EFFECTS OF ENRICHMENT TYPE, METHOD OF PRESENTATION AND SOCIAL STATUS ON ENRICHMENT USE, BEHAVIOUR AND STRESS RESPONSE OF GESTATING SOWS

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OVERALL ABSTRACT

This study examined how enrichment type, different methods of presentation and social status of individual sows affect enrichment use, behaviour and stress in sows. Eight groups of 28 sows were studied, with additional data collected on six focal sows (3 dominant [Dom] and 3 subordinates [Sub]) per group. Four treatments were given in random order and lasted for 2 weeks. Treatments: 1) constant provision of wood on chains (Constant), 2) rotation (rope, straw, wood on chain: Rotate), 3) rotation with an associative stimulus (bell or whistle: Stimulus), and control (no objects). It was hypothesized that frequent rotation of enrichments would increase enrichment use and reduce habituation and use of an associative stimulus would increase the initial response to new enrichments. Cameras were mounted over pens and time lapse photos taken at 10-minute intervals for an 8-hour period on days 1,8,10 and 12 to determine enrichment use and sows' activity. Body weights of focal sows were recorded at beginning and end of study, aggression was evaluated using skin lesion scores on a scale of 0 (no injury) to 3 (severe injury). Saliva samples were collected and analyzed for cortisol level. Body weight and parity were compared between Dom and Sub sows using Proc Mixed. Enrichment use, and sows activity were compared across treatments using analysis of variance with repeated measures (Glimmix procedure SAS 9.4). Dom sows were of higher average parity and significantly heavier than Sub sows. Behavioural observations showed that a similar percentage of sows was present in the enriched area regardless of the enrichment treatment provided *($P>0.05$)*. Enriched sows were more active, spending a greater amount time standing than Control sows *($P<0.05$)*. There was tendency for greater percentage of sows contacting and near enrichments when materials were rotated and paired with a stimulus than constant *($P=0.066$)*. There were similar levels of enrichment use and no difference in lesions or cortisol levels between Dom and Sub sows. In live observations, a time of day by social status interaction was found, with Dom sows spending a greater amount of time standing and bar biting than Sub sows in the morning *($P<0.05$)*. Stage of gestation influenced saliva cortisol level, with an increase at 14 weeks of late gestation. In conclusion, the provision of enrichment objects increased sow activity with a greater percentage of enriched sows standing. No clear effect of habituation was found because the short treatment duration used in this study was not sufficient to observe sows' response over time. Regularly changing the enrichments, especially with inclusion of straw on the floor tended to increase sows' response to enrichment. Similar levels of enrichment use were observed among Dom and Sub sows. However, Dom sows were more active and showed more stereotypic bar biting compared to Sub sows. The results suggest that there was minimal

competition in the group system studied as social status did not significantly affect enrichment use, aggression or stress levels.

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DEDICATION

"I dedicate this work to my uncle, Mr. Emmanuel J.K. Agyei, for his encouragement and support towards my career".

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1.0 CHAPTER

LITERATURE REVIEW: DEVELOPING EFFECTIVE ENVIRONMENTAL ENRICHMENT FOR GROUP HOUSED GESTATING SOWS

1.1. Introduction

Environmental enrichment is seen as an important way of improving the biological functioning and well-being of animals through the alteration of their environments (Newberry, 1995). For pigs, enrichment provides an opportunity to express their highly motivated exploratory behaviour and exhibit a wider range of behavioural choices (Van de Weerd et al. 2003). In North America, most of the housing systems for commercial pig production have been described as "barren" and criticized for being artificial and lacking complexity, e.g. stall housing for sows. The current Canadian Code of Practice for Care and Handling of Pigs requires that all new or renovated housing for gestating sows use group housing (NFACC, 2014). Group housing has the potential to increase social interactions, reduce stereotypies and increase the general activity of sows (Karlen et al. 2007; Chapinal et al. 2010). However, pigs in barren group housing have been found to exhibit abnormal behaviours such as ear and tail-biting, biting pen-mates, bar-biting and increased aggression and stereotypic behaviours which affect their welfare (Lyons et al. 1995; Van de Weerd et al. 2006). Grower-finisher pigs in enriched environments are more active and spend a greater proportion of their time in exploration and show different patterns of behaviour. (Beattie et al. 1996). Studies have also shown that they are less aggressive and have better growth performance and meat quality (Beattie et al. 2000).

Piglets that received preweaning enrichment showed reduced tail-biting and increased play behaviour post-weaning compared to those that did not (Dudnik et al. 2006). Studies have shown that sows in barren group housing also perform greater number of stereotypies and aggressive behaviours, of which the latter could lead to reduced productivity resulting from abortions and stillbirths (Stansbury, 1986). Sows have been shown to be highly motivated to access enrichment materials (Elmore et al. 2011). Thus, provision of enrichment in group housing systems for sows has the potential to improve their welfare by encouraging exercise and reducing stereotypies and harmful behaviours such as biting pen-mates (Karlen et al. 2007), whilst also providing an outlet for the performance of highly motivated exploratory behaviours. However, compared to grower-finisher pigs, there is much less scientific information about what enrichment materials will benefit the health and welfare of sows in unbedded group housing systems.

Different forms of enrichment materials have been explored for their attractiveness to pigs and effectiveness as enrichment. Substrates such as straw, sawdust, mushroom compost, peat moss (van de Weerd and Day, 2009), earth and hay (Bracke et al. 2006) have all been tested on pigs at different ages, sizes, weights and breeds. Substrates such as straw effectively increased exploratory behaviours in sows (Beattie et al. 1995; Day et al. 2008). However, use of these substrates is a challenge in systems with partially or fully slatted floors because of risk of blocking the liquid slurry system. Use of substrates can also increase the cost of production (van de Weerd et al. 2006). Other objects have been used including: rubber bars, rubber balls, ribbons, ropes, garden hoses, wood and chains (Van de Perre et al. 2011; Courboulay 2014).

For enrichment to be effective, it should be kept clean and not soiled with feces, easily accessible, attractive to the animals, chewable, ingestible, destructible and immobile so that the sows are able to hold firmly and manipulate it properly (Courboulay, 2014). Effective enrichment should encourage foraging and exploratory behaviour in sows. Research has shown that presenting enrichment materials in different ways to keep it novel to helps to maintain attractiveness (Trickett et al. 2009). Announcing the provision of enrichment (e.g. by using a sound stimulus) showed a significant increase in play behaviour and reduced weaning stress in piglets (Dudnik et al. 2006). However, not every enrichment material or object is feasible or appropriate for maintaining novelty and enhancing exploratory behaviour in sows (Van de Perre et al. 2011). Research has shown that social status can affect activity and behaviour of sows in group environment. Thus, dominant sows mostly displace subordinates from getting access to resources such enrichments (Elmore et al. 2011).

In the current study, one broad experiment was conducted, and the data are evaluated in two parts. The first part (Chapter 2) looks at the effects of enrichment use on the behaviour of all sows in the group, and the second part (Chapter 3) compares enrichment use, social behaviour and cortisol levels in a sub-sample of subordinate and dominant ranking sows within each group.

1.2. What is Environmental Enrichment?

Environmental enrichment is a complex concept that has been described in many ways. The term "environmental enrichment" does not have an exact definition and it has been used inconsistently within the scientific literature (Newberry, 1995). According to Newberry (1995), the term is often incorrectly used to refer to alteration of an animal's environment by simply adding one or more objects without stating any specific or beneficial biological endpoint that would suggest the animal has been enriched. Rather, effective environmental enrichment should result in a measurable benefit that improves the physical, psychological or biological functioning of the animal(s) involved. Globally, environmental enrichment is starting to be recognized as important due to the opportunities it provides to improve the lives of animals in captive or intensive farming environments, especially those in barren environments with limited social interaction (Harris et al. 2006). In pigs, these opportunities include the ability to perform a wider range of species typical behaviours, the ability to adapt to novelty, improved learning capabilities as well as decreased fearfulness and stress, and a reduction in negative behaviours such as aggression, stereotypies, belly nosing, tail and ear biting, (Lyons et al. 1995; Dudnik et al. 2006; van de Weerd et al. 2006; Day et al. 2008; van de Weerd and Day, 2009; Van de Perre et al. 2011).

Environmental enrichment has been studied in several species with the objective of reducing abnormal behaviours and increasing desirable or species-specific behaviours (Tarou and Bashaw, 2007). Abnormal or undesirable behaviours that have been observed in various species of farmed animals include stereotypies and oral manipulative behaviours directed towards pen-mates or objects, such as ear, tail or bar biting in pigs (Van de Perre et al. 2011), feather pecking and cannibalism in poultry (Gunnarsson, 1999; Kjaer and Sørensen, 2002), tongue rolling in cattle (Shahhosseini, 2013), and wind-sucking/crib biting and the stereotypic movements, pacing, weaving and route-tracing in horses (Price, 2008; Albright et al. 2009). Most farmed animals experience one or more stressful situations in their production cycle, such as interaction with different human handlers, housing changes, weaning, mixing with unfamiliar group members, changes in feed type and feeding systems (Spoolder et al. 2009). These situations can cause stress and can interfere with the normal biological functioning and welfare of animals. Enrichment is thought to reduce stress associated with these events (Pearce et al. 1989) and promote better welfare by increasing positive affective states and enhancing animals' ability to cope (Douglas et al. 2012).

1.3 Categorization of Enrichment Types

In guidelines for an environmental enrichment program for non-human primates, Bloom-Smith et al. (1991) categorized enrichments into five main groups: social, physical, nutritional, occupational and sensory. The five types of enrichments have been evaluated in many captive species including zoo, laboratory and farm animals. In this section the five enrichment categories will be discussed in relation to commercial pig housing systems.

1.2.1. Physical Enrichment

Physical enrichment is designed to encourage natural behaviours through the identification and provision of essential or appropriate stimuli. Physical enrichment is achieved by providing materials (temporary or permanent) or changing the size or complexity of the animal's environment (Bloom-Smith et al. 1991). For pigs, permanent materials can include pen partitions, lying areas, and ramps, while temporary enrichments can include objects such as ropes or bedding materials (Bergeron and Gonyou, 1997; Van de Perre et al. 2011). Providing pigs with adequate space is a form of physical enrichment. When pigs are provided with adequate space, they will naturally exhibit spatial separation of various behaviours such as lying, feeding and excretion, even in restricted environments. The separation of behaviours within the pen can be promoted by providing pigs with enough space, and by subdividing the pen into different functional areas. Provision of adequate distinct functional areas can reduce behavioural problems such as fear, aggression, injuries, and stress (Rodenburg and Koenoe, 2007).

When developing the Family Pen system, an enriched housing system that would accommodate the natural behavioural repertoire of pigs, Stolba and Wood-Gush (1984) subdivided pigs' enclosures into areas for rooting, nesting, feeding, wallowing, drinking and excretion. It was found that pigs housed in the Family Pen System exhibited more natural behaviours such as rooting, nosing, nesting, foraging and there was a reduction in fear (Stolba and Wood-Gush, 1984). Similarly, Simonsen (1990), subdivided pens into sections with straw racks, straw bedding, drinking, defecation, feeding, a pig-operated shower and logs hung on chains, and found a significant increase in foraging and exploratory activities. Provision of adequate space enhances the ability of pigs to thermoregulate by choosing to huddle for warmth or lying separately, and laterally. Raising pigs in a system that would encourage all types of desirable behaviours is important and may also benefit productivity.

1.2.2. Nutritional Enrichment

Nutritional enrichment is achieved by introducing variety or novel food types to the diet, changing the daily feeding regimen or methods of feed delivery to improve the health and welfare of animals (Bloom-Smith et al. 1991). Changing the method of delivery includes altering the frequency or schedule of feed delivery, how it is presented, and the amount of time required for consumption. Animals in nature spend a lot of time foraging. Pigs for instance, are highly motivated to root, nose, nest, forage and explore (Stolba and Wood-Gush, 1989). Exploration and foraging are very important behaviours for pigs (Bergeron and Gonyou, 1997). Nutritional enrichment provides an opportunity for pigs to express this highly motivated behaviour. Encouraging foraging behaviours does not necessarily mean increasing the meal size or energy level of diets for pigs (Bergeron and Gonyou, 1997). Straw has been provided as nutritional enrichment material to pigs and it encouraged foraging and exploratory behaviours (Beattie et al. 2000; Olsen et al. 2002).

The main nutritional enrichment studied in pigs is increasing dietary fibre, which increases the volume of feed provided and time spent feeding. Feeding high fiber diets promotes good welfare by increasing weaning weight and does not interfere with fertility or reproductive performance (Peltoniemi et al. 2010). For example, Stewart et al. (2010) increased the fibre content in a gestating sows ration to provide 15% crude fibre. They found that sows on the high fibre diet spent a greater amount of time resting while control sows (at 5% crude fibre) spent a greater amount of time sham chewing, head thrusting and in pen-directed behaviours (Stewart et al. 2010). Studies by Bergeron and Gonyou (1997) and Meunier-Salaün et al. (2001) found similar results, increasing fibre content in the diet for pigs increased feeding time, gut fill and reduced harmful social interactions and stereotypic development. Other studies have examined nutritional enrichment through the provision of straw. For instance, Stewart et al. (2008) provided 0.3kg of chopped barley straw per sow each day and observed an increased foraging and reduction in pen-directed stereotypic behaviours. Nutritional enrichment has beneficial effects for sows that are restricted fed and therefore provision of nutritional enrichment in group environment has the potential to improve their welfare.

1.2.3. Occupational Enrichment

Occupational enrichment deals with psychological activity (involving tasks or control over environment) and exercise i.e. exercise pen or mechanical devices (Bloom-Smith et al. 1991). Occupational enrichment can be achieved by encouraging foraging, exploration, play behaviour, nestbuilding, physical exercise and cognitive activities (Coleman et al. 2013). Occupational enrichment has been studied in pigs through the provision of objects or substrates to enhance mental and physical well-being. Straw and other substrates have been well studied as occupational enrichment materials (Peeters et al. 2006; Scott et al. 2006) and research has also compared different objects to the use of straw as enrichment material (Van de Weerd et al. 2003; Scott et al. 2006). Occupational enrichment has been studied in both bedded and unbedded systems in pig production.

In bedded systems, the bedding, most commonly straw (or rice hulls in tropical climates) serves both as an occupational enrichment and as bedding for pigs (Bracke et al. 2006; Beattie et al. 1995). Most of research examining bedding as enrichment material has been conducted in piglets and growing pigs (Beattie et al. 2000; Bolhuis et al. 2005; Peeters t al. 2006; Day et al. 2008) with fewer studies in sows (Anderson and Bøe, 1999; Durrell et al. 1999). Straw has been used mostly because it serves several functions. Straw promotes foraging and exploratory behaviours (Beattie et al. 2000), ensures thermal comfort especially in cold seasons or environments, encourages maternal bonding between new born piglets and sows when used as nesting material during farrowing (Jensen et al. 2000) and allows pigs to exhibit natural behaviours such as rooting, nosing, nesting, foraging and exploration (Beattie et al. 2000; Stolba and Wood-Gush, 1984). The use of straw as bedding in sows decreases injuries and increases the amount of time spent standing during feeding (Anderson and Bøe, 1999; Whittaker et al. 1999). However, grower pigs showed higher aggression within areas of a pen containing straw bedding enrichment, although overall aggressive interactions were minimized (Olsen et al. 2002). Pigs showing high aggression at the straw area could mean there was limited quantity of straw (high value enrichment).

Occupational enrichment in partially or fully slatted systems is primarily achieved through provision of point source objects. Point source objects are whole objects that people frequently associate with enrichment, they have limited size and their use is also restricted to one location in the pen (Van de Weerd and Day, 2009). Some examples of these objects include rope, wood, chains, rubber bars or ball, ribbons, and garden hoses (Van de Perre et al. 2011; Courboulay, 2014). Provision of different forms of enrichment objects have been shown to reduce tail-biting and other oral manipulative behaviours towards pen mates in growing pigs (Van de Perre et al. 2011). Straw and other substrates such as mushroom compost, peat can be provided in racks or troughs in partly or fully slatted flooring systems to reduce the difficulties in slurry management. For example, Durrell et al. (1997) provided mushroom compost in racks for sows in slatted floors and found an increase in exploratory behaviour. Beattie et al. (2000) found that provision of peat and straw racks to market age pigs influenced meat quality, with pork from enriched pigs having increased tenderness and backfat and reduced cooking losses such as shrink, drip loss compared to barren housed pigs. When growing pigs in fully slatted housing were provided with Bite-Rite (handing chewable objects) and shreds of unmolassed sugar beet pulp, pigs spent more time interacting with sugar beet pulp compared to the Bite-Rite enrichments (Scott et al. 2006).

Methods of presenting point source objects can influence their use. The position or location of the objects in the pen can affect the ease of access to the objects and make them more or less attractive. For example, Courboulay, (2014) investigated the effects of position and location (height, place in the pen) of point source objects (chains, plastic balls, pieces of wood) for 9 to 10 weeks old pigs. The results showed that objects placed at the corner of the pen, in the excretion area or beside feeders were the least used by the pigs compared to those placed in resting areas of the pen (Courboulay, 2014). The pigs preferred objects that hung down to floor or low level (5cm above the floor) to those placed high (at snout level). Objects fixed to the floor were used most often because the pigs could easily grasp, hold and manipulate them, and objects loose on the pen floor were least attractive because they were soiled easily (Courboulay, 2014). Blackshaw et al. (1997) provided weaner pigs with metal and plastic objects which were either fixed object hanging from the ceiling or freely moving on the pen floor and found that pigs preferred the fixed objects to the object loose on the pen floor. The preference of fixed objects over loose ones suggests that mobile objects on the pen floor were soiled quickly and therefore were less attractive to pigs. Pigs prefer clean and hygienic enrichment objects (Bracke et al. 2006). Pigs are attracted to objects that are deformable, odorous and chewable (van de Weerd et al. 2003), however, objects that sustain their interest are both ingestible and destructible (van de Weerd et al. 2003). Therefore, enrichment management and maintenance should be performed in order to sustain the interest of the pigs.

1.2.4. Sensory Enrichment

Sensory enrichment is the provision of materials that stimulate animals' senses: visual, hearing, touch, taste or smell (Bloom-Smith et al. 1991). Sensory enrichment stimuli include auditory (vocalizations/music), visual (television, computer) and other forms e.g. olfactory, tactile, taste. Sensory enrichment encourages animals to assess their environment and promotes natural behaviours like exploration, scent marking, licking and rolling (Bloom-Smith et al. 1991). In the wild, animals are exposed to many forms of sensory stimuli. However, in barren intensive systems there are few sensory cues that are offered to animals. In order to solve this problem and promote better welfare, studies have explored methods for increasing sensory stimulation by providing materials designed to trigger one or more senses. Pigs have sense of smell, taste, touch, vision and hearing. They vocalize, communicate and have visual cues which are essential to survival. Naturally, pigs perceive a variety of olfactory cues which help them in their habitat. From the moment piglets are born, piglets use olfactory cues to identify and locate the teats (Curtis et al. 2001). Adult pigs use olfactory cues to recognize individual members in a social group. Pigs have a sense of taste and studies have shown that there are 1500 taste buds in the oral and pharyngeal cavities of a pig (Ficken, 1963; Kare et al. 1993). Pigs will avoid items that taste bitter to humans (Kare et al. 1993) and they have a high preference for sucrose and a mild preference for glucose, lactose and sodium chloride (Curtis et al. 2001). The snout is sensitive to touch and is widely used by pigs to explore the environment (Curtis et al. 2001).

