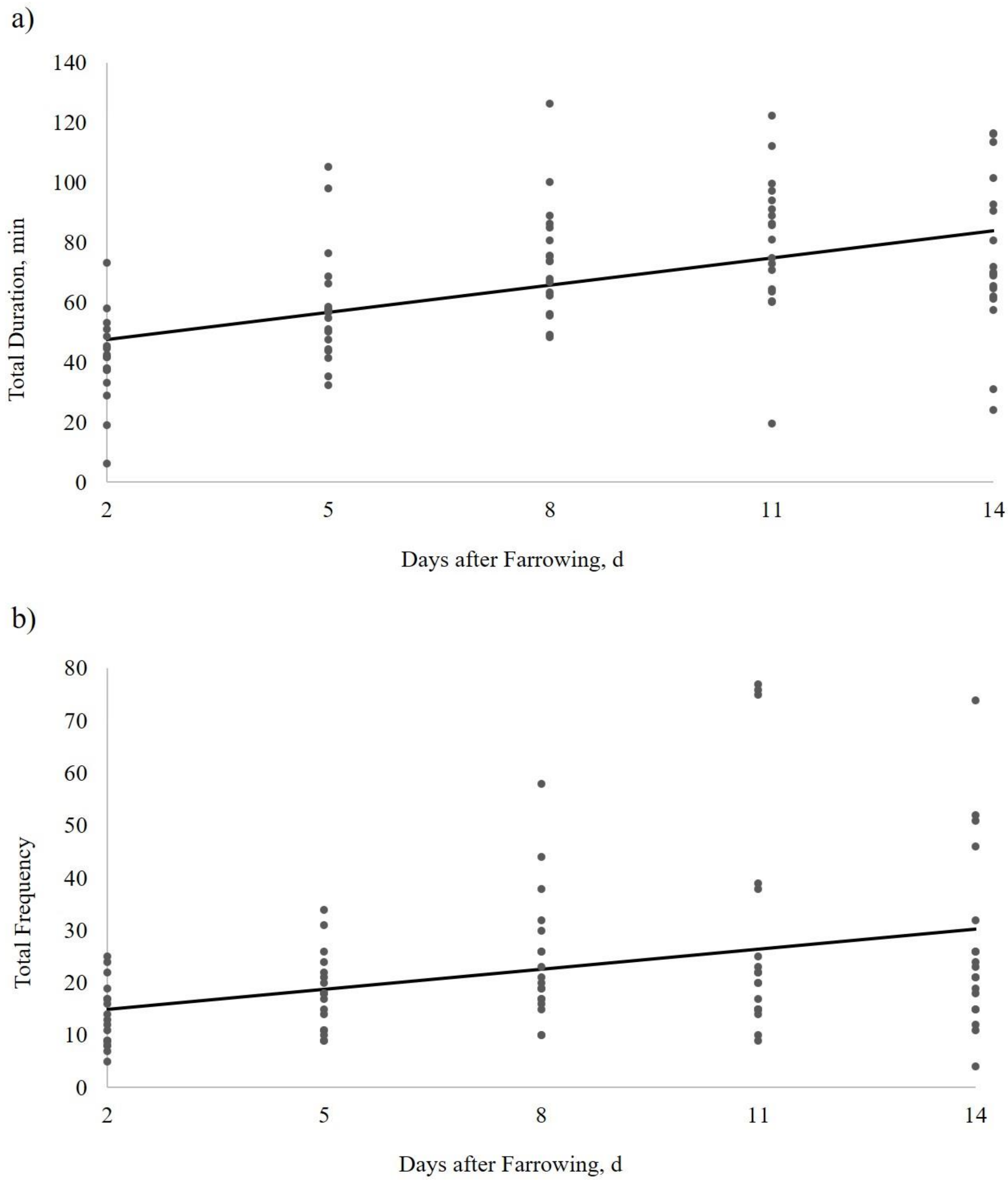


Figure 3.5. Predicted average (a) total duration and (b) frequency of eating for all sows per day (predicted LSM = black line). As the experiment progressed the sows spent more time eating (a; $F_{1,71} = 52.80$, $P < 0.0001$) and ate more frequently (b; $F_{1,71} = 21.27$, $P < 0.0001$). Grey scatter plot dots are (a) the total durations and (b) total frequencies of eating per sow over each data collection day.