Piglets rely largely on smell, touch and taste to align themselves immediately after birth (Rohde Parfet et al. 1989; Marrow-Tesch and McGlone, 1990). Pigs are sensitive to heat but the sweat glands in their skin do not respond to heat stress (Ingram, 1967). Rather, pigs rely on panting and other behavioural means such as wallowing for thermoregulation in response to temperature changes within their surroundings (Ingram and Legge, 1969; Bracke and Spoolder, 2011).

When pigs are reinforced with food rewards, pigs can learn and associate olfactory, vocal and colour cues with them (Croney et al. 2003). For instance, pigs use the scent of dimethyl sulfide to locate buried truffles (Talou et al. 1990). When sensory cues are paired with rewards, including enrichment materials, they stimulate play and anticipatory excitement of pigs (Dudnik et al. 2006). Auditory stimulation can be achieved by recording sounds specific to a species' natural habitat and playing the sound in a captive environment (Shepherd et al. 1989). Most of these forms of auditory stimulation have been conducted among wild animals in captivity. For example, Tromborg et al. (1993), observed a significant increase in auto grooming and vocalization and a decrease in the occurrence of allogrooming and scanning in two cotton-top tamarins exposed to recorded sounds of conspecifics and ambient environmental noise. However, the authors failed to explain the importance of these behaviours to the tamarins. Other sounds, such as different styles of music that are not familiar to the animals' natural habitat, can also improve welfare. Country and classical music have been suggested to have animal health and welfare benefits among various species. For instance, when dairy cattle were exposed to country music, they entered the milking parlour more readily than when 'rock' and roll' was played (Wisniewski, 1997). Gvaryahu et al. (1989) also observed an increase in growth rate and reduction in fear of chickens exposed to classical music.

Care must be taken when implementing auditory stimulation. For instance, what may be considered natural sound of conspecifics or similar to sounds within the species natural habitat may not necessarily be biologically relevant and can potentially lead to stress (Wells et al. 2006; Robin et al. 2016). Playing a particular type of music or sound as enrichment to larger groups of animals can negatively or positively influence the behaviour of non-target species e.g. staff, visitors or other animals, especially when mixed species are housed together in zoos or captivity. For example, Robin et al. (2016) examined if auditory stimuli designed for enrichment in primates influenced the behaviour of captive birds in zoo settings. They observed that the auditory enrichment led to increased flight and vocalizations of birds. Also, playing particular music or sounds at high volume can damage the auditory systems in animals (Peterson, 1980). Although, auditory stimulation has enriching benefits to animals, playing music or natural sound can be done in such a way that animals can exert control over the systems (switching on or off) when the need arises (Novak and Drewson, 1989).

Other studies have looked at the use of odours or scents to stimulate olfactory senses of pigs. The introduction of olfactory stimuli for pigs has many enriching effects, facilitating the goals of environmental enrichment. For example, aggressive behaviour during regrouping of pigs was decreased when pigs were exposed to sexual pheromones (Petherick and Blackshaw, 1987). Similarly, pigs showed less aggressive behaviour post-weaning when exposed to synthetic compounds containing elements of maternal pheromones (McGlone and Anderson, 2008). Although sensory enrichments have beneficial effects; selecting the appropriate stimuli for the target senses is required to enhance health and welfare.

1.2.5. Social Enrichment

Social isolation is uncommon in commercial pig production but has been shown to cause both acute and chronic stress in pigs (Ruis et al. 2001). Because social enrichment is defined as either direct or indirect contact with other animals, sows in stalls and groups are both considered to have social enrichment (Bloom-Smith et al. 1991). It has been suggested that sows in stalls may be frustrated because they cannot exhibit the full range of social behaviours, such as escaping from aggressive animals, or establishing social status through aggression (Arey and Edwards, 1998). From a welfare perspective, the move towards group housing has both positive and negative consequences. Sows in groups have much greater freedom of movement and are more able to interact with conspecifics, whereas sows in stalls are restricted in their interactions (Broom, 1988). Chapinal et al. (2010) evaluated the welfare and productivity of pregnant sows kept in groups and stalls. They observed more resting behaviours and a decrease in stereotypies among group sows compared to stall sows. Also, keeping sows in groups has been shown to be more beneficial and improve maternal behaviour than housing them individually. For instance, Grimberg-Henrici et al. (2016a) investigated if housing sows in groups or singly influences maternal behaviour. They observed fewer piglet losses e.g. crushing, less weight, spay legs, runting and good maternal reaction such responding quickly to piglet screams and been docile. Sows also reacted less aggressively towards handlers and showed higher exploratory behaviour (Grimberg-Henrici et al. 2016a). However, unless sows in groups are provided with sufficient space and access to feed there can be serious negative consequences, especially for subordinate individuals such as injuries from excessive aggression (Karlen et al. 2007). Thus, social enrichment alone does not necessarily benefit welfare but must be considered in combination with other management factors.

1.3 Benefits of Enrichment to Animal Health and Welfare

Animal welfare is concerned with the state of the animal. Good animal welfare requires good heath, physical and mental well-being of the animals. Fraser et al. (1997), defined animal welfare based on three categories: basic health and functioning, affective states and natural behaviour. Thus, sows should be able to live naturally using their natural features and abilities. Secondly, they should be free from chronic or intense stress, pain, hunger, fear and other negative states and experience normal pleasures, comfort and contentment. Lastly, pigs should live a satisfied life through growth, health and normal functioning of behavioural and physiological systems (Fraser et al. 1997). Raising sows in barren intensive systems can lead to major animal welfare concerns. Some of welfare concerns include an increase in injuries, stress, fear, frustration, diseases, aggression, stereotypies and other abnormal behaviours (FAWC, 2009). There are several factors or farm practices that can increase the risk of stress or undesirable behaviours on-farm and including improper space allowance or higher stocking densities, the type of housing system, negative human handling or animal interactions, feeding and drinking systems, diseases, negative social or climatic conditions, low feed intake or feed restrictions (Moinard et al. 2003; Spoolder et al. 2009) and lack of suitable substrates for rooting and foraging (Breuer et al. 2003).

Environmental enrichment is seen as a way to improve pig welfare by providing opportunities that will promote natural behaviour, affective states and biological functioning. The environment can be modified to allow sows to perform types of natural behaviours that would be otherwise impossible in a barren intensive housing system. This includes increased time spent in exploration and foraging, greater activity levels, rooting, nosing, nestbuilding, wallowing, maternal and nursing behaviours (Beattie et al. 2000; Scott et al. 2009; Yun et al. 2015). Enrichment can also improve the affective state of pigs. Although this is a relatively recent area of research, studies show improved cognitive abilities and increased 'positive bias', reductions in fear, pain, aggression and stress (Dudnik et al. 2006; Douglas et al. 2012). Providing enrichment allows pigs to have greater control over their environment (Coleman et al. 2013). Tail biting is a major welfare concern and causes huge economic losses because it increases mortality rate, rate of infections, abscesses, paralysis, pyaemia, injuries to tail and spine and increases the chances of meat condemnation during slaughter especially in market aged pigs (Van Putten, 1969; Penny and Hill, 1974). These losses are because of reduced weight gain, on-farm culling and downgrading of carcasses during slaughter (Penny and Hill, 1974). Provision of straw, rootable substrate or well designed, pig appropriate object enrichment reduces the severity or prevents harmful social behaviours directed towards pen mates such as tail-biting and belly nosing in growing pigs (Moinard et al. 2003; Van de Perre et al. 2011).

Lastly, environmental enrichment can promote better health and the biological functioning of pigs. There is increased growth performance, reproductive success, health and reduction in distress, boredom and frustration (Schaefer et al. 1990; Blackshaw et al. 1997; Beattie et al. 2000; Van de Weerd and Day, 2009). Providing environmental enrichment to pigs has beneficial outcomes and is necessary to help promote good animal welfare and address concerns.

1.4 Factors Affecting Enrichment Use

When developing an effective enrichment program several factors need to be considered including that caregivers must be interested and willing to devote their time, resources and energy to make the program successful. Many factors are known to influence the effectiveness of enrichment provision (Tarou and Bashaw, 2007). First of all, the goals of enrichment need to be considered and clearly identified. The problem of habituation and shortcomings such as financial constraints, failure to consider previous experience of animals and effects of developmental factors, high demand and ethical concerns can affect the success of enrichment program (Newberry, 1995). Other aspects include the properties of enrichment materials which will be most attractive to pigs and methods of presentation that will sustain interest and reduce habituation need to be considered. Some of these factors which affect effective enrichment for use in pig production are explained below.

1.4.1. Identifying the Goals of Enrichment

Knowing the aims or objectives of providing enrichment, and then designing enrichments to target those objectives will increase the likelihood that the program will be effective. For example, identifying an abnormal behaviour and the methods to prevent that behaviour (abnormal) and to motivate other behaviours (normal or species-specific) will help in the design of enrichment (Novak et al. 1998). According to Novak et al. (1998), abnormal behaviours can be prevented or minimised by: 1. Identifying the causal factor for the behaviour; 2. Preventing any reinforcement associated with the behaviour; and 3. Redirection to mutually exclusive behaviour. Enrichment programs are done with the goal of increasing normal behaviours and preventing the frequency or severity of stereotypies or abnormal behaviours (Bergeron and Gonyou, 1997). Therefore, the aim and design of enrichment programs should be based on knowledge and understanding of the physiological and natural behaviours of the animals in question, rather than the enrichment materials alone.

1.4.2. Habituation

Habituation is a major issue when it comes to developing an enrichment program. Animals tend to lose interest in enrichment, especially when the same object is left continuously for long periods of time example wood. Normally, the initial response and interaction with enrichment is greater and then declines over time (Van de Perre et al. 2011). Although the same enrichment material can be used several times, pigs lose interest for it very fast when it becomes soiled especially substrates like straw (Bracke et al. 2006). The initial response and interaction with point source objects is generally high within the first 24 hours and starts to decline over the subsequent days or weeks (Trickett et al. 2009). However, habituation to point source objects is also dependent on properties and the method of presentation (Trickett et al. 2009). For example, Van de Weerd et al. (2003) observed that hanging sisal rope had a higher initial response and interaction frequency on day 1 when compared with loose concrete blocks or rubber boot provided on the same day.

Novelty plays a significant role in affecting an animal's responses to enrichment. For substrate enrichments, the materials can be renewed regularly, and this will enhance novelty and reduce habituation. In the same way, bedding can act as enrichment and when renewed regularly, helps to retain interest. For example, Whittaker et al. (2008) provided straw enrichment to growing pigs, which was renewed every morning. With each addition of materials there was an increase in play behaviour, and increased response in the pigs. For point source objects, habituation is more of a problem because replacing the same object on a regular basis does not show much effect in terms of sustaining animal interest and reducing habituation (Trickett et al. 2009). Point source objects can be alternated or rotated with different objects regularly in order to retain novelty and maintain the interest of pigs (Van de Perre et al. 2011). Presentation of single point-source enrichment object also results in habituation more quickly than when multiple enrichment objects are provided (Van de Weerd et al. 2003).

Schaefer et al. (1990) suggested that when pigs become more familiar with the enrichment objects, it reduces their effectiveness and increases habituation. Van de Perre et al. (2011) showed this by providing growing pigs with a single object (chain) or a rotation of seven different enrichment objects (rope, yellow and purple ribbon, yellow and grey garden hose, rubber bar, rubber ball), once a week, until slaughter weight. The rotation of multiple enrichment objects increased the pigs interest and reduced tail-biting and other pig-directed oral manipulative behaviours more than the constant presentation of a single object.

Withholding enrichment for a period and exposing for not less than two days can help maintain the exploratory value of enrichment materials (Grifford et al. 2007). Moreover, the sequence of enrichment presentation is important in terms of habituation. The frequency of changing the enrichment and order of presentation is crucial because it can affect novelty. For example, Van de Perre et al. (2011) indicated that presenting a different enrichment after a less attractive could result in more attention being given to a new enrichment and presenting enrichment objects in the same order could reduce pigs interest. For instance, randomly changing the four different enrichment objects for female growing pigs increased their interest and improved their memory, learning abilities and lowered stress level (Grimberg-Henrici et al. 2016b).

1.4.3. Types and Properties of Enrichment Material

Considering the type of enrichment to be provided will also increase the chance of enrichment being effective. For example, Van de Weerd et al. (2003) examined the intensity of interactions to 74 different enrichment objects to identify common characteristics of preferred objects in grower and weaner pigs. They found that the major features common to preferred objects included odorous, deformable and chewable materials. However, the preferred objects that sustained interest of the pigs had additional characteristics such as being ingestible and destructible. Another study in growing pigs by Courboulay (2014) suggested that for enrichments to be effective, they should be chewable, deformable, destructible, clean (not soiled with faeces), easily accessible and immobile so the pigs can hold firmly and manipulate the materials. Most studies about type or property of enrichment materials have been done in growing pigs, with less information available about the enrichment preferences of sows.

1.4.4. Provision of Multiple Enrichment Materials

The provision of a variety of objects also increases the effectiveness of enrichment because animals can choose the materials they prefer (Van de Perre et al. 2011). Bedded systems are one of the most effective forms of environmental enrichment for pigs because of the increased spatial access that bedding provides for all pigs in the pen and because the bedding spread over the whole floor area (Van de Weerd et al. 2006). In comparison to bedded systems, there is a challenge with object enrichments (e.g. Wood) because spatial access is restricted. Pigs are able to manipulate bedding enrichments from different postures such as lying, sitting, or standing which increases interest and the activity level of pigs (Van de Weerd et al. 2006). To enhance the interest and activity level when using object enrichments, multiple objects can be provided. Pigs are social foragers and prefer to forage in groups. If pigs are crowded with limited spatial access to enrichment objects, pigs may become involved in redirected behaviours such as biting pen-mates (Scott et al. 2007). Limiting access increases competition which renders enrichment less effective in a group environment. Providing multiple objects provides room for subordinate animals to benefit because they can more easily avoid dominant animals. Introduction of multiple objects gives room to pigs, regardless of social status, to benefit from enrichment use. For instance, in a study by Van de Perre et al. (2011) where multiple objects on chains were presented continuously in the pen, the risk of biting pen-mates was significantly reduced compared to when a single object was provided.

In the contrary, Scott et al. (2006) found no significant effect of the number of hanging enrichment objects provided on the level of pig- or pen-directed behaviours in finishing pigs. This is possibly due to space or choices per pig. For example, Scott et al. (2007) investigated the ratio of pigs to enrichment objects using hanging helicopter-like objects (single vs. 4 multiple objects) in fully slatted flooring systems and observed no significant difference in enrichment-directed behaviour for the pigs provided with either single versus four objects. Scott et al. (2007) suggested that, limited competition over objects can be attributed to the objects low value and the ratio of pigs to enrichment objects. This shows that space or ratio of pigs to enrichments will be important when high value materials are provided. Provision of sufficient enrichment objects reduces aggression due to competition over materials and biting pen-mates in the social environment (Van de Perre et al. 2011).

1.4.5. Methods of Enrichment Presentation

The way in which the enrichment is presented is essential in terms of maintaining its effectiveness over time. Several studies have indicated that the rotation of multiple enrichments can increase pigs interest over time and strengthen response (Trickett et al. 2009; Van de Perre et al. 2011). Some materials are reinforcing anytime introduced, while others result in habituation due to properties and methods of presentation (Van de Perre et al. 2011). Pairing the provision of enrichment with an associative stimulus (e.g. sound stimulus) has been shown to increase effectiveness. For example, when the provision of enrichment was paired with an associative stimulus in newly weaned pigs, there was an increase in play behaviour compared to when enrichment alone was provided (Dudnik et al. 2006). There are two forms of learning. The classical conditioning also known as Pavlovian conditioning and the Operant conditioning also known as instrumental learning. In the operant conditioning procedure, the strength of a behaviour is modified by reward or punishment. Research has shown that announcing enrichment through a Pavlovian conditioning paradigm can increase anticipatory excitement and play behaviour in pigs (Dudnik et al. 2006). In the Pavlovian conditioning paradigm, a biologically potent stimulus (e.g. food, Unconditioned Stimulus or CS) is paired with a neutral stimulus (e.g. bell, Conditioned Stimulus or CS), by pairing the arrival of the conditioned stimulus and delivery of the Unconditioned stimulus (Von Friitag et al. 2000).

Research has shown that hanging enrichment improves its effectiveness (Bracke et al. 2006). Also, position of the enrichment in a pen can affect its effectiveness and the welfare of the animals. For instance, when a straw dispenser was provided in farrowing crates next to sows, it increased play behaviour and activity of sows and piglets (Bulens et al. 2014). However, positioning a straw dispenser too close to sows was not effective as dispenser position caused the sows to lie more ventrally, leading to lower milk consumption and reduced growth rate of piglets due to less access to the udder (Bulens et al. 2014). Also, appropriate presentation of materials in the pens and allowing animals to have more access to the objects helps to reduce undesirable behaviours and lesions or injuries (Scott et al. 2007).

1.4.6. Individual Factors and Enrichment Use

Individual factors such as the social status, age, gender or breed of animals have been studied and can influence the animal's interest in enrichment or ability to access enrichment materials.

Social status: In a group environment for sows, there is increased social interaction and reduced stereotypies (Karlen et al. 2007). But there is increased social pressure and aggression due to hierarchy formation in dynamic groups (van de Weerd et al. 2006). Social status can affect or reduce the activity level of sows and the use of available resources in group environment especially in subordinate sows. Dominant sows are more aggressive and spend more time in exploratory activity than subordinates (Elmore et al. 2011). Both high and low-ranking sows are highly motivated to use available resources in their home pen, but when resources are limited, subordinates may be bullied and denied access to resources by dominants (Elmore et al. 2011). Bronwyn et al. (2015) identified that sows in group housing, especially those in larger ones experience acute stressors in early stage of gestation in dynamic groups. These stressors include increased aggression and a higher tendency for increased cortisol concentrations in week one of gestation. To avoid competition, stress and overt aggression over resources in group environment, certain factors must be considered when housing sows in groups such as, feeding systems, group management, group size, stocking density, pen design, floor type, enrichment and bedding materials (Hodgkiss et al. 1998; Spoolder et al. 2009; Chapinal et al. 2010). Research has shown that provision of sufficient enrichment materials in group environment for sows has the potential to reduce pen-directed behaviour and sham chewing (Stewart et al. 2008). However, while there has been abundant research for suitable enrichment materials in growing pigs there is little information about enrichment preferences for sows.

Age and gender: Animals of different ages may require different types of enrichment objects in order to improve and maintain their exploratory or other natural behaviours. Studies have shown that age and previous experience can both influence the amount of enrichment use in pigs (Beattie et al. 1995; Dudnik et al. 2006). The frequency of play behaviour with enrichment objects decreases with increasing age (Van de Perre et al. 2011). However, exploratory behaviour increases with increasing age (Dudnik et al. 2006). This means that growing pigs will require different enrichment materials than piglets, and that mature animals will require different materials than growing pigs. Provision of materials that encourage more play behaviour will be relevant for young pigs and weaners, whilst materials that promote more exploratory behaviour are more appropriate at older ages. Most of the research on enrichment use has been done on grower-finisher or weaner pigs, with less information about enrichment materials for sows. Since sows are restricted fed, they may prefer more manipulable and consumable enrichments than piglets (Tarou and Bashaw, 2007).

Pig age also influences the extent and rate of synchronization of activity with enrichment use. For example, pre-weaned pigs (3wks of age) showed greater synchronization of activity than weaners 5 weeks and growers 13 weeks when provided with enrichment objects (Docking et al. 2008). Few studies have compared enrichment use between male and female pigs and different breeds. Docking et al. (2008) found no significant effects of gender on duration of enrichment use or latency to object approach. Similarly, gender and age had no significant effects on exploration and standing behaviours of growing pigs provided with plastic star and wood on chains (Tönepöhl et al. 2012).

Breed: Some studies suggest that the genetic make-up of an animal can influence enrichment use. For instance, Duroc pigs have been observed to be more active, and involved in exploration and most social behaviours compared to Large White and Landrace pigs (Breuer et al. 2003). However, Tönepöhl et al. (2012) investigated breed differences in purebred German landrace and crossbred growing pigs in the use of enrichment objects and found no significant effects of breed on standing and exploratory behaviours among the purebred and crossbred pigs.

1.5 Suitable Enrichment for Group Housed Sows

With the increasing emphasis on animal welfare and ability of animals to perform more natural behaviours, pork producers in many parts of the world are making the transition from stalls to group housing for gestating sows. Sows have unique behavioural patterns and lack of opportunity to perform such behaviours can cause boredom and frustration. This can result in stress and development of abnormal or stereotypic behaviours (Karlen et al. 2007). Sows in intensive systems are exposed to several stressors throughout the production cycle. Management factors such as housing design, handlers and feeding equipment can cause stress for individual sows. Research has looked at a variety of methods for improving the welfare and health of sows managed in group housing. These methods include grouping practices, timing of mixing (Harris et al. 2006; Spoolder et al. 2009; Greenwood et al. 2014), diets, feeding systems (Bergeron and Gonyou 1997; Meunier-Salaün et al. 2001) and environmental enrichment materials (Durrell et al. 1997; Elmore et al. 2011; 2012; Horback et al. 2016).

While there has been abundant research looking at suitable environmental enrichment for growing pigs (Beattie et al. 2000; Day et al. 2008; van de Weerd and Day, 2009; Van de Perre et al. 2011; Tönepöhl et al. 2012; Courboulay 2014; Henrici et al. 2016), relatively few studies have looked at the use of enrichment for sows (Durrell et al. 1997; Elmore et al. 2011; 2012; Horback et al. 2016). Because sows in gestation are restricted fed they are more likely to be motivated to interact with consumable enrichments, such as straw, mushroom compost, peat moss or other fibrous materials (Elmore et al. 2011; 2012). Provision of suitable consumable enrichments can increase gut fill and absorption time, resulting in increased satiety (Meunier-Salaün et al. 2001). However, due to problems associated with providing fibrous enrichments in partially or fully slatted systems such as blocking the slurry systems, harbouring pathogens and posing biosecurity risks there is the need to explore the use of object enrichments which do not cause problems in fully or partially slatted floors for sows.

1.5.1. Provision of Substrates as Enrichments for Sows

While different forms of substrates such as straw, sawdust, mushroom compost, peat moss, earth, hay and silage have been evaluated in growing pigs (Beattie et al. 1995; Bracke et al. 2006), the most commonly used substrates for sow enrichment are straw, mushroom compost and sawdust (Elmore et al. 2011, 2012; Whittaker et al. 1998; Durrell et al. 1997; Yun et al. 2013). Straw is generally recommended because it is a highly valued enrichment for pigs (Day et al. 2008; van de Weerd and Day, 2009). Straw provides thermal and physical comfort when used as bedding, satiety when ingested and enhances natural behaviours such as nestbuilding, rooting, nosing, exploratory and chewing activities (Moinard et al. 2003; Van de Perre et al. 2011; Yun et al. 2013). Straw also increases sows interest and activity levels by increasing the proportion of time spent manipulating the materials (Whittaker et al. 1998). Straw can be provided as bedding in concrete systems or in straw racks as nutritional enrichment in partially or fully slatted systems for sows. There is an increase in productivity and general activity for sows when provided with straw racks (Stewart et al. 2011).

Also, Elmore et al. (2011) provided gestating sows with a straw rack, rubber mat, mushroom compost and cotton ropes hung freely in the pens. The sows spent 24% of their time using straw, 21% with compost and 5% with the cotton ropes. Most of sows' inactive hours were spent lying on the rubber mat. Another study by Elmore et al. (2012) examined how motivated gestating sows were to access different forms of enrichment materials using an operant panel Operant panels measure motivation by way of elastic demand. Operant panels measure how much a sow is willing to expend in order to access enrichments i.e. to measure how valuable each enrichment is to the sow. Elmore et al. (2012) observed that gestating sows were highly motivated and willing to work harder for food rewarding enrichments compared to objects like cotton ropes and rubber mats. This confirms the reason why straw or substrate enrichments mostly produce the greatest response when used as enrichments for sows. Moreover, provision of mushroom compost has been observed to be effective in reducing aggression and encouraging more exploratory, foraging and resting behaviours in sows (Durrell et al. 1997). Giving sawdust as nesting material to gestating sows prior to parturition increased sows' oxytocin concentration resulting in improved nursing and maternal behaviours during early lactation (Yun et al. 2013).

1.5.2. Provision of Objects as Enrichment Materials for sows

While sows may prefer consumable enrichments, object enrichments compare to substrates other than straw are less expensive, locally available, easier to provide and pose less of a problem for liquid manure systems. For example, straw is mostly recommended as suitable enrichment material but since most housing in Canada are using partially or fully slatted flooring where it is difficult to use straw or substrates, it is more suitable to use alternatives such as hanging objects.

Object enrichments have been effective in providing some form of occupation for growing pigs but few of object enrichments studies have been done on sows. Sows show interest and value access to object enrichments in the pen (Elmore et al. 2012).

However, sows interest for object enrichments is more likely to habituate as objects lack consummatory aspects of foraging behaviour (provision of gut fill) (Meunier-Salaün et al. 2001). Several studies in growing pigs have shown that rotation and use of associative stimulus with enrichment objects helps to increase interest and reduce habituation (Grifford et al. 2007; Dudnik et al 2006; van de Perre et al. 2011; Courboulay, 2014). However, none of enrichments studies have looked at different methods of presenting object enrichments to reduce habituation in sows. Although sows may have less interest in object enrichments and habituate to objects presence quickly compared to consumable enrichments, different methods of presenting object enrichments to reduce habituation in sows should be studied to see how the novelty of these enrichments can be maintained over time.

1.5.3. High Fiber Diets as Enrichment for Sows

Provision of a high fiber diet is another husbandry practice to improve the health and welfare of sows. Numerous studies have looked at providing high fiber diets to sows as nutritional enrichment. Sows are highly feed motivated and feeding high fiber diets in feed restricted sows has been shown to increase feeding time and reduce stereotypic sham chewing behaviours (Bergeron and Gonyou 1997). For instance, provision of bulky type of feed reward would reduce restlessness, aggression, reduce feeding rate by 20%, 7-50% reduction in stereotypies and 30% decrease in operant feeding motivation tests (Meunier-Salaün et al. 2001). Sows fed fibrous diets have more continuous nutrient absorption and greater microbial fermentation in the large intestine prolongs satiety (Meunier-Salaün et al. 2001). This improves gut health, reducing the prevalence of ulcer formation and stomach torsion. Feeding a high fiber diet does not affect fertility or reproductive success of sows (Peltoniemi et al. 2010). Stewart et al. (2011) studied the effects of increasing dietary fibre and provision of access to straw in racks on the welfare of sows housed in static groups. Stewart et al. (2011) provided sows with concentrate ration formulated to contain 9% crude fibre and a control diet with 4.5 percent crude fibre and found that sows with access to straw or fed high fibre diet showed less stereotypic head thrusting and more exploratory and resting behaviours.

However, greater reduction in sham chewing and bar-biting was observed when sows received both 9% crude fibre (soya hulls) and straw in racks (Stewart et al. (2011). A previous study by Stewart et al. (2010) investigated the effects of increasing dietary fibre in concentrate ration (15% crude fibre, soya hulls) on the welfare of dry sows housed in large dynamic groups. Control sows had 5% crude fibre in sows diet. Authors results showed that control sows spent more time sham-chewing, head-thrusting and biting pen-mates compared to sows fed 15% crude fibre. From Stewart et al. (2010; 2011) it was observed that, even though 9% crude fibre (soya hulls) promoted resting behaviour in sows, it was necessary to combine with access to straw to reduce stereotypic sham chewing and bar biting behaviours. However, 15% crude fibre (soya hulls) was sufficient to reduce stereotypic sham chewing, head thrusting and biting pen-mates behaviours. Whittaker et al. (1998) examined the influence of a high fibre diet (600g of unmolassed sugar beet pulp per kg of feed) during gestation in sows housed in groups. Sows fed the high fibre diet spent less time vacuum chewing, tongue sucking, and bar-biting compared to conventional fed sows. Evidence from these studies show that feeding a high fiber diet has significant benefits to highly feed motivated sows and therefore can be incorporated into enrichment programs to improve the welfare of sows as measured using prevalence of stereotypic behaviours.

1.6 Conclusion

Numerous studies have demonstrated that environmental enrichment can promote the health and welfare of pigs. From a functional perspective, enrichment can reduce stress, aggressive behaviour and improve growth rate and meat quality (Beattie et al. 2000; Day et al. 2008; Oliviero et al. 2008; van de Perre et al. 2011; Greenwood et al. 2014).

Enrichment can also improve affective states by promoting positive social interaction, cognitive function and reducing fear and pain (Dudnik et al. 2006; Douglas et al. 2012). Moreover, enrichment increases aspects of natural living in pigs, by providing an opportunity for greater activity and a focus for foraging and exploratory behaviour (Bergeron and Gonyou, 1997; Olsen et al. 2002; Scott et al. 2006; Stewart et al. 2008). However, relatively little is known about enrichment use for sows and there is a need for enrichment information as group housing is being adopted in commercial practice. In particular, a better understanding is needed of point source object enrichments for sows and methods of presentation that can reduce habituation and maintain sow interest over time. In the current study, four different enrichment treatments were provided to sows. Each enrichment object had properties known to be attractive to pigs. The objective was to examine how enrichment type, method of presentation and social ranking of sows affects enrichment use in a group environment. It was hypothesized that frequent rotation of enrichments would increase enrichment use and sow activity and reduce habituation, and that use of an associative stimulus would increase the initial response to new enrichments. Also, it was hypothesized that provision of straw will increase activity and enrichment use compared to rope or wood on chains. Regarding sow social status It was hypothesized that: 1. Provision of enrichment would increase general activity and reduce stereotypic behaviours among dominant and subordinate sows; 2. Sub sows would receive more skin lesions due to aggression than Dom sows, especially when more desirable enrichments were given (e.g. straw); and 3. Dominant sows would have lower cortisol levels compared to subordinates.

2.0 CHAPTER

EFFECTS OF ENRICHMENT ON THE BEHAVIOUR OF GROUP-HOUSED GESTATING SOWS

2.1 Abstract

The increasing trend towards group housing during gestation and the Canadian Code of Practice (NFAAC, 2014) requirements for environmental enrichment have created a need for further research into effective enrichments for sows. This study examined how enrichment type and method of presentation affected enrichment use and postures of sows. Groups of 27 ± 1 gestating sows were given a series of four enrichment treatments, with each treatment provided for two weeks. Treatments consisted of: 1) constant provision of wood on chains (Constant), 2) rotation of three objects (rope, straw, wood on chain: Rotate), 3) rotation of three objects with an associative stimulus (bell or whistle: Stimulus), and 4) control (no objects: Control). It was hypothesized that frequent rotation of enrichments would increase enrichment use and activity levels of sows and reduce habituation, and that use of an associative stimulus would increase the initial response to new enrichments. Cameras were mounted over the pens and time lapse photos taken at 10-minute intervals over an 8-hour period on days 1, 8, 10 and 12 to determine enrichment use and the postures of sows. The behaviour and postural data were processed by using a generalized linear mixed model with repeated measures (Glimmix procedure SAS 9.4). Behavioural observations showed similar percentage of sows' present in the enriched areas of the pen regardless of type of enrichment provided. Enriched sows were more active, spending a greater amount time standing than Control sows (P<0.05). Enrichment type affected the frequency of enrichment use (P<0.05) and the average total percentage of sows in the enriched area with highest number of sows using straw (P<0.05). There was a strong tendency for percentage number of sows observed contacting and within one meter of enrichment when materials were rotated and paired with a stimulus than constant treatments (P=0.066). Day of observation had a significant influence on sows' activity and enrichment use. More sows were observed contacting and within one meter

of enrichment on day 10 when straw was provided compared to d 1, 8 or 12 when rope or wood enrichments were given. In conclusion, rotating enrichments increased sow interaction, especially when straw was included in the rotation. However, the use of an associative stimulus in conjunction with enrichment did not result in greater enrichment interaction.

2.2. Introduction

There is an increasing trend towards group housing for sows during gestation as the use of stall housing has gradually been restricted due to concerns regarding the welfare of sows in stalls. The European Union initiated a welfare action plan to improve gestating sows' welfare in the year 2001 (EU Directive 2008/120/EC). All 28 EU member states were given 11 years of grace period to transition from stall housing to group housing. Outside of the EU there are still many countries, such as Brazil, Asia and Canada that continue to use stall housing. In Canada, the Code of Practice for the Care and Handling of Pigs (NFACC, 2014) requires from July 2014 any newly built or renovated barns must house bred sows and gilts in groups. By 2024 all bred sows and gilts must be housed in groups, or a pen, or can be housed in stall providing they are given periodic opportunities for a greater freedom of movement. Producers however, are reluctant to use group housing because of the cost of renovation and fears of increased aggression (Karlen et al. 2007), feed competition and labour requirements (O'Connell et al. 2003). Stalls are considered very economical and reduce production cost due to their efficient use of space and ability to facilitate monitoring of sow performance (Backus et al. 1997). However, in terms of animal welfare, stalled sows lack freedom of movement and there is a greater prevalence of abnormal and stereotypic behaviours (Karlen et al. 2007).

On the other hand, group housing is gaining increasing attention because of the possibility to remove behavioural restriction, providing animals with opportunities to perform a range of natural behaviours such as an increased social interaction, foraging, exploration, rooting and nosing and have reduced abnormal and stereotypic behaviours (Karlen et al. 2007; Chapinal et al. 2010). Although group housing benefits sows by increasing natural behaviours and reducing abnormal or stereotypic behaviours, there is still prevalence of aggression and stereotypic behaviours. associated with group housing, stereotypies and aggression can be prevalent in group systems. Aggressive behaviours can potentially lead to economic losses as sows that are injured, fearful or stressed and if overt, this may influence conception rates and production (Peltoniemi et al. 1999). Multiple studies in growing pigs have shown that providing an enriched environment can provide benefits by decreasing negative behaviours such as aggression, stereotypies, ear and tail-biting, fearfulness, boredom and stress (Dudnik et al. 2006; van de Perre et al. 2011), while increasing growth rate (Beattie et al. 2000). Enrichment can also result in an increase in positive behaviours such as exploration, foraging and play (van de Perre et al. 2011). However, there is very little research on the use of enrichment objects in group gestation systems. The type of enrichment, and methods of presentation that can reduce habituation in sows and overall welfare has not been well studied. In Europe, straw is used for enrichment, however, on most North American farms producers are reluctant to provide substrate enrichment due to the added costs, biosecurity risk and problems with block liquid manure systems. Thus, there is a need to identify alternative enrichments for use in barns with slatted floors. While there are a lot of research on point-source object enrichment for growing pigs, the use of point-source object enrichments, effectiveness and how presentation influences sow interest has not been studied in sows.

In this study, four different enrichment treatments were provided to sows. Each enrichment object had properties known to be attractive to pigs. The objective was to examine how enrichment type and method of presentation affect enrichment use, postures and habituation in group housed sows. It was hypothesized that frequent rotation of enrichments would increase enrichment use and activity and that pairing an associative stimulus with enrichments would increase sows response to enrichments. Also, provision of straw in Rotate and Stimulus treatment would increase activity and enrichment use compared to rope or wood on chains.

2.3 Materials and Methods

The research was conducted at the Prairie Swine Centre Inc. (Saskatoon, Saskatchewan, Canada). Sows were managed according to PSC Inc. Standard Operating Procedures and the experiment was approved by University of Saskatchewan Committee on Animal Care and Supply (UCACS), protocol (20140037), and adhered to the Canadian Council on Animal Care guidelines for humane animal use (CCAC, 2009).

2.3.1. Animals and Housing

Eight replicates of 28 gestating sows (PIC Camborough x Line 337) were studied, with four treatments, resulting in a total of 224 sows on trial. Sows were housed in walk-in/lock-in stall (free access stall) gestation pens (Egebjerg INN-O-STALL® free access stalls, Egebjerg International A/S, Nykøbing Sjælland, Denmark). Each stall had a nipple drinker and a single space feeder located at the front. The gestation pen consisted of concrete slatted flooring (slot width 30mm, slat width 120mm) running between two rows of sixteen free-access stalls (0.65m x 2.1m) and a solid floored T-area/loafing area (3.05m x 7.3m) at one end of the pen (Figure 2.1). Sows also had access to one nipple drinker in the loafing area. Water was given ad libitum through the drinkers. Sows were provided 2.3kg of a standard gestation diet once a day at 7:00 am. Sows were artificially inseminated with pooled semen and remained in breeding stalls for four to five weeks. A new group was moved to gestation pens every 2 weeks post-breeding. Routine health checks were conducted by the production staff in the morning and afternoon.