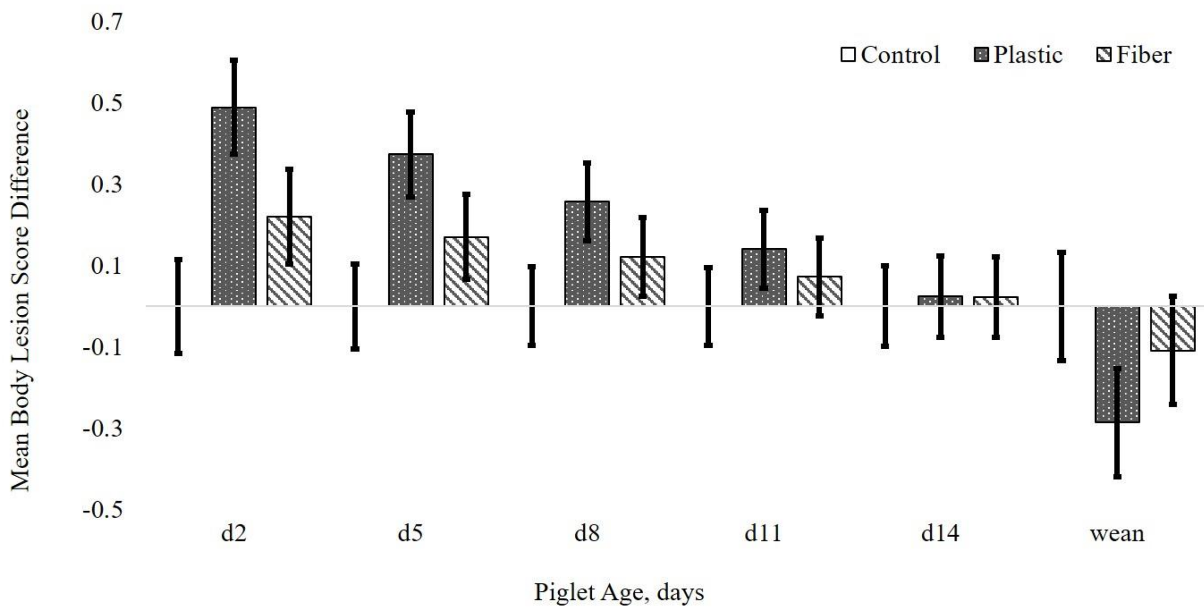


Figure 3.6. Average body lesion scores per sow (LSM ± SEM) on data collection days after farrowing (d 2, 5, 8, 11, and 14 after farrowing and at weaning) according to treatment (Control, Plastic, Fiber). The score difference represents the scores taken during data collection days minus the baseline score (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. * represents a significant difference of $P < 0.008$ (Bonferroni alpha correction).