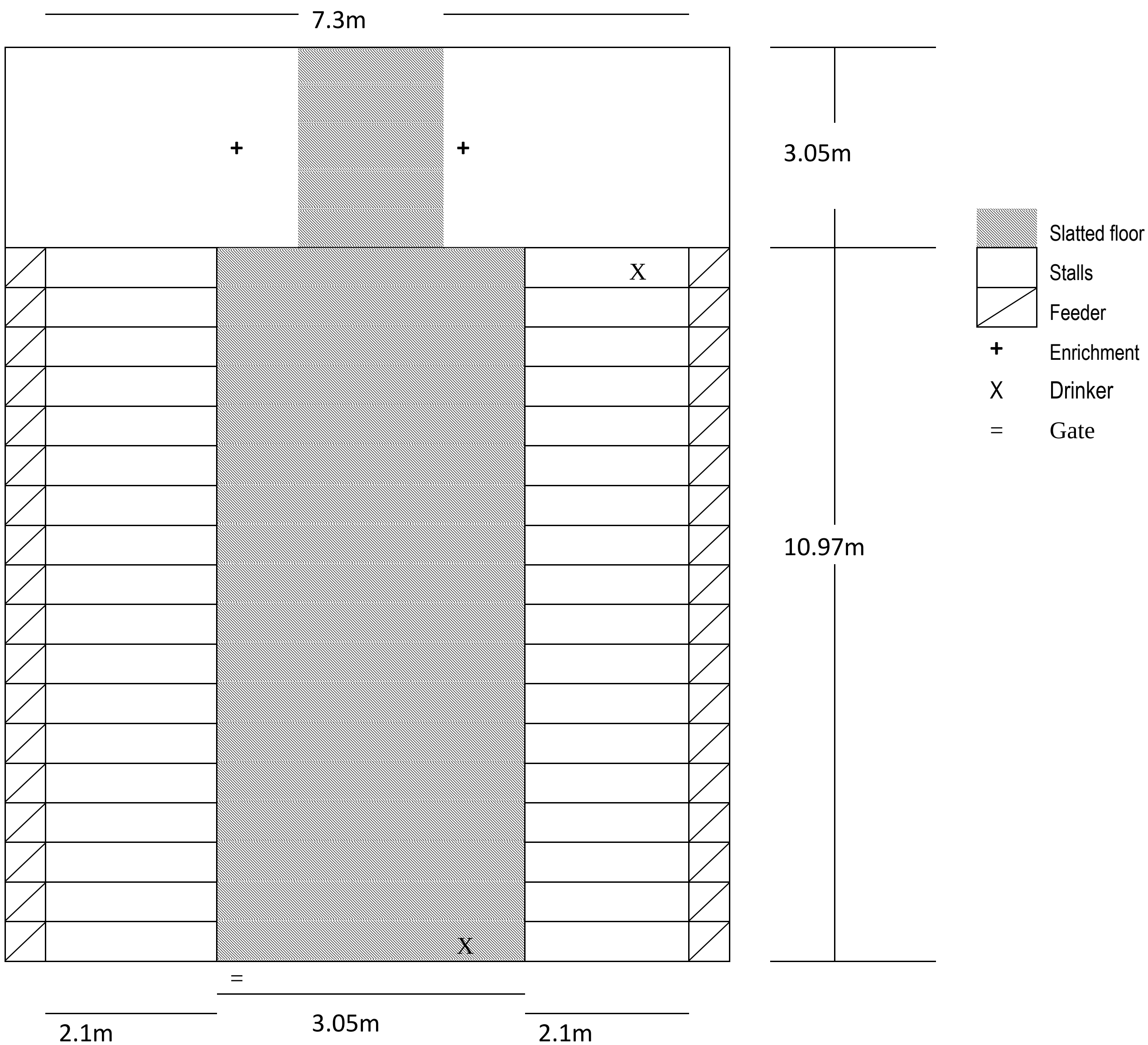


Figure 2. 1 Gestation pen schematic detailing the layout of the different pen areas.

2.3.2. Treatments

Four enrichment treatments were administered to each of the eight groups of 27 ±1 sows. Treatments consisted of: 1) constant provision of wood on chains (Constant), 2) rotation of three objects (rope, straw, wood on chain: Rotate), 3) rotation of three objects with an associative stimulus (bell or whistle: Stimulus), and 4) control (no objects: Control). The enrichments in the Rotate and Stimulus treatments were rotated three times in a week in the same order i.e. rope on Mondays, straw on Wednesdays and wood on Fridays. In the Rotation treatment, the observer entered the pen at 08:00 to place the enrichment materials in the pen. Sows could see the observer as she entered the pen and some sows raised their heads or walked towards the person as the materials were placed in the pen. The Stimulus treatments were given an associative stimulus i.e. bell or whistle rung or blown immediately before given each enrichment (rope, straw, wood on chain). The associative stimulus used was a bell or whistle, and was switched half-way through the study, so that no sows would be familiar with the stimulus. No enrichment acted as a Control treatment. Wood on chains and rope enrichments were suspended from metal frames mounted in the T-area of each pen (4 pens in total). The rope was a 1.2m (including 15cm tassel at sow end), three-stranded cotton rope 3/8" in diameter (previously we used 1/2" diameter rope due to local availability) and hung 20cm above floor level. Straw was provided on the floor such that there was 300g per sow (8.4kg in total). The wood was 1.2m in length and hung on chain so the end pivots on the ground at 45-degree angle.

Each treatment lasted 12 days (so that all 4 treatments could be covered on each group from 5 to 14 weeks gestation), followed by two days off treatment (Saturdays and Sundays) and the four treatments were provided consecutively and in random order over a period of eight weeks (i.e. beginning at 5 to 6 weeks and ending at 13 to 14 weeks of gestation).

2.4. Data Collection

One camera was mounted above each pen, and time lapse photos were taken at 10-minute intervals from 0800 to 1600 h on days 1, 8, 10 and 12 of each treatment (Figure 2.2). Only the T-area of the pen was clearly visible in photographs. One trained observer transcribed the photos and determined the location and posture of all sows visible in the T-area. All sows in the photo whose head and/or body were clearly visible, and their posture could be determined were included. Postures were recorded as the number of sows standing, lying, or sitting at each time point. Table 2.1 shows an ethogram of behaviour categories that were recorded.

Live observations were also recorded for Rotation and Stimulus treatments for a total of 5 minutes following provision of new enrichments on days 5 and 10. This was to allow comparison between the two treatments as to whether the associative stimulus showed a benefit in terms of increasing the sows' response to enrichment. Using a stop watch, the following was observed and recorded: 1) the latency for first contact with enrichment, 2) the number of sows contacting enrichments in 5 minutes, 3) the frequency of any vocalizations, and 4) the speed of movement to the enrichment (walk, run).

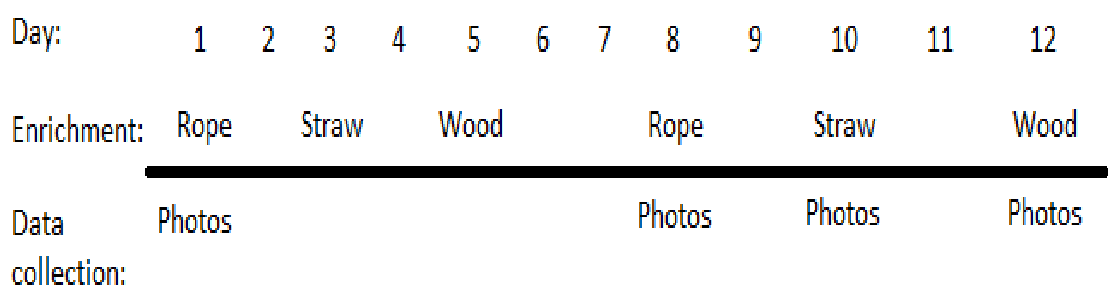


Figure 2. 2 Timeline for data collection. Enrichments shown for Rotate and Stimulus treatments.

Table 2. 1 Ethograms for sow location relative to enrichment and posture. Only sows present in the T-pen area were counted

Location relative to enrichment and definition		
In contact	-	Sow's snout is in contact with enrichment
	-	If back is to camera, sow placement and posture suggest the sow is engaging with enrichment
	-	Rope may be swinging/blurred with no sows in contact, but showing clear evidence of recent interaction
	-	For straw enrichment- the sow is standing on or facing the straw, and appears to be contacting the material with her snout
Less than 1 M	-	Sow is not in contact with enrichment, but head is within approximately 1 meter of enrichment
	-	For straw enrichment- if sow is lying or standing in proximity to the straw (head is <1 m from straw)
Greater than 1 M	-	Sow's head is greater than 1 meter from enrichment
	-	Includes all visible sows in the T-area that are not in contact or >1 m
Total sows	-	The sum of sows in contact, <1m and >1m

Posture		**Definition**
Standing	-	Sow is upright on four legs (not sitting or lying)
	-	If in the process of lying- sow is still upright and rear end is supported on hind legs
Sitting	-	Hind end is in contact with the floor, front end is raised and supported by front legs
Lying	-	Lying- the sum of sows in ventral and lateral lying (Ventral lying- sow's body is in contact with the floor with belly region in contact with the floor; Lateral lying-sows body is in contact with the floor, with one side in contact and legs extended to one side
Total sows	-	The sum of sows standing, sitting and lying postures

2.5 Statistical Analysis

Pen was the experimental unit for all data analyses. The variables describing the sows' behaviours were collected and combined. Behaviour data from time lapse photos were transcribed and analysed using only four of the replicate trials. The frequency that each behaviour category in the ethogram occurred was expressed as the percentage of observations where the behaviour was viewed out of the total number of observations during the 8-hour observation period (0800 to 1600). The mean percentage of sows performing the behaviour was calculated by determining how many sows on average were performing the behaviour (when it was present) during the 8-hour observation period. The distribution of all data was checked for normality using Proc Univariate (SAS 9.4, SAS Institute Inc., Cary, NC, USA) prior to statistical analyses. Non-normal data were transformed to obtain normality or analyzed using Proc Glimmix.

The postural and behavioural data were processed by analysis of variance with repeated measures in SAS 9.4 using Proc Glimmix (SAS Institute Inc., Cary, NC, USA) with Poisson distribution. The fixed effects included treatment, day and their interaction. Sow group (replicate) was used as the random effect. Interactions were removed from the model when not significant. The significance level was set at $P < 0.05$ and results are presented as LSmeans (±SEM). Tendency was set at $P < 0.1$.

Live observations compared the Rotation and Stimulus treatments following provision of new enrichments on days 5 and 10 for the latency to contact enrichments, number of sows in contact and vocalizations. Data were analyzed using a mixed model with treatment (Rotation or Stimulus) and enrichment (wood or straw) as fixed effects. The number of vocalizations were not normal, so the data were log transformed and analyzed using Proc Glimmix in SAS with a Poisson distribution. The speed at which sows approached the enrichment (classified as walk or run) was compared for treatment and stimulus using the Chi Square option in Proc Freq (SAS 9.4).

2.6 Results

2.6.1. Enrichment Use

The enrichment treatments had no significant effect on the frequency or number of sows in contact, or within 1m of enrichments (Table 2.2). However, there was a strong tendency for a greater percentage frequency of sows contacting the enrichments in Rotate and Stimulus treatments compared to Constant (*P*= 0.066, Table 2.2). Similarly, there was a weak tendency for sows to be <1m from enrichments for a greater duration of observations in the Rotate and Stimulus treatments compared to Constant (*P*= 0.099). Treatment had a significant effect on the percentage of sows being observed >1m from enrichment; sows in the Constant treatment were most frequently observed >1m away from enrichment, Stimulus sows were observed least at this location, and Rotate sows were intermediate (*P*= 0.001, Table 2.2).

Day of observation had a significant effect on all measures related to enrichment use and proximity (Table 2.2 and 2.3). The most notable effect was on day 10, when straw was provided in the Rotate and Stimulus treatments. There was treatment by day interaction with significantly more enrichment contacts and more sows within 1M of enrichments in Rotate and Stimulus treatments on day 10 compared to days 1 or 8 when rope was provided, or day 12, when wood on chain was provided (Figures 2.3 and 2.4).

2.6.2. Live Observations

The response of sows to enrichments (wood and straw) provision was compared in Rotate and Stimulus treatments. No treatment effect was found for the latency to contact enrichments after provision, the number of sows contacting over 5 minutes, or the number of vocalizations (*P*

> 0.05). On average, sows contacted the enrichments 7.3 ± 13.6 s after the enrichments were delivered, with 5.56 ± 1.19 sows contacting enrichments over 5 minutes, and an average of 0.66 ± 1.15 vocalizations. The speed (walk or run) that sows moved towards enrichments also did not show any significant treatment effect (Chi Square value: 0.368, $P = 0.544$).

On the other hand, the type of enrichment provided had a significant effect on the number of sows contacting the enrichments over 5 minutes and tended to affect their latency to contact enrichments. The total number of sows contacting over 5 minutes was significantly greater when straw was provided (Straw: 6.00 ± 0.29, Wood: 5.13 ± 0.29 (sows/5min/pen); $P = 0.031$), and the latency to contact tended to be shorter when straw was provided compared to wood (Straw: 3.12 ± 1.82 s, Wood: 11.53 ± 1.37 s; $P = 0.063$). The duration of vocalizations was not affected by the enrichment provided, but the speed of approach tended to be greater when straw was provided, with 3 of 16 groups of sows running when straw was provided, while no sows ran when wood was provided (Chi Square value: 3.31, $P = 0.069$).

2.6.3. Sow Location and Postures

The total duration that sows were observed in the T-area (enrichment area) was high, sows were present in >99% of observations for all treatments over 8-hour period (Table 2.4). However, there was a tendency for more sows to be present in the enrichment area in Rotate and Stimulus treatments, compared to Constant ($P=0.061$). On average, 18% of sows were observed in the enrichment area in the rotate treatment and 16% in Stimulus as compared to 14% in Constant during an 8-hour observation period (Table 2.4).

In terms of sow postures, there was no effect of treatment on the total duration (% of observations) in which the different postures (standing, sitting and lying) were observed (Table 2.4). On average, sows were observed lying in 96% of photos, standing in 54%, and sitting in 4%.

A significantly higher percentage of sows was observed standing in the enrichment treatments than in the Control treatment (Table 2.4). There was a tendency for more sows to be lying in the Rotate and Control treatments compared to Constant, with the Stimulus treatment being intermediate (P= 0.050, Table 2.4). Day of observation had a significant effect on sow postures (Table 2.3).

Table 2. 2 Effect of enrichment treatments on the duration (% of observations) and number of sows (% of group) near or in contact with enrichment in the T-pen area (LS Means).

Behaviour*	**Treatment**				**P-value**
	Rotate	**Stimulus**	**Constant**	**SEM**	**Trt**
Duration in Contact (% of observation)	35.8	33.44	23.46	1.130	0.066
Sows in contact (%)	4.66	4.87	4.26	1.040	0.089
Duration < 1M (% of observation)	29.26	21.81	17.47	1.180	0.099
Sows < 1M (%)	4.89	5.09	4.19	1.070	0.187
Duration >1M (% of observation)	89.63^{b}	66.02^{c}	98.13^{a}	1.040	0.001
Sows > 1M (%)	11.77	11.73	12.39	1.070	0.825

***** The duration (% of observation) and average percent of sows of each behaviour was observed during 8-hour period (8:00am-4:00pm) for four different days (1, 8, 10 and 12) using time lapse photos of 10-minute intervals.

< 1M: sows located less than one meter from objects, **>** 1M: sows located greater than one meter from objects.

Trt; Treatment, Day; day of observation, Trt x D; Treatment by day interaction, SEM: Standard error of means.

^{ab} Within rows, means with different superscripts are significantly different at P <0.05.

Table 2. 3 Effect of day of observation on the duration (% of observations) and number of sows (mean % of group) near or in contact with enrichment in the T-pen area (LS Means).

Behaviour*	Days				*P*-value
	1	**8**	**10**	**12**	**Day**
Duration in Contact (% of observation)	31.11^{b}	25.57^{b}	45.33^{a}	23.68^{b}	0.011
Sows in contact (%)	4.55^{b}	4.18^{b}	5.76^{a}	4.05^{b}	0.001
Duration < 1M (% of observation)	16.79^{bc}	11.7^{c}	54.13^{a}	23.42^{b}	0.001
Sows < 1M (%)	4.14^{b}	3.53^{b}	8.57^{a}	3.93^{b}	0.001
Duration >1M (% of observation)	98.53^{a}	99.82^{a}	49.62^{b}	99.26^{a}	0.001
Sows > 1M (%)	14.52^{a}	14.19^{a}	7.45^{b}	13.32^{a}	0.001

*The duration (% of observation) and average percent of sows of each behaviour was observed during 8-hour period (8:00am-4:00pm) for four different days (1, 8, 10 and 12) using time lapse photos of 10-minute intervals. Trt; Treatment, Day; day of observation, SEM; Standard error of means. ^{ab} Within rows, means with different superscripts are significantly different at $P < 0.05$.

Table 2. 4 Effect of enrichment treatments on the postures of sows in the T-area. LS Mean duration (% of observations) and number of sows (%) in each posture.

	Treatment					*P-value*
Behaviour[*]	**Rotate**	**Stimulus**	**Constant**	**Control**	**SEM**	**Trt**
Duration of Standing (% of observation)	56.99	54.96	53.93	48.78	1.060	0.389
Average sows standing (%)	6.52[a]	6.70[a]	6.28[a]	5.35[b]	1.040	0.005
Duration of sitting (% of observation)	11.61	10.25	10.90	14.35	1.200	0.568
Average sows sitting (%)	4.13	4.11	4.05	3.72	1.080	0.796
Duration of lying (% of observation)	97.11	95.66	95.88	95.96	1.010	0.869
Average sows lying (%)	14.04[a]	12.28[ab]	10.62[b]	13.28 [a]	1.070	0.05
Duration of total sows (% of observation)	99.83	99.74	99.6	99.07	1.000	0.514
Average total sows (%)	18.06	16.19	13.99	16.16	1.060	0.061

[*] Percentage frequency and average percent of sows of each behaviour was observed during on 8-hour period (0800 to 1600 h) on four different days (1, 8, 10 and 12) using time lapse photos of 10-minute intervals. Trt; Treatment, Day; day of observation, SEM; Standard error of means. [ab] Within rows, means with different superscripts are significantly different at $P < 0.05$.

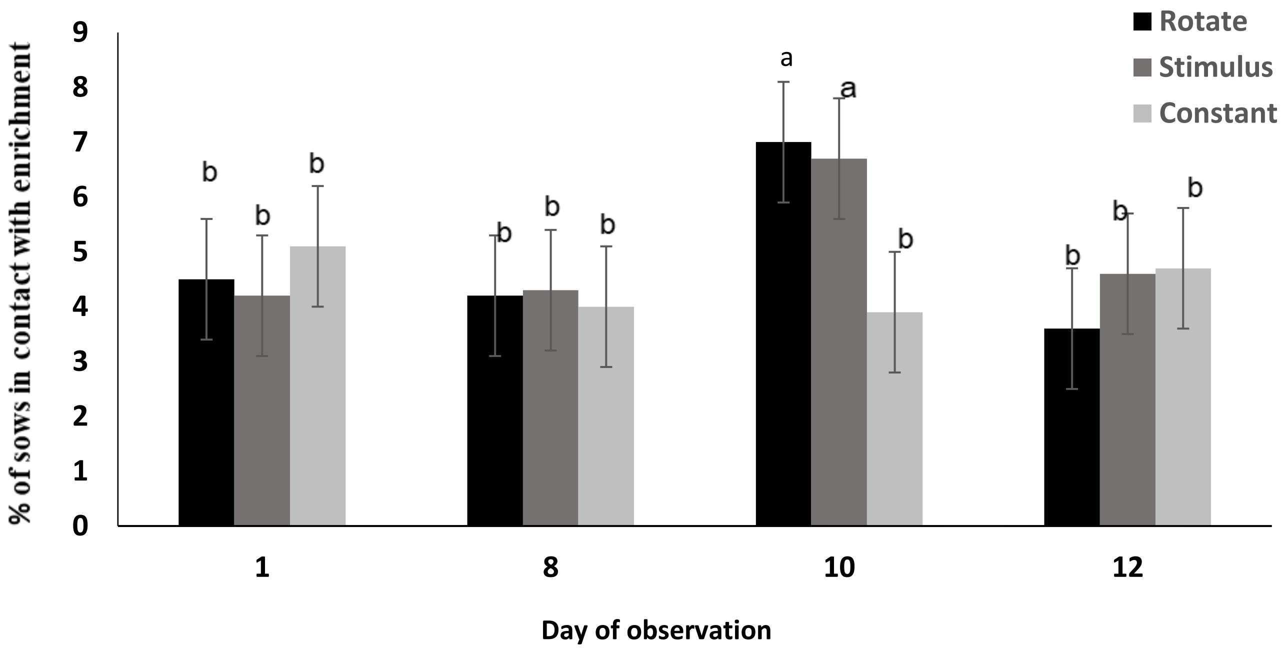


Figure 2. 3 (LS±SEM) for percentage number of sows in contact for each observation day. For Stimulus and Rotate treatments, rope was provided on days 1 and 8, straw on day 10 and wood on day 12. Observations from time lapse photos taken from 08:00-16:00 at 10min interval. [ab] Means with the same letter are not significantly different at $P<0.05$.

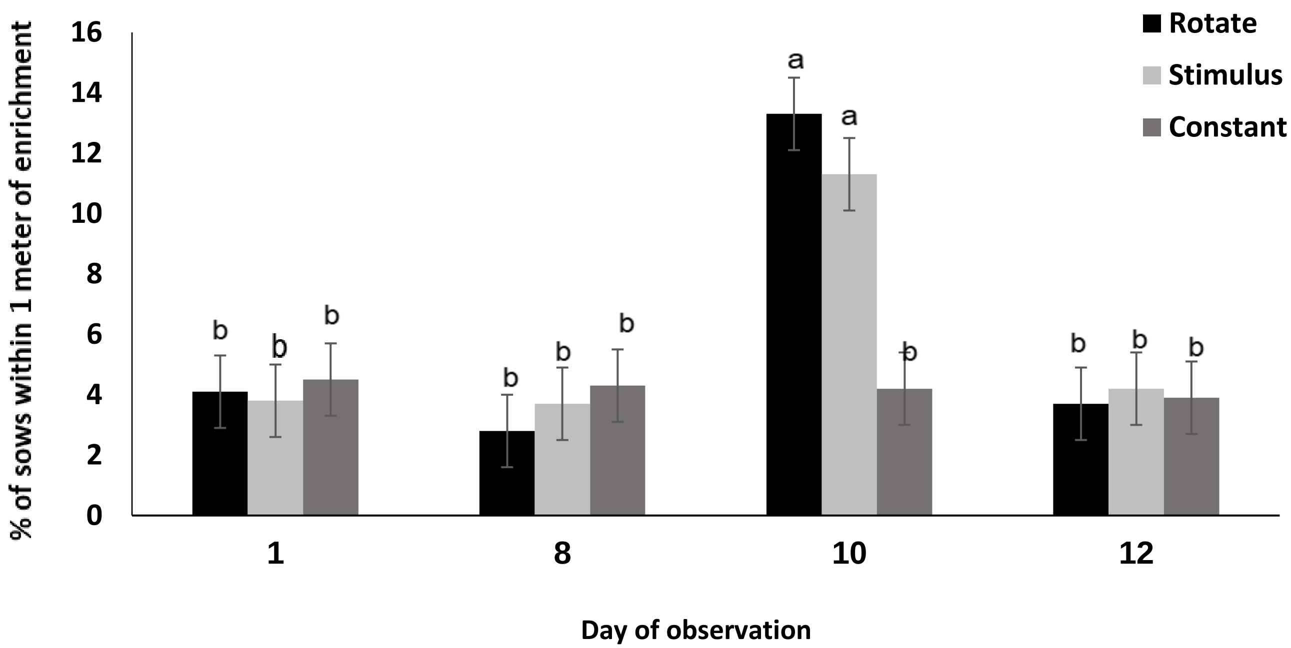


Figure 2. 4 LS Means (±SEM) for percentage number of sows within one meter of enrichment for each observation day. For Stimulus and Rotate treatments, rope was provided on days 1 and 8, straw on day 10 and wood on day 12. Observations from time lapse photos taken from 0800 to1600 at 10 mins interval. [ab] Means with the same letter are not significantly different at $P<0.05$.

2.7 Discussion

The goal of this study was to investigate how enrichment type and method of presentation of different enrichment materials (straw, rope and wood on chains) affect enrichment use and sows postures and habituation in group housed sows. Some authors have suggested that pigs' interest in enrichment can be sustained by changing objects or renewing substrates on a regular basis (Grandin et al. 1983; Van de Perre et al. 2011). Thus, it was hypothesized that frequent rotation of the enrichments (the Rotate and Stimulus treatments) would maintain novelty and increase the activity level of sows. Our results showed that the rotation of the enrichment objects did not impact the frequency with which sows were observed to be present in the enrichment area compared Constant treatment. It is possible that sows habituated to the order of presentation, since the same order of presentation was used throughout the study (rope, straw and wood). Van de Perre et al. (2011), suggested that presenting enrichment objects in the same order could reduce their attractiveness and level of interaction. When comparing enrichment treatments over time, no clear effect of habituation was found. This is likely because the duration of treatments was quiet short and also because there was no constant straw or rope treatment for comparison.

Although all the enrichment objects (rope, wood on chains) and substrate (straw) examined were used by the sows to some extent, there was a tendency for a greater frequency of sows to be in contact and close to the enrichments in the Rotate and Stimulus treatments, compared to Constant. It is likely that the change of enrichments every three to four days was responsible for this result. In a study of growing pigs, Trickett et al. (2009), investigated the role of novelty on environmental enrichment and observed that rotation of the objects increased novelty compared to continuous presentation. Grifford et al. (2007) suggested that restricting object exposure to not less than two days in rotated objects can enhance exploratory value of objects. However, since Grifford et al. (2007) and Trickett et al. (2009) studies used growing pigs of different ages, it is not clear if the same treatment would be effective for sows. Since novelty is important to keep the interest of sows, further study is needed in this area to examine the ideal duration of rotating object enrichments in sows.

Another method that has been used to increase the value of enrichments is pairing the enrichment with a stimulus. For example, in a study by Dudnik et al. (2006) the use of an associative stimulus with enrichment provision increased play behaviour and anticipatory excitement in pigs. By presenting enrichments in conjunction with an associative sound stimulus in our current study, we hypothesized that the stimulus would increase the initial response of sows to new enrichments. However, based on the similar responses observed in Rotate and Stimulus treatments, it is possible that our sows did not learn the association, because there was no training or delay of enrichment after the sound cue, or the enrichments were not very rewarding. In Dudnik et al. (2006) studies, the piglets were given straw in addition to food rewards in the form of mixed seeds after the sound cues. Dudnik et al. (2006) also used an intensive training period for the pigs to learn the association between the rewards and sound cues; there was a 30 second delay after the sound cue before rewards were given and the sequence of the rewards and auditory cues was randomized (Dudnik et al. (2006). These methodological differences Dudnik et al. (2006) and our current may have increased the value of the stimulus and association of the cue with rewards in their studies as compared with the present study. Ideally, the reward should be given immediately following the sound cue. However, if this is not practical to achieve in production environments, further work is needed to determine the best training process and the maximum time to delay the reward or enrichments after the sound cue for sows to make good association. The timing of the associative stimulus was kept constant across treatment groups, however, sows may have determined that enrichments were being delivered based on other cues than the associative stimulus (technician activity).

Pigs have been shown to prefer malleable and consumable enrichments (Tarou and Bashaw, 2007). Substrates such as straw generally produce a greater response as compared to object enrichments when used as enrichment material (Whittaker et al. 1999; Scott et al. 2006). Previous studies have compared object enrichments to straw bedding in growing pigs, for example: Bite-Rite object (Van de Weerd et al. 2005; Scott et al. 2006) and a chewable liquid dispenser providing flavoured water (Van de Weerd et al. 2006) and observed significantly higher use of straw as compared with the Bite-Rite objects or dispenser. In other studies, hanging objects have been compared with rootable substrates presented in racks or troughs for sows. For instance, Elmore et al. (2011) observed that stalled gestating sows spent 24% of their time using a straw rack, 20% with mushroom compost and 5% with rope. However, an extensive study by Van de Weerd et al. (2003) has shown that, in sows, some hanging objects can be as effective as substrates in providing occupation. Straw was therefore included in the Rotation and Stimulus treatments as a 'positive control' for comparison with object enrichments. As predicted, more sows were observed contacting and within one meter of straw enrichments and tended to run towards the enrichments when straw was being provided when compared to rope or wood on chain enrichments. Sows spent over 70% of 8-hours of observation time contacting and close to the straw enrichment, compared to 59% for wood on chains and 48% for rope. Horback et al. (2016) investigated gestating sow preference for different enrichment objects by comparing hanging ropes, rubber sticks and a fixed wooden block in the pen. In that study, the percentage of time sows were in contact with ropes was 62%, rubber sticks 32% and fixed woodblock 24%.

The greater use of straw on day 10 compared to rope or wood enrichments by sows in the current study could be because the straw was provided on the floor. When straw is provided on the floor, straw occupies the whole floor area and allows more sows to interact simultaneously, compared to simple hanging enrichments (Van de Weerd et al. 2006). If straw were placed in a rack, it would be more comparable to object enrichment as sow access would be limited. However, straw was provided on the floor in this study which made it difficult to compare with object enrichment. Also, gestating sows demonstrated higher motivation for consumable enrichments compared to objects (e.g. preferring straw over cotton rope or rubber mat objects) -because sows are feed restricted (Elmore et al. 2012). Studies suggest that for enrichment to sustain interest; pigs should be able to hold enrichment firmly and manipulate and enrichment should be ingestible and destructible (Van de Weerd et al. 2003; Van de Perre et al. 2011; Courboulay, 2014). There may also be an additive effect of an object's 'flexibility' and 'destructibility', contributing to object success as an enrichment material (Courboulay, 2014). These factors likely contributed to sows preferring the straw enrichments compared to wood on chains or ropes. Unfortunately, due to the design of enrichment treatments there was a confound between the enrichments provided and day of treatment. To explore the effects of enrichments more effectively it would have been useful to include constant straw and constant rope treatments for comparison.

Another goal of providing enrichment is to increase the number and frequency of normal behaviours (Novak et al. 1998). If enrichment is effective, we would expect to see a higher level of activity when enrichment is present than in a barren pen environment. In terms of sows' postures, enriched sows were more active as sows spent more time standing than the control sows. Similarly, Beattie et al. (2000) observed more active behaviour among growing pigs provided with enrichments. In barren group housing, sows spend over 80% of their time lying (Bergeron et al, 2000). Being more active is therefore positive because greater activity has been associated with improvements in cardiovascular health, muscle tone and bone strength (Bench et al, 2013).

2.8 Conclusion

The provision of enrichment objects did not influence the total number of sows in the enriched area compared to the control treatment, although results suggest that enrichment increased sow activity with a greater percentage of enriched sows standing. No clear effect of habituation was found because the short treatment duration used in this study was not effective to observe sows' response over time. However, regularly changing the enrichments, especially with inclusion of straw increased sows' response to enrichment. The current findings demonstrate that novelty and the type of material provided play a role in increasing attractiveness and enrichment use by sows. Straw enrichment provided on the pen floor in Rotate and Stimulus treatments produced a greater response compared to object enrichments, although sows also made use of the wood on chains and rope enrichments.

3.0 CHAPTER

EFFECTS OF SOCIAL STATUS ON SOW BEHAVIOUR, ENRICHMENT USE AND CORTISOL

3.1 Abstract

Providing environmental enrichment would reduce aggression and improve the welfare of sows. However, if enrichment is considered a valuable resource, then dominant individuals may obtain greater access than subordinates. This study observed the effects of four enrichment treatments on behaviour and enrichment use in sows of differing social status. Eight groups of 27 ±1 sows were studied, with additional data collected on six focal animals (3 dominant [Dom] and 3 subordinates [Sub]) per group (48 sows in total), identified using a feed competition test. Each group received four treatments in random order, with each treatment lasting for 2 weeks. Treatments consisted of: 1) Constant provision of wood enrichment, 2) Rotation of three objects (rope, straw, wood), 3) rotation of three objects with an associative stimulus and 4) No objects. Cameras were mounted over pens and time lapse photos taken on days 1,8,10 and 12 to determine enrichment use and postures of sows. Initial and final body weights of sows were recorded and aggression was evaluated using skin lesion scores on a scale of 0 (no injury) to 3 (severe injury). Body weight was analyzed using Proc Mixed and treatment and dominance effects were analyzed using Proc Glimmix in SAS 9.4. Dom sows were of higher average parity and significantly heavier than Sub sows. A greater number of Dom sows were observed active and standing for a greater percentage of time and displayed a greater amount of bar biting than Sub sows. Social status did not influence aggression scores. Social status had no significant effects on cortisol level, but stage of gestation influenced cortisol level with an increase in final cortisol at 14 weeks of gestation. In conclusion, similar levels of enrichment use were observed among Dom and Sub sows. However, Dom sows were more active and showed more stereotypic bar biting compared to Sub sows. The results suggest that there was minimal competition in the group system studied as social status did not significantly affect enrichment use, aggression or stress levels.

3.2. Introduction

Grouping animals of different sizes, weight, age, sex, parity and breed can be challenging. Typically, farms operating group sow gestation units house sows individually in stalls and group them with other sows after confirmation of pregnancy thus 4 weeks post-breeding. Aggressive behaviours increase when sows are mixed in new social grouping, and aggression can be aggravated further when there is insufficient space (Turner et al. 2000). Social status can influence how the sow competes in mixed social groupings (O'Connell et al. 2003). Sows that are not able to cope within the gestation group as such may be at increased risk of developing poor health and welfare. Poor health and welfare are seen mostly through injuries to the sow skin from aggression, loss of appetite, and impaired reproduction, reduced productivity and sometimes death (Beattie et al. 2000; Einarsson et al. 2008; Teixeira et al. 2016). It has been identified that sows which are involved in a greater number of agonistic and aggressive behaviours have a greater number of scratches or injuries (Hodgkiss et al. 1998; Stukenborg et al. 2012). As of July 1st, 2014, the new Canadian Code of Practice for the Care and Handling of Pigs requires that newly built or renovated barns house bred sows and gilts in groups (NFACC, 2014). Group housing removes behavioural restriction and benefits animals by allowing greater activity, natural behaviour expression, improved bone strength and reduces heart rates (De Jong et al. 1998; Harris et al. 2006; Chapinal et al. 2010). However, aggression and stress in the group environment is still prevalent and unavoidable since hierarchies need to be established (Verdon et al. 2015). Sows often fight to establish hierarchy, and this can increase length of stress (Pedersen et al. 1998). Stress increases in newly formed groups will continue until hierarchy is established at around two days post-grouping but can continue beyond eight days in larger groups (Stookey and Gonyou, 1994).

Under certain sow mixing management conditions, group-housed sows have a tendency for increased in cortisol concentrations and higher return to estrus rate after mating than conventionally stall-housed sows in first four weeks of gestation (Karlen et al. 2007; Bronwyn et al. 2015). In growing pigs, environmental enrichment has been found to increase exploratory behaviours (Beattie et al. 2000; Van de Weerd and Day, 2009), reduce aggression, stress and harmful social behaviours such as biting pen mates (van de Weerd et al. 2006; Karlen et al. 2007) and promotes good welfare by enabling pigs experience positive affective states (Douglas et al. 2012). Both dominant and subordinate sows are equally motivated to use available enrichment resources in their home pen (Elmore et al. 2011). However, there is less scientific information about the effects of social ranking of sows and enrichment preferences in group environments. Therefore, the objective of study was to examine the effects of social status on sow behaviour and enrichment use, aggression, and cortisol levels in a group gestation system. It was hypothesized that: 1. Provision of enrichment would increase general activity and reduce stereotypic behaviours among dominant and subordinate sows; 2. Sub sows would receive more skin lesions due to aggression than Dom sows, especially when more desirable enrichments were given (e.g. straw); and 3. Dominant sows would have lower cortisol levels compared to subordinates.

3.3 Materials and Methods

The research was conducted at the Prairie Swine Centre Inc. (Saskatoon, Saskatchewan, Canada). Sows were managed according to PSC Inc. Standard Operating Procedures, and the experiment was approved by University of Saskatchewan Committee on Animal Care and Supply (UCACS), protocol (20140037), and adhered to the Canadian Council on Animal Care guidelines for humane animal use (CCAC, 2009).

3.3.1. Animals and Housing

Eight sub-groups of six focal sows (Camborough x PIC 337) were studied within larger group (27 ±1 sows/group) to obtain a total of 48 focal sows (6 focal sows' x 8 replicates) on trial.

The sub-group was composed of primparous and multiparous sows (parities 1 to 7). Sows were housed in walk-in/lock-in stall (free access stall) gestation pens (Egebjerg INN-O-STALL® free access stalls, Egebjerg International A/S, Nykøbing Sjælland, Denmark). The gestation pen consisted concrete slatted flooring (slot width 30mm, slat width 120mm) running between two rows of sixteen free-access stalls (0.65m x 2.1m) and a solid floored T-area/loafing area (3.05m x 7.3m) at one end of the pen (Figure 2.1). Each stall had a nipple drinker and a single space feeder located at the front. Sows also had access to one nipple drinker at the loafing area. Water was given ad libitum through the drinkers and 2.3kg of standard gestation diet was provided once a day at 0700 h. Sows were artificially inseminated with pooled semen and remained in the breeding stalls for four to five weeks. sows were moved to gestation pens every two weeks, thus at four or five weeks post-breeding. Routine health check was done by the production workers in the morning and afternoon.

3.3.2. Social Status

The trial began one week after each group of 28 sows were moved to the gestation pen at five weeks of gestation. The body weight and parity of all focal sows in the groups was recorded as the sows entered the gestation pen. Social status was determined in a sub-sample of 6 sows out of 28 using a feed competition test to identify three dominant and three subordinate sows per group. The feed competition test was done on 3 to 5 days post mixing, when any initial mixing aggression was resolved. In the afternoon at 1300 h, the solid floor area was scraped, and 4 kg of feed was poured onto the floor in two lines (2 kg per line, approx. 1 meter long in 2 lines, spaced at least 2 m apart). Once the feed was placed, all sows (28) in the group were moved from stalls and allowed to compete for floor feed. The feed competition test was repeated on three consecutive days, with focal sows being identified and individually marked using spray marker on the third day. Sows were observed carefully on the third day, and three sows gaining first access/dominating the feed were identified as 'Dominant' (Dom) and three sows that refrained from feed competition and/or were driven away were identified as 'Subordinate' (Sub). The Dom sows were marked with blue spray marker and Subs were marked with red spray marker.