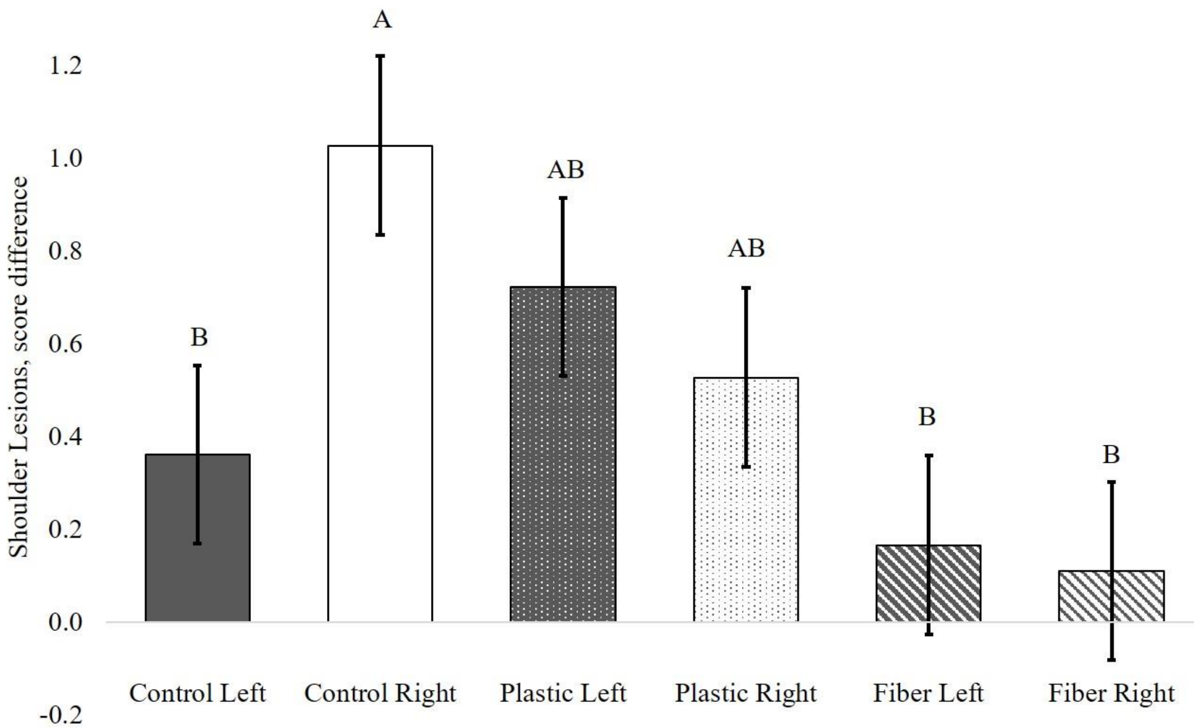


Figure 3.7. Average shoulder lesion scores per sow according to treatment (Control, Plastic, Fiber) and the side which the sow's scapula was scored (left or right; LSM ± SEM). Negative values represent score improvement as each data collection day score had the baseline score (score taken when sows first entered the crates) subtracted from it to account for previous injuries. Different letters represent a significant difference. Significance was set at $P < 0.05$.