3.3.3. Sow Behaviour

Time lapse photos were taken at 10-minute intervals for 8 hours per day (0800 to 1600 h) on days 1, 8, 10 and 12 of each treatment (Figure 3.1). Focal sows were locked out of the stalls during photo observation days. Four treatments were provided in random order, with each treatment lasting for 2 weeks. Treatments consisted of: 1) constant provision of wood on chains (Constant), 2) rotation of three objects (rope, straw, wood on chain: Rotate), 3) rotation of three objects with an associative stimulus (bell or whistle: Stimulus), and 4) control (no objects: Control). The photos were transcribed by a single trained observer. The location and posture of individual Dom and Sub sows were determined in proximity to the enrichments. The total number of focal sows present in the T-pen area was recorded. The ethogram for various behaviours was similar to that for the group study presented in chapter 2 (Table 2.1). Location was recorded by a single trained observer for each time point by observing the number of Dom and Sub sows that were: the touching enrichment, within one meter of the enrichment, or greater than one meter from the enrichment. Postures recorded included the number of Dom and Sub sows standing, lying, and sitting at each time point.

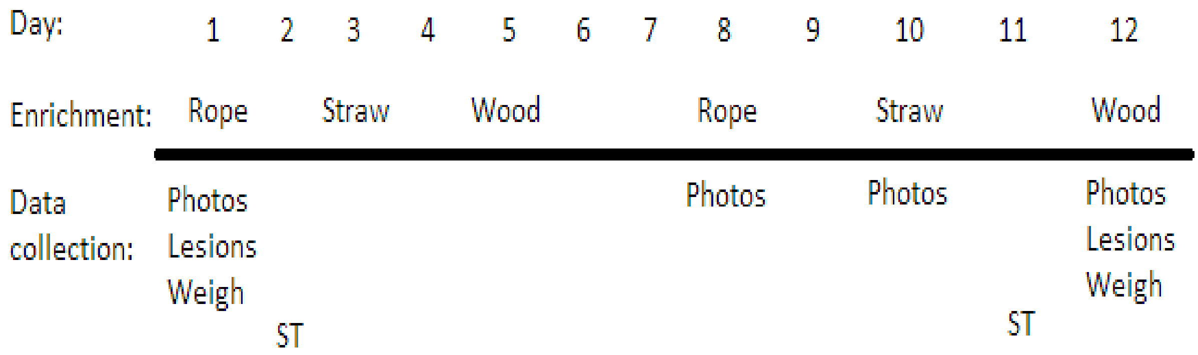


Figure 3. 1 Timeline for data collection. ST: Stereotypy observations

3.3.4. Stereotypic Observations

Stereotypies are repetitive invariant behaviour patterns with no obvious goals or functions (Mason, 1991). Stereotypic behaviours were observed in Dom and Sub sows using live observations on days 2 and 11 of each treatment at two-time periods per day. Initial observations of sows were first conducted to determine the type of stereotypies present. Common stereotypic behaviours identified included bar biting, prolonged bouts of drinking or licking feeders, floor licking and vacuum or sham chewing. Live observations were conducted continuously by a single trained observer for 60 minutes in the morning between 0800 and 0900 h (30 minutes after sows received their daily meal) and 60 minutes in the afternoon between 1300 and 1500 h. The observer stood outside the pen, and every 15 minutes the location, posture and behaviour or type of stereotypies being performed by focal sows was recorded. Each sow was observed in turn for roughly 3 seconds and the first behaviour observed was recorded. Behaviours recorded included bar biting (sow is seen licking bar, feeders, drinkers), Sham/vacuum chewing (sow is chewing mouth without any substrate in mouth), Inactive (sow is quiet and not involved in any activity), Other stereotypies (other behaviours not specified but met stereotypy criteria i.e. repeated behaviour with no apparent function). Postures included; lying, dog siting and standing, Location; sow is in stall, enriched area or slatted area.

3.3.5. Lesion Scoring

Lesion scores were used to determine aggressive interactions of pigs, using methods adapted from Hodgkiss et al. 1998. Skin lesion scores were assessed twice for each treatment period, on day 1 (before any enrichment was provided) and on day 12 (final day of treatment). Sows were scored on eleven regions (head, ear, neck, and shoulder, top of back, tail, vulva, hind leg, side, udder and front leg) on both the right and left sides of the body. Lesion scores were assigned to each region using a scale of zero to three with 0 (no injury) and 3 (severe injury).

3.3.6. Physiological Response

Sample collection and storage: The stress level of sows was determined by cortisol analysis from saliva samples. Saliva was collected from the focal sows between 8 and 9am at three-time points: 5, 9 and 14 weeks of gestation. Saliva was collected when sows were confined in feeding stalls by allowing them to chew on large cotton buds wrapped on a metal support rod until the buds were thoroughly moistened, about 30 to 60 seconds per sample. The moistened buds were placed in tubes and centrifuged immediately for 15 minutes at 4000 rpm. The saliva sample was collected and placed in labeled storage tubes using disposable pipettes and stored at -20^{o} C until analysis (saliva collection methods followed those of Cook et al. 2012).

Cortisol analysis: The cortisol concentration in saliva samples was determined using the Salimetrics® Cortisol Enzyme Immunoassay Kits (Salimetric, LLC, 101 Innovation Blvd, Suite 302, State College, PA 16803, USA) modified for research use in humans and animals only. The kit is a competitive immunoassay specifically designed and validated for quantitative measurement of salivary cortisol and uses ELISA plates with 96 wells. A precision estimate was performed by doing 20 sample intra-assay and inter-assay calculation of standard deviation and coefficient of variation (%). During the cortisol analysis, saliva samples were allowed to thaw for 2 hours, followed by an additional 2 hours at room temperature. The samples were then centrifuged at 20^{o} C at 1530 x g for 15 mins and transferred into 1.5 ml snap cap tubes. To prepare the wash buffer; 280 ml of deionized water was diluted with 30 ml of wash buffer. Also, enzyme conjugate was diluted 1:1600 by adding 15µl of the conjugate to 24 ml tube of Assay Diluent. The conjugate tube was spun for a few second to force the liquid to the bottom of the tube. The Standards, Controls and saliva samples (200 µl/sample) were pipetted into individual wells and the plate was then mixed on a plate rotator for five minutes at 250 rpm and incubated at room temperature for a total of 1 hour. The plate was then washed three times with 300 µl wash buffer. TMB substrate (200 µl) solution was added to each well with multichannel pipette and again mixed on a plate rotator for five minutes at 250 rpm (if green colour remains continue until it turns yellow) and the plate was incubated in the dark (covered with foil) at room temperature for an additional 25 mins. Lastly, 50 µl of stop solution was added to each well, the plate was vortexed and put in the plate rotator for three mins and afterwards the cortisol values read in a plate reader at 450 nm

Cortisol in standards and samples compete with cortisol conjugated to horseradish peroxidase for the antibody binding sites on a microtiter plate. After incubation, unbound components are washed away. Bound cortisol enzyme conjugate is measured by the reaction of the horseradish peroxidase enzyme to the substrate tetramethylbenzidine (TMB) and the reaction produces a blue color. A yellow color is formed after stopping the reaction with an acidic solution. The optical density is read on a standard plate reader at 450 nm. The amount of cortisol enzyme conjugate detected is inversely proportional to the amount of cortisol present, in the sample.

3.4 Statistical Analysis

Each sow group was considered an experimental unit for lesion scores, stereotypies and cortisol analysis. Data were checked for normality before analysis. All statistical analyses for behaviour data, lesions, stereotypies and cortisol were conducted in SAS 9.4 (SAS Institute Inc., Cary, NC, USA) using the Proc Glimmix procedure with Poisson distribution. Body weight was normally distributed and so analyzed by Proc Mixed. The fixed effects included social status, parity code, treatment, day and period, with replicate group as a random effect. The period for stereotypies was coded as morning (0800 to 0900) and afternoon (1300 to 1400). Behaviour data from time lapse photos were transcribed and analysed using only four of the replicate trials. Behaviour data describing sow activity and enrichment use were collated and the duration at which each occurred was expressed as percentage of all the total number of observations over the 8-hour period. For enrichment use, the total number of sows in each behaviour category in the ethogram (Table 2.1) was expressed as a percentage of the total number of observations. For stereotypic data, the frequency at which each occurred was expressed as percentage of all the total number of observations over two 1-hour periods (0800 to 0900, 1300 to 1400) and data analyzed in SAS. In addition, the relationship between the total number of sows in stalls and the frequency of stereotypic sham chewing and bar biting were tested using Proc Corr in SAS 9.4. Focal sows were classified into three parity codes for analysis. Parity code 1 consisted of sows of parity 1 and 2, parity code 2 consisted of parity 3 and parity code 3 consisted of parity 4, 5, 6 and 7. Because there were few lesions on front and hind legs and rear (rear/tail, vulva, udder), lesions data was grouped into five regions for analysis. These five regions included side (left and right), shoulder (left and right, back), head (left and right ears, neck, head, front/face), total lesions for day 1 and day 12 (all regions). Significance level was set at $P < 0.05$ and tendency was set at $P < 0.1 \geq 0.05$. The data are presented as LS means (± SEM), except where otherwise indicated.

3.5 Results

3.5.1. Body Weight and Parity

3.5.1.1. Social Status

Dom sows were significantly heavier than Sub at 5 and 14 weeks' gestation ($P<0.05$; Table 3.1). Weight change during gestation was similar for Dom and Sub sows ($P<0.05$; Table 3.1).

3.5.1.2. Parity Code

The average parity of Dom and Sub sows were 3.11±0.09 and 2.89±0.08, respectively. There were more Parity code 2 and 3 sows identified d as Dom, and more Parity code 1 sows/gilts selected as Sub. Parity code had significant effect on sows' body weight (Table 3.1). Dom sows were of higher average parity than Sub sows (Table 3.1). Older sows of parity code 2 and 3 weighed more than younger sows of parity code 1, both at the initial and final weighing (Table 3.1). However, the older sows (parity code 2 and 3) gained less body weight during gestation, when expressed as either as absolute kg or % BW than parity 1 (Table 3.1).

3.5.1.3. Social Status by Parity Code

There was a significant interaction between social status and parity in terms of initial and final BW, weight change and % weight change (Table 3.1). Initially, parity 1 Dom and Sub gilts/sows were of similar body weight, although Sub animals were numerically heavier than Doms. There was a tendency for parity 2 Dom animals to be heavier than Sub, and parity 3 Doms were significantly heavier than parity 3 Subs. At the end of gestation, Dom and Sub sows were significantly different in all parity categories.

Table 3. 1 LS Means of sow body weights by social status and parity code.

Item	Social status*			Parity code**			SEM	*P values*		
	Dom	**Sub**	**SEM**	**1**	**2**	**3**		**SS**	**P**	**SS × P**
N	93	92		73	57	55				
Initial BW (kg)	256.5^{a}	239.3^{b}	5.347	222.7^{c}	255.3^{b}	265.7^{a}	5.893	0.001	0.001	0.001
Final BW (kg)	290.0^{a}	$28\ 2.4^{b}$	4.697	261.4^{c}	$28\ 4.5^{b}$	297.6^{a}	5.498	0.001	0.001	0.001
BW change (kg)	33.2	33.2	3.244	38.5	30.8	30.2	7.532	0.978	0.001	0.001
BW change (%)	13.6	14.4	2.374	17.8	12.4	11.9	1.731	0.263	0.001	0.005

ab Within rows, means with different superscripts are significantly different at $P < 0.05$

*****Dom=Dominant (high ranking sows), Sub=Subordinate (low ranking sows), SEM; Standard error means.

**Parity code 1: parities 1 and 2; 2: parity 3, and 3: parities 4- 7. SS: social status, P: parity, SSXP: status and parity interaction. Body weight was recorded on the first and last day of treatments.

3.5.2. Behavioural Measures

3.5.2.1. Social Status and Enrichment Use

Enrichment use did not differ due to social status (P<0.05; Table 3.2). There were no significant effects of social status on the number of Dom and Sub sows' present in the enriched area during an 8-hour observation period. On average, Dom and Sub sows were found in the enrichment area in 42% and 43% of observations, respectively, during the 8-hour period (Table 3.2). The social status of sows did not have any effects on sow postures (P<0.05; Table 3.2).

3.5.2.2. Day and Interaction by Social Status

Significant day effects were observed for all measures related to enrichment contact and the proximity of sows to enrichment (within less than or greater than one meter of enrichment; Table 3.2). Sows were observed to spend more time in contact with enrichment and within one meter of enrichments on day 10 when straw was provided compared to days 1, 8 and 12 (Figures 3.2 and 3.3). On average, sows were observed in contact and within one meter of enrichment in 74% of observations on day 10 compared to 50%, 46% and 57% of observations on days 1, 8 and 12 respectively (Figure 3.2). There was a strong tendency (P=0.06) of day effects for percentage number of focal sows standing (Table 3.3). On average, more sows were observed standing on days 10 (straw; 38.94±1.03%) and 1 (rope; 38.43±1.03%) than on day 8 (rope; 35.48±1.03%) or day 12 (wood; 36.54±1.03%). There was no significant status by day interactions for postures, frequency of visits or number of sows in contact, within or away from enrichments.

Table 3. 2 Effects of social status and day on duration (% of observation) and number of sows (%) in each behaviour (LS Means ± SEM).

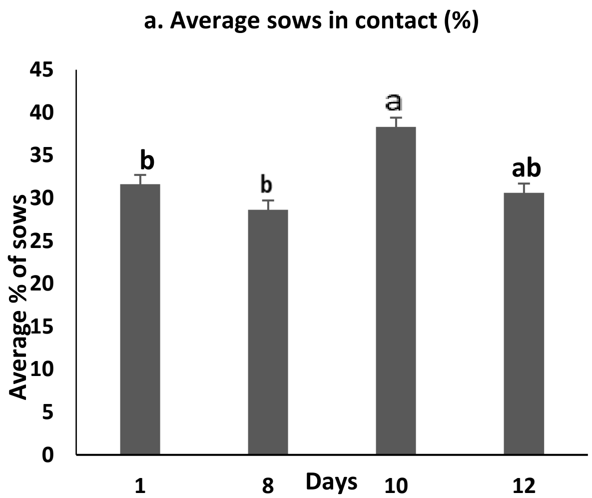
Behaviour*	**Social Status****		**SEM**	**P-value**
	Dom	**Sub**		**SS**
Duration of contact (% of observation)	10.53	8.82	1.130	0.134
Sows in contact (%)	32.79	31.45	1.050	0.532
Duration < 1 M (% of observation)	4.37	4.29	1.210	0.934
Sows < 1 M (%)	23.97	22.69	1.110	0.629
Duration >1 M (%)	42.48	39.39	1.090	0.519
Sows > 1 M (% of observation)	36.45	37.15	1.040	0.751

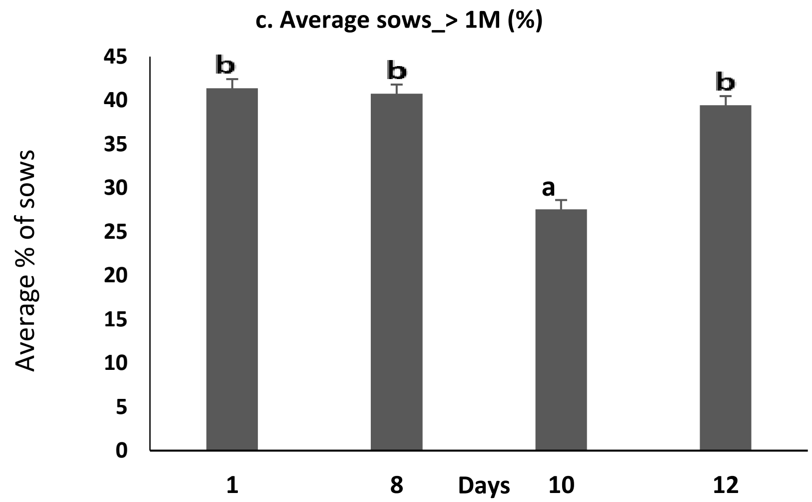
* Percentage frequency and average percent of sows of each behaviour observed during 8-hours (8:00am-4:00pm) on four different days (1, 8, 10 and 12) using time lapse photos at 10-minute intervals. **Dom=Dominant sows (higher ranking), ***Sub=Subordinate sows (low ranking), SEM=Standard error means, SS=Social status effect, Day= Day of observation.

Table 3. 3 Effects of Social status and day duration (% of observation) and number of sows (%) in various postures (LS Means ± SEM).

Behaviour*	Social Status**		SEM	P-value
	Dom	Sub		SS
Duration of standing (% of observation)	20	18.09	1.070	0.249
Sows standing (% of animals)	37.08	37.57	1.020	0.631
Duration of sitting (% of observation)	3.53	2.71	1.170	0.216
Sows sitting (% of animals)	21.06	21.33	1.110	0.936
Duration of lying (% of observation)	49.53	50.65	1.070	0.809
Sows lying (% of animals)	38.38	39.39	1.020	0.323
Duration total Sows (% observation)	66.14	65.71	1.050	0.92
Total sows (% of animals)	42.52	43.21	1.020	0.609

*Average percentage number of sows and percentage frequency of each behaviour was observed during 8-hour period (8:00am-4:00pm) for different days (1, 8, 10 and 12) using time lapse photos of 10-minute intervals. ** Dom=Dominant sows (higher ranking), *** Sub=Subordinate sows (low ranking), SEM=Standard error means, SS=Social status effect, Day= Day of observation





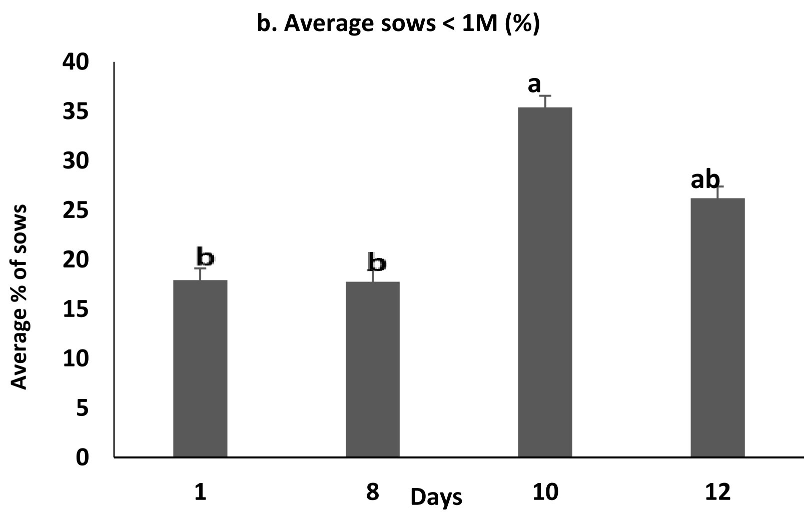
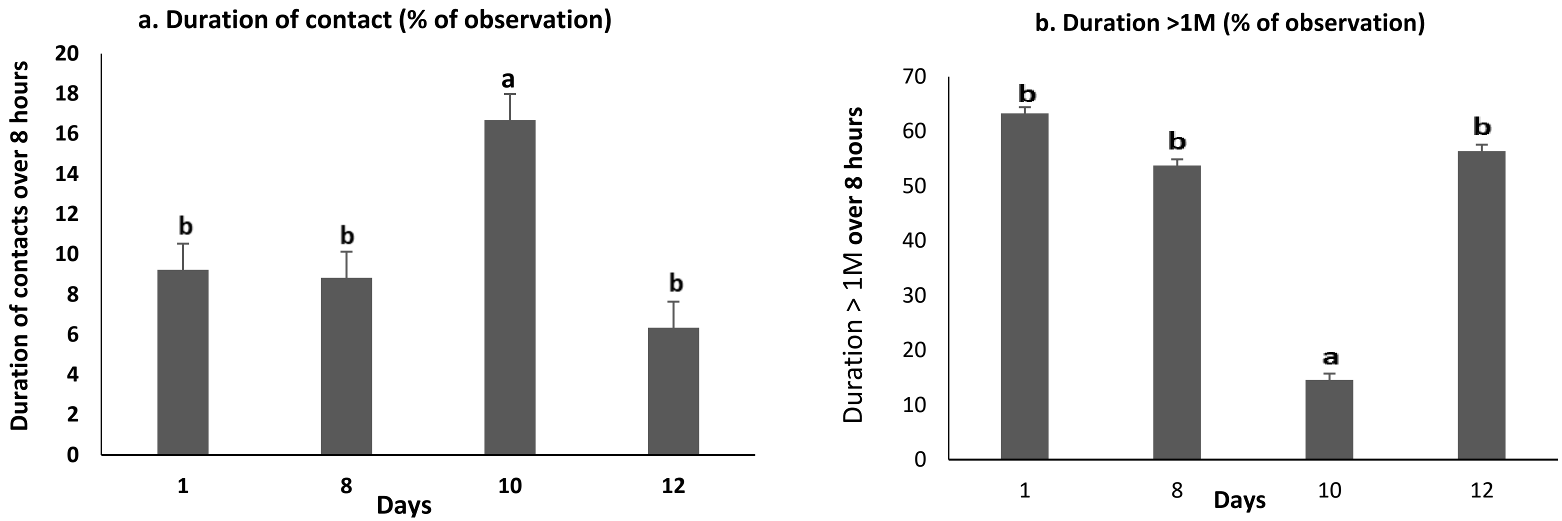


Figure 3.2 LS Means (±SEM) for a. % of sows in contact, b. within <1m, and c. greater than 1m of enrichment on each observation day from time lapse photos taken at 10min intervals Enrichments: rope: d 1, 8; straw: d 10; and wood: d 12. [ab]Means with the same superscripts are not significantly different ($P<0.05$).



a. Duration of contact (% of observation)
Duration of contacts over 8 hours
20
18
16
14
12
10
8
6
4
2
0
b
b
a
b
1
8
10
12
Days
b. Duration >1M (% of observation)
Duration > 1M over 8 hours
70
60
50
40
30
20
10
0
b
b
a
b
1
8
10
12
Days

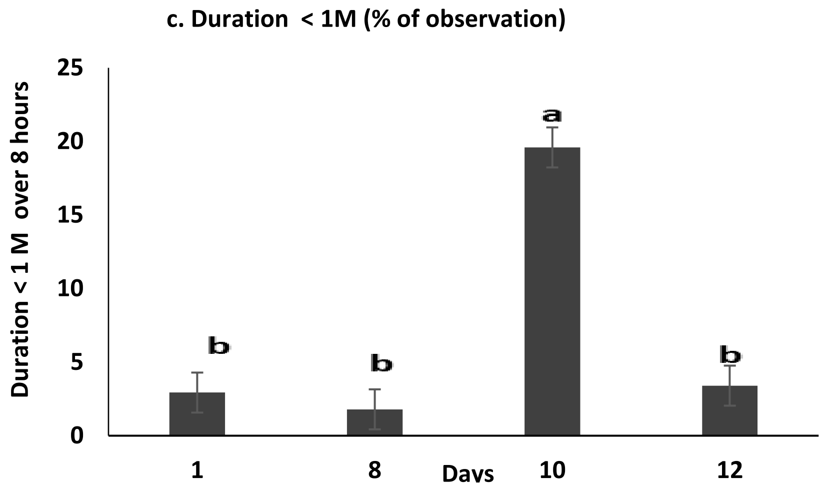


Figure 3. 3 LS Means (±SEM) for **a**. duration of contact, **b**. within < 1m, or **c.** > 1m of enrichment on each observation day from time lapse photos taken at 10min intervals. Enrichments: rope: d 1, 8; straw: d 10; and wood: d 12. [ab] Means with the same superscript are not significantly different P<0.05

3.5.3 Sow Activity and Stereotypic Behaviours

3.5.3.1. Social Status

There was a strong tendency (*P* = 0.06) for percentage frequency of Sub sows observed in stalls than Dom sows (73% vs 68%) respectively (Table 3.4). Social status had a significant effect on the percentage frequency of sows standing, lying, object biting and inactive during live observation (8-9am and 1-2pm) on days 2 and 11 of treatment (Table 3.4). On average, a higher percentage frequency of Sub sows was observed inactive and lying compared to Dom sows (*P* = 0.001). Dom sows were observed more frequently active and spending greater time standing and object biting (Table 3.4). There were no social status effects for percentage frequency of sows 'sham chewing and present in the enriched area during live observations (Table 3.4).

3.5.3.2. Treatment Effects

Enrichment treatments had no effect on the percentage frequency of activity and stereotype behaviours (*P>0.05*).

3.5.3.3. Period and Day Effects

Sham chewing was observed in a higher percentage frequency of sows on day 2 (49.48 ±1.04%) compared to day 11 (42.79 ±1.04%) during live observation periods. Standing, dog sitting, object biting, and sham chewing were observed more frequently in the morning post feeding than afternoon (Table 3.4; Figure 3.4). More sows were observed to be inactive and lying in the afternoon than morning (Table 3.4; Figure 3.4). Significantly more sows were observed in the stalls in the morning (Table 3.4; Figure 3.4). More sows were present in the enriched area in the afternoon during the live observations (Table 3.4; Figure 3.4).

A significant positive correlation was observed between the total number of sows in the stalls and stereotypic bar biting (*p=0.001 <0.01*; coefficient of correlation (r) = 0.15) and sham chewing behaviours (*p=0.001 <0.01*; coefficient of correlation(r)= 0.19). However, the total number of sows in the T-area was negatively correlated with stereotypic sham chewing and bar biting [Sham chewing (*p=0.001 <0.01*; (r) = -0.18; bar biting (*p=0.001 <0.01*;(r) = -0.19) This suggests that stereotypic bar biting and sham chewing behaviours of sows occurred more when sows were in stalls, (Table 3.4) and especially in the morning (Figure 3.4 below).

3.5.3.4. Social Status by Period

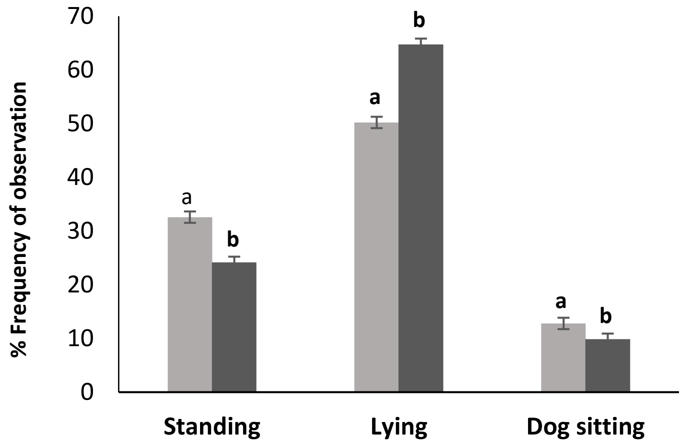
There was a significant social status by period interaction for percentage frequency of standing, object biting, inactive and lying behaviours (Table 3.4). Dom sows showed a greater frequency of object biting and standing behaviour in the morning compared to Sub sows (Figure 3.5a, b). Similar frequencies of standing behaviour were observed in the afternoon for Dom and Sub sows (Figure 3.5a). Sub sows spent a similar amount of time object biting in both the morning and afternoon and were similar to Dom sows in the afternoon (Figure 3.5 c). Both Dom and Sub sows were observed lying and inactive more in the afternoon than morning (Figure 3.4 b, d).

Table 3. 4 Effect of social status on sow location, posture and stereotypic behaviour (% frequency of observations) determined in live observations on days 2 and 11

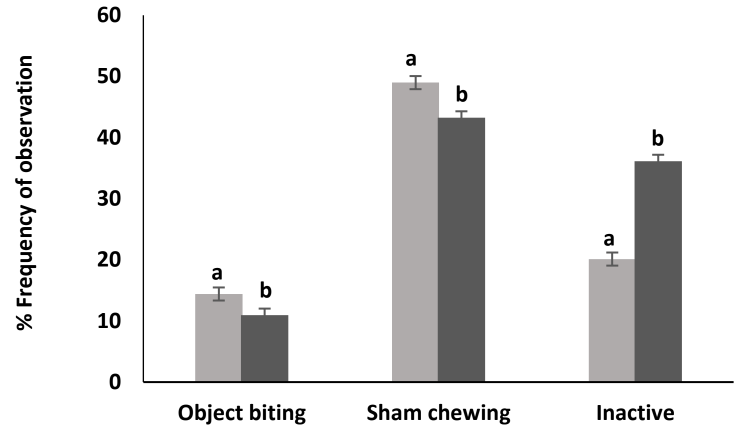
Behaviour[*]	Social status[**]		SEM	P-value		
	Dom	**Sub**		**SS**	**Period**	**SS×P**
Location:						
T-Area (% frequency of observation)	26.96	22.73	1.080	0.133	0.001	0.421
Stalls (% frequency of observation)	67.55[b]	73.22[a]	1.030	0.058	0.003	0.382
Posture:						
Standing (% frequency of observation)	33.29[a]	23.67[b]	1.060	0.001	0.002	0.004
Lying (% frequency of observation)	51.17[a]	63.57[b]	1.030	0.001	0.001	0.001
Dog sitting (% frequency of observation)	12.8	11.08	1.090	0.245	0.002	0.992
Behaviour:						
Object biting (% frequency of observation)	14.55[a]	11.11[b]	1.090	0.029	0.017	0.003
Sham chewing (% frequency of observation)	45.05	46.99	1.040	0.431	0.021	0.208
Inactive (% frequency of observation)	23.37[b]	31.09[a]	1.060	0.001	0.001	0.006

[ab] Means with different superscript within same row are significantly different at P <0.05. **[*]** Behaviour data was collected over 2-hour live observation period on days 2 and 11 during enrichment provision. [**]Dom=Dominant (high ranking sows), Sub=Subordinate (low ranking sows), SEM; Standard error means, SS; Social status, Trt; Treatment, Day; day of observation, Period; Time of day when observations were conducted 3-way interaction.

(a) Posture



(b) Behaviour



(c) Location

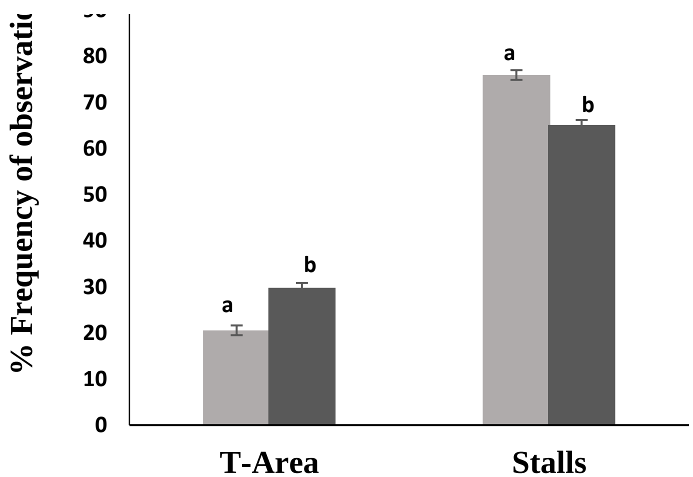
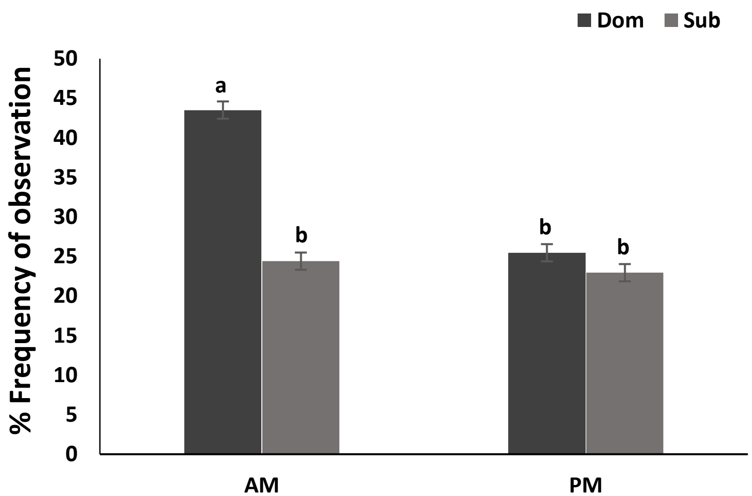
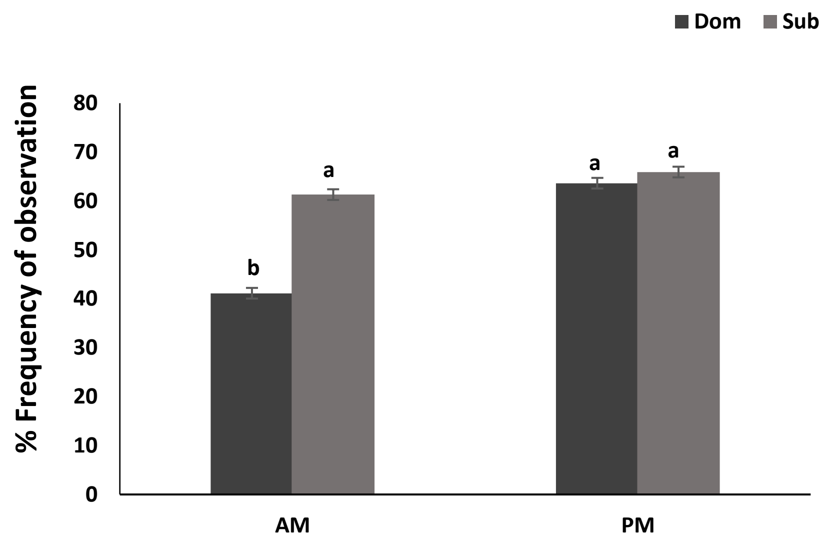


Figure 3. 4 LSmeans ± SEM of period (AM: grey bars vs PM: black bars) effects on % frequency of observation of a) sow postures, b) stereotypic behaviours and c) location. Live observations were collected on focal sows in two 1-hour periods of live observation on days 2 and 11 during enrichment provision. [ab] Means with different superscript are significantly different at P <0.05

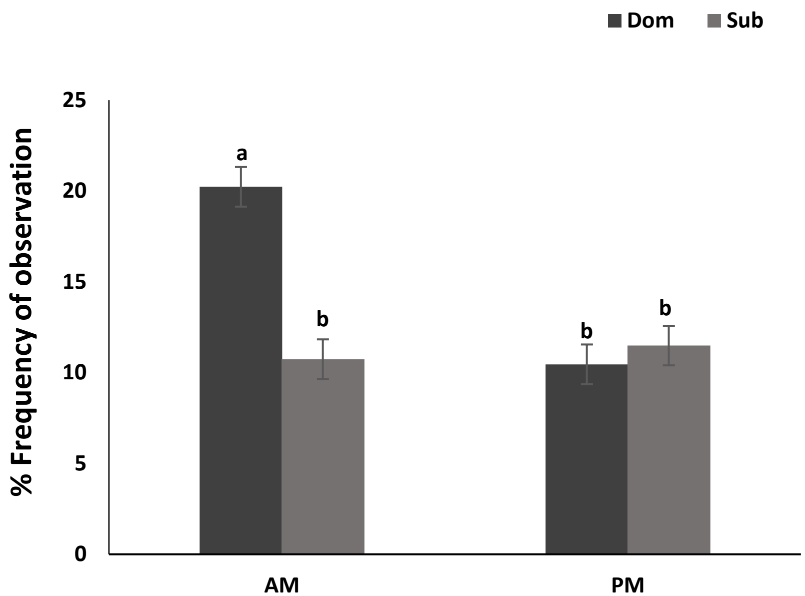
(a). Standing



(b). Lying



(c). Bar biting



(d). Inactive

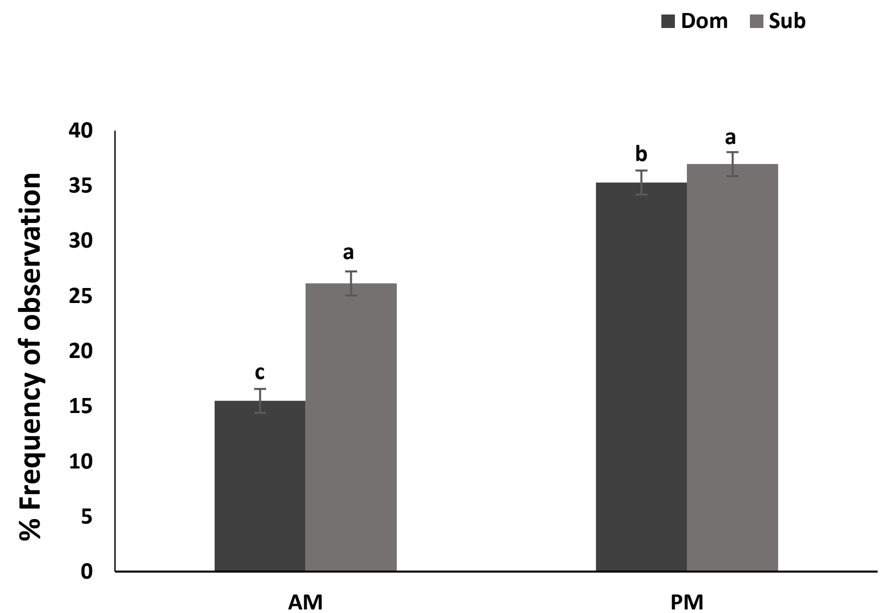


Figure 3.5 Social status by period (AM vs PM) interaction effects on a) standing, b) lying, c) bar biting and d) inactivity. Live observations were collected on focal sows in two 1-hour periods (8-9am, 1-2pm) on days 2 and 11 of enrichment provision[ab] Means with different superscript within same row are significantly different at P <0.05.

3.5.4 Skin Lesion Scores

3.5.4.1. Social Status and Parity Code

There were no effects of social status and parity on sow skin lesions (Table 3.5). A significant social status by parity code interaction was found for head lesions on day 1 (Table 3.5). There was a tendency for a social status by parity code interaction for total lesions on day 12 (Table 3.5).