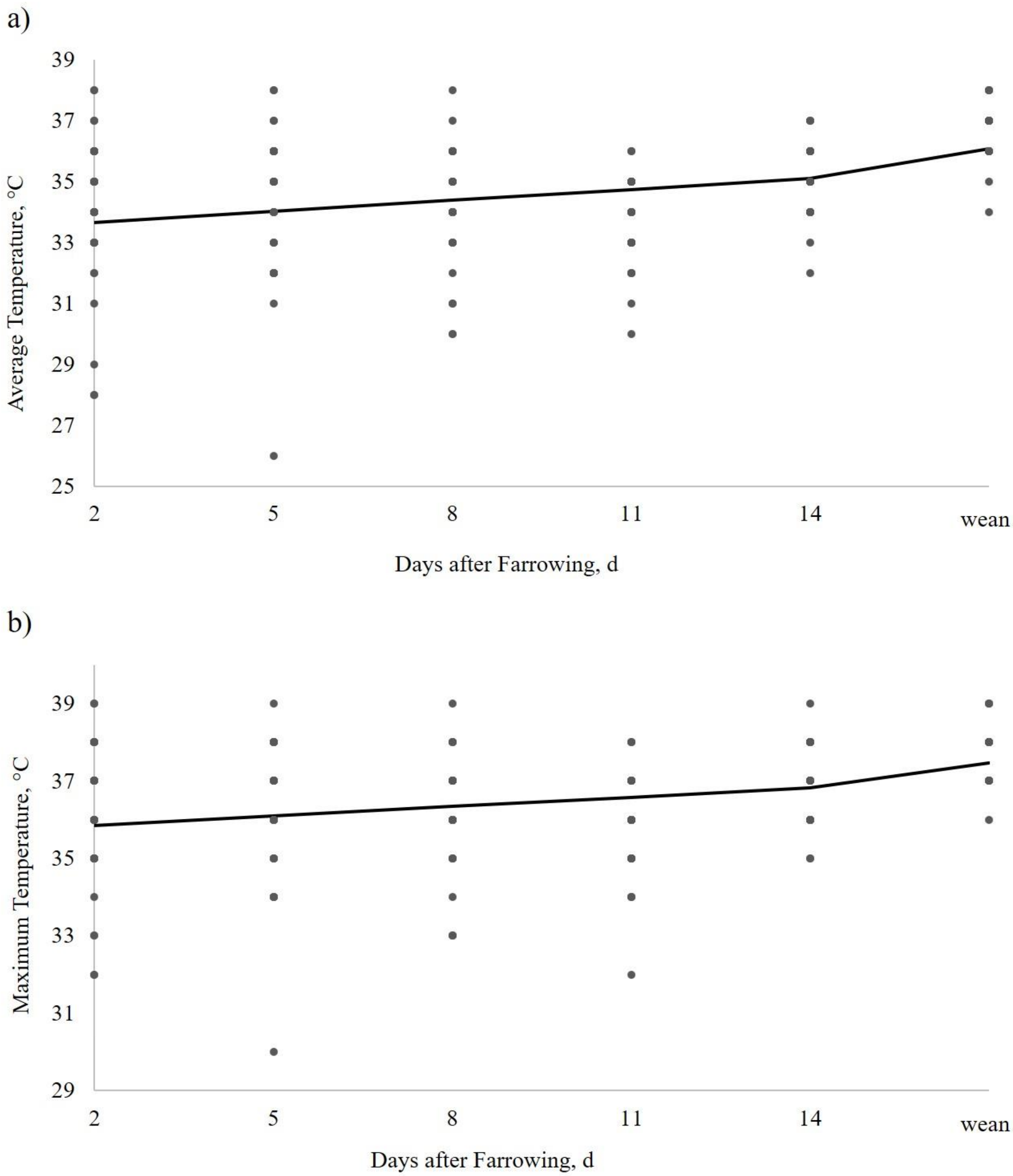


Figure 3.8. Predicted average of (a) average and (b) maximum skin temperatures (°C, predicted LSM = black line) increased as the experiment progressed (days after farrowing; a) $F_{1,195.9}$ = 31.91, $P < 0.0001$; b) $F_{1,195.9}$ = 24.16, $P < 0.0001$). The grey scatter plot dots are the (a) average and (b) maximum skin temperatures (°C) per side of the sows on each data collection day.

CHAPTER FOUR. CONCLUSIONS AND FUTURE DIRECTIONS

4.1 Conclusions

The objective of this study was to explore scratching behavior as an enrichment target to improve sows' welfare in farrowing crates. Improving the welfare of livestock has become increasingly important as public concerns continue to rise. Enrichments for sows are scarce and sows in farrowing crates face many challenges. In chapter 2, we gave sows different choices between a range of materials to determine their preference of substrate to scratch on. In chapter 3, we took the sows' preferences and placed them in farrowing crates.

Chapter 2 established that even with a lot of planning animals can surprise you. In Exp. 1, pigs preferred to Interact and Scratch on Plastic Mats, Fiber Mats, and Plastic Combs over Red and White Brushes. A harder surface with more resistance seemed to be preferred over softer materials. In Exp. 2, pigs Interacted with Fiber Mats more than Plastic Mats but Scratched on both with the same frequency and total duration of time. Plastic Combs were removed from the study early on as the sows ate the expensive materials. They also ate a lot of Fiber Mats, so it is suggested that further scratching studies in gestation pens use Plastic Mats or similar materials. The pigs scratched on all materials and scratched on cement walls and fences. This behavior appears to be performed often during the day and in rapid sessions.

In chapter 3, we demonstrated that P2 sows spent more time scratching on Plastic compared to Fiber or Control. Plastic mats may be considered a successful enrichment since it increased scratching and abnormal behaviors stayed constant; however, more measurements need to be explored. Scratch pads did not affect the time spent lying down or shoulder lesion occurrence, so may best be used in addition to other enrichments. The time spent inactive is heavily influenced by piglet nursing and enrichments may not be able to persuade sows to be more active in crates. Future studies could explore the motivation sows have to scratch and in relation to other behaviors.

4.2 Future Directions

There is a lot to learn about pig scratching. The motivation a pig has to scratch would be valuable to know. If pigs value scratching, providing scratching enrichment would improve their welfare as it would allow them to display this behavior fully. Determining what scratching is to a pig would also be valued. It is not known if pigs scratch because they have an itch or if it is part of their grooming process. Why pigs scratch, what they enjoy scratching on, and how motivated they are to scratch are all questions that when answered would broaden our knowledge on pigs themselves and then allow us to improve their welfare and their quality of life.

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