3.5.4.2. Treatment Effects

There was a tendency (P=0.065) for enrichment effects on the total skin lesions of sows on day 1 (Table 3.6). Enrichment significantly affected the number of shoulder lesions on day 1, with Constant treatment having the highest shoulder lesions and similar effects for Control and Stimulus but Rotate having the lowest. (Table 3.6). There were significant effects on total lesion scores of sows on day 12 (Table 3.6). Sows in the stimulus treatment had the highest lesions on day 12 followed by the control, Rotate and constant having the least value.

Table 3. 5 Effects of social status and parity code on skin lesion scores of sows.

Lesion scores[*]	**Social status**[**]			**Parity code**[***]				***P-value***		
	Dom	**Sub**	**SEM**	**1**	**2**	**3**	**SEM**	SS	P	SS×P
Day 1	0.29	0.33	1.333	0.31	0.28	0.33	1.367	0.603	0.848	0.186
Shoulder day 1	0.18	0.14	1.253	0.18	0.17	0.12	1.309	0.397	0.544	0.189
Side day 1	0.04	0.06	1.468	0.05	0.04	0.07	1.575	0.581	0.469	0.772
Head day 1	0.01	0.02	1.374	0.01	0.02	0.02	1.477	0.339	0.882	0.041
Day 12	0.40	0.39	1.287	0.41	0.47	0.32	1.357	0.977	0.679	0.056
Shoulder day 12	0.09	0.06	1.357	0.09	0.10	0.05	1.449	0.385	0.502	0.508
Side day 12	0.03	0.04	1.588	0.03	0.06	0.03	1.761	0.575	0.422	0.422

Lesion scores were observed on days 1 and 12; first and last day of enrichment provisions using scale of zero to three with 0(no injury and 3(severe injury) on both right and left body regions of sows. Lesions data was grouped into 5 for ease of analysis; thus, side (left and right), shoulder (left and right, back), head (left and right ears, neck, head, front/face), total lesions for day 1 and day 12. [**]Dom=Dominant (high ranking sows), Sub=Subordinate (low ranking sows), SEM; Standard error means**.** [***]Parity code 1: parities 1 and 2; 2: parity 3, and 3: parities 4- 7. SS: social status, P: parity, SS×P: status and parity interaction.

Table 3. 6 Effects of enrichment treatments on skin lesion scores of sows.

	Treatments					
Lesion scores	**Rotate**	**Stimulus**	**Constant**	**Control**	**SEM**	***P*-value**
Day 1	0.26	0.33	0.62	0.17	0.440	0.065
Shoulder day 1	0.07[c]	0.16[b]	0.31[a]	0.17[b]	0.310	0.011
Side day 1	0.04	0.06	0.12	0.02	0.540	0.099
Day 12	0.32[c]	0.77[a]	0.21[d]	0.47[b]	0.330	0.027
Shoulder day 12	0.06	0.11	0.06	0.07	0.400	0.589

[ab] Means with different superscript within same row are significantly different at 5%. Lesion scores were observed on days 1 and 12; first and last day of enrichment provisions using scale of zero to three with 0(no injury and 3(severe injury) on both right and left body regions of sows. Lesions data was grouped into five categories for analysis; thus, side (left and right), shoulder (left and right, back), head (left and right ears, neck, head, front/face), total lesions for day 1 and day 12. **[**]**Dom=Dominant (high ranking sows), Sub=Subordinate (low ranking sows), SEM; Standard error means**.**

3.5.5 Cortisol Level

Social status did not have a significant effect on the cortisol level of sows (Table 3.7). However, samples one (5 weeks) and two (9 weeks), collected in early and mid-gestation) were significantly lower than sample three (late gestation) (Table 3.8). All samples were collected at the same time of day (8am to 9am) to control for diurnal variation in cortisol levels.

Table 3. 7 Saliva cortisol levels (ug/dl) in Dominant and Subordinate sows.

Social status*	**Cortisol (ug/dl) ****	**SEM**	***P-value***
Dom	0.18	0.240	0.930
Sub	0.19	0.230	

*Dom=Dominant (high ranking sows), Sub=Subordinate (low ranking sows), SEM; Standard error means**.** **Cortisol levels were determined from saliva samples were collected from the focal sows between 8 and 9am at three-time points: 5 (early), 9(middle) and 14 (late) weeks of gestation.

Table 3. 8 Effects of phase of gestation on saliva cortisol levels (ug/dl).

Samples*	**Cortisol (ug/dl) ****	**SEM**	**P-value**
1 (early gestation)	0.14^{b}	1.360	0.043
2 (middle gestation)	0.14^{b}		
3 (late gestation)	0.33^{a}		

ab Means with different superscript within a column are significantly different at $P < 0.05$. Saliva samples were collected from the focal sows between 8 and 9am at three-time points: 5 (early), 9(middle) and 14 (late) weeks of gestation.

3.6 Discussion

3.6.1. Body Weight and Parity

Social status can influence the behaviour and activity of sows in a group environment. When resources are limited, there is increased competition over resources between dominant and subordinate sows (Elmore et al. 2011). Subordinate sows are frequently displaced from limited resources and can show reduced body weight due to restricted access to feeders and a higher prevalence of injuries (O'Connell et al. 2003). Dominant social status in sows has been shown to be positively correlated with age, body weight and parity (Martin and Edwards, 1994). Therefore, it was expected in this study that Dom sows would be of higher parity and heavier than Sub sows. As predicted, social status had a significant effect on the initial and final body weight of sows at 5 and 14 weeks of gestation. At both time points, Dom sows were significantly heavier than Sub sows. However, similar weight gains were observed for both Dom and Sub sows between 5 and 14 weeks of gestation. On the contrary, O'Connell et al. (2003) studied the effect of social status on welfare of sows in dynamic groups. The authors measured body weight, injury and salivary cortisol levels for an 11-week period. O'Connell et al. (2003) found that dominant sows gained significantly higher body weights during gestation compared to subordinates. Similar weight gained by Dom and Sub sows in the current study is possibly due to equal access to feed due to the walk-in lock-in stalls system used. In the present study, Dom sows were of higher average parity than Sub sows. There was also a significant influence of parity on body weight; where sows of parity categories 2 and 3 weighed more than sows of parity 1, both at the initial and final weighing.

3.6.2. Social Status and Enrichment Use

This study observed the effects of social status on enrichment use and the behaviour of sows. It was hypothesized that if enrichment is considered a valuable resource, dominant sows will have greater access to enrichment and/or have access at preferred times, compared to subordinates. The results show that, regardless of social status, sows gained access to enrichments. Similar percentages of Dom and Sub sows were observed in the enrichment area, regardless of the enrichment treatment provided. Elmore et al. (2011) found no significant effects of social status on stall-housed gestating sows' motivation to access an enriched group pen. Elmore et al. (2011) study, both Dom and Sub sows showed similar willingness to press a panel to access enrichment objects. However, in another study (Elmore et al. 2010), social status had a significant effect on enrichment use, with Dom sows spending more time interacting with the objects than Sub sows. Although social status did not affect enrichment use, day of treatment had a significant effect, with both Dom and Sub sows showing greater interaction with enrichment materials on day 10, when straw was provided, compared to day 1, 8 and 12 when rope and wood on chains were provided.

Dom sows were observed to be more active, as they spent more time standing compared to Sub sows during live observations in this study. Elmore et al. (2011) observed significant effects of social status on active and inactive behaviours, with Dom sows being more active and standing more compared to Sub sows. The lack of a difference in enrichment use between Dom and Sub sows in the present study could possibly be due to a sufficient quantity of materials provided to avoid aggressive competition over resources. For example, Scott et al. (2007) assessed the ratio of pigs to enrichment objects in a form of hanging single versus 4 multiple objects in fully slatted flooring systems. The study found no significant difference in enrichment-directed behaviour or level of skin lesions for the growing pigs. Scott et al. (2007) authors attributed this result to sufficient access to resources to avoid aggressive competition, despite a situation where 32 pigs were sharing four objects, of which only four to six pigs could easily manipulate at the same time. Therefore, in the current study having 28 sows per four objects was possibly enough to avoid competition. Also, since sows were in free-access stalls, Sub sows could avoid Dom sows by hiding in stalls and therefore limit aggressive interactions or competition over resources. Further research is needed to clarify the optimal ratio of sows to enrichment objects in a group environment.

3.6.3. Sow Activity and Stereotypic Behaviours

Stereotypies have been defined as relatively invariant, repetitive behaviour patterns with no obvious goal or functions (Mason, 1991). Apart from having no obvious goal or function, studies have suggested that stereotypic behaviour must be performed at a level greater than 5% of animals' active time to have negative impact on animal welfare (Broom and Johnson, 1993; Flannigan and Stookey, 2002). Stereotypic behaviours have been observed frequently among animals with insufficient quality or quantity of space (Stolba et al. 1983) or those in barren environments with limited occupational opportunities (Bergeron and Gonyou, 1997). Examples of stereotypies in sows include bar biting, continuous licking of feeders or drinkers and vacuum/sham chewing (Karlen et al. 2007; Van de Perre et al. 2011). Stereotypy development in sows has been suggested by Brouns et al. (1994) to be primarily due to feed restriction and frustration from the absence of sufficient foraging substrate.

In the present study, the effects of social status and enrichments on sow activity and stereotypic behaviour such as sham chewing and bar biting was examined. Behavioural observations showed that, regardless of social status, sows showed some level of stereotypic sham chewing behaviour. Social status, however, had a significant effect on the frequency of object biting in sows, with Dom sows performing more bar biting compared to Sub sows (>10% observation time). All sows were given the same amount of feed, and Dom sows exhibiting more bar biting is possibly due to their larger size resulting in Dom sows receiving greater feed restriction and thus having a higher motivation to feed and performing more bar biting than Sub sows. Stewart et al. (2011) examined the effect of increasing dietary fibre and the provision of chopped barley straw in racks on the welfare of pregnant sows housed in static groups. Sows were provided with 0.32kg of straw per sow per day, of which 0.27kg was consumed. This result showed that the sows provided with a high fibre diet and straw explored more and had greater reduction in sham chewing and bar biting compared to control sows (Stewart et al. 2011). Therefore, in the present study, it is possible that the methods of presenting straw enrichments were not effective (e.g. of insufficient duration) as the enrichment treatments had no significant effects on sham chewing or bar biting. Also, a higher consumption of chopped straw and the high fiber diet might have increased gut fill causing satiety in sows (Stewart et al. 2011). Thus, in the current study, a continuous provision of chopped straw may have been more effective than frequent rotation with other objects for reducing stereotypic behaviours in Dom and Sub sows.

In terms of sow location, the frequency of sham chewing and bar biting was positively correlated with the total number of sows in stalls, indicating that sows performed sham chewing and bar biting behaviours more when in stalls. Live observations were done in both morning post feeding and afternoon, with more sows being present in stalls in the morning period. Studies suggest that confinement and limited occupational opportunity can increase stereotypy development, indicating frustration (Karlen et al. 2007; Bergeron and Gonyou, 1997). Therefore, sows performing stereotypies more in the stalls and in the morning after feeding could be due to confinement and hunger. Other research has shown that ingestion of food specifically triggers stereotypies in sows (Terlouw et al. 1993). This suggests that stereotypy development in gestating sows is partly induced by motivation to feed because of insufficient feedback from digestion to decrease feeding motivation. Sows performing stereotypies more in the morning and in the stalls post-feeding in the present study possibly reflects the heightened feeding motivation of gestating sows, having just fed in stalls in the morning, since stereotypic behaviours were negatively correlated with access to loose housing and enrichments.

3.6.4. Sow Lesion Scores

Lesion scores have been used in previous studies to determine the aggression level of pigs (Barnett et al. 1992; Beattie et al. 1997). Studies suggest that the severity of overt aggression or fighting can be estimated by looking at the number of scratches or injuries on pigs, especially injuries to the anterior region of the body (Barnett et al. 1992; Stukenborg et al. 2012). Lesion scores have been found to be positively correlated with the number of aggressive interactions of sows (Barnett et al. 1992) and can be used as an indication of welfare (Barnett et al. 1996). However, aggression is influenced by several factors such as the familiarity of pigs, space allowance, group size and composition, pen design, time of day, food and bedding (Arey and Edwards, 1998). According to Arey and Edwards (1998), aggression level or its stability in the social environment is affected largely by the degree of competition over resources. For example, an increase in aggression was found when group-housed grower-finisher pigs were given limited access to a highly valued enrichment (straw; Olsen et al. 2002).

We hypothesized that Sub sows would receive more skin lesions due to aggression than Dom sows, especially when more desirable enrichments were given (e.g. straw). However, because no effect of social status or parity on enrichment use or lesion scores was found, we conclude that the competition between Dom and Sub sows was low. This is consistent with previous observations of sows in free-access stalls, as the stalls give all sows equal access to feed and provide a protected environment where they can escape from aggression.

3.6.5. Cortisol Level

Stress results from an animal's reaction to stimuli which the animal perceives as threatening and can interrupt the normal biological functioning or homeostasis of the body (Moberg, 1985**).** Stress can be chronic or acute. Chronic stressors can affect fertility and reduce the reproductive success of pigs (Spoolder et al. 2009). Acute and chronic stressors can alter the physiology, productivity and endocrinology of sows (Karlen et al. 2007). Sows involved in physical interactions have an increased heart rate, which is greater in subordinate sows than in dominant sows (Marchant et al. 1995).

In general, cortisol levels rise shortly after mixing due to social aggression and after which cortisol level is typically reduced (Pedersen et al. 1993). However, if there are insufficient resources such as space, food or environmental enrichment for the group then stress levels remain elevated (Cornale et al. 2015). It was hypothesized that Dom and Sub sows would not differ in cortisol level in the present study and this was confirmed, as indicated by no increase in cortisol level among Dom and Sub sows. Also, there was no increase in cortisol level from the first sample and this could be because the samples were collected one week after mixing when the initial aggression was settled, and hierarchy had been formed. O'Connell et al. (2003) examined the effects of social status on the welfare of sows in dynamic groups. The authors found no difference in salivary cortisol levels among low and high-ranking sows at one week after mixing. Also, elevated cortisol levels were expected to be seen among Sub sows if the housing system used in the current study was stressful. In contrast, there was no difference in cortisol level in Sub sows compared to Dom Sows. Rather, sampling period had a significant effect, with samples one and two (collected at 5 and 9 weeks of gestation) being significantly lower than sample three (14 weeks of gestation). All samples were collected at the same time of day (between 0800 to 0900 h) to control for diurnal variation in cortisol levels. The increase in cortisol level during late gestation is known to occur as animals' approach farrowing (Bronwyn et al. 2015). Average plasma cortisol level increased significantly from 6 to 14 weeks stage of gestation (Hay et al. 2000). It can be concluded that the cortisol results from the present study show there were minimal effects of chronic stress on sows due to social status in this study.

3.7 Conclusions

In conclusions, there were similar levels of enrichment use among Dom and Sub sows. However, Dom sows were more active compared to Sub sows. Enrichment did not have significant effect on stereotypic sham chewing and bar biting behaviours, however, Dom sows showed more bar biting than Sub sows. There was no difference in skin lesions or cortisol levels among Dom and Sub sows. Enrichment treatment also had no effect on skin lesions. Stage of gestation had greater influence on the cortisol level of gestating sows than social status, as cortisol levels rose significantly in late gestation.

The results suggest that there was minimal competition in the group system studied as social status did not significantly affect enrichment use, aggression or stress levels. This could be because the enrichment treatments were not very rewarding, or the housing system may have provided adequate resources to minimize competition (free access stalls).

4.0 CHAPTER

GENERAL DISCUSSION AND CONCLUSION

4.1 Overall Discussion

The current revision of the Canadian Code of Practice for the Care and Handling of Pigs shows that by 2014 new builds or rebuilds are required to group-house gestating sows (NFACC, 2014). There are welfare challenges associated with group housing of sows because of the potential for increased aggression, injury and stress. Also, the Code requires multiple forms of enrichment to be provided to pigs to improve both physical and social well-being (NFACC, 2014). The present study was therefore carried out to examine how the welfare of sows in group-housing can be improved through the provision of environmental enrichment. Previous studies have shown that environmental enrichments benefits sows by reducing aggression, stereotypies, stress, biting behaviours and increasing natural behaviours such as exploration and foraging (Karlen et al. 2007; Chapinal et al. 2010). Studies have also shown that the type and methods of enrichment provision can affect their use in terms of their ability to sustain interest and reduce habituation (Trickett et al. 2009; Van de Perre et al. 2011).

Although there has been abundant research on suitable enrichment materials and methods of presenting them for growing pigs, there is much less scientific information about the materials and methods suitable for sows. Most enrichment studies for sows have been done in European countries where the use of enrichment is mandatory (EU Directive, 2001/88/EC and 2001/93/EC). In North America, producers often use fully slatted floors and are reluctant to implement substrate enrichments such as straw, because of concerns over manure management, cost and the risk to biosecurity. Therefore, this study examined different types of enrichment objects with straw included in the Rotation and Stimulus treatments as positive control. A study by Elmore et al. (2011), showed that social status can influence effective enrichment use in group environments. The present study also examined the effects of social status on enrichment use, stereotypies, lesions and cortisol level of sows.

The present study found that the presence of the enrichment objects did not impact the amount of time that sows spent in the enrichment area. However, there was a tendency for sows to spend more time in contact and close to the enrichments in the Rotate and Stimulus treatments, compared to Constant. This result suggests that methods of enrichment presentation affected enrichment use in gestating sows, with rotation of enrichment having a benefit. Previous studies have found that rotating or changing objects can enhance object exploratory value (Grandin et al. 1983; Grifford et al. 2007; Van de Perre et al. 2011). The present study thus supports conclusions from previous studies that novelty is important to sustain sows interest and increase enrichment interactions in group-housed gestating sows.

The type of material provided affected enrichment use, with straw producing a greater response compared to ropes and wood on chains. Straw was provided on day 10 of Rotate and Stimulus treatments and since a strong treatment by day interaction was found for Rotate and Stimulus on day 10, it is likely that straw caused this increase in activity and enrichment use. Previous studies have found greater activity and enrichment use when straw was provided as bedding or when compared with other objects (Van de Weerd et al. 2005, 2006; Scott et al. 2006; Whittaker et al. 2008; Elmore, et al. 2011). A study by Elmore et al. (2011) concluded that since gestating sows are restricted fed, they are highly motivated to interact with consumable and ingestible enrichments. This is because consumable and ingestible types of fibrous materials induce gut fill and increase satiety in sows (Meunier-Salaün et al. 2001). Studies suggest that for enrichment to sustain interest, enrichment should be deformable, odorous, chewable, ingestible and destructible (Van de Weerd et al. 2003; Courboulay, 2014). The enrichment characteristics described above are common to straw enrichments and this may be the reason why sows responded more to straw than to object enrichments in the Rotate and Stimulus in the present study. Evidence from the present study suggests that although straw produced the greatest response, sows also made use of ropes and wood on chains, indicating that ropes and wood on chains can be used as enrichment materials in fully or partially slatted systems. The study design would have benefitted from inclusion of constant rope and straw treatments, as this would have allowed a more thorough comparison.

In the present study, social status did not affect enrichment use. This is in contrast to a previous study which found a significant influence of social status on enrichment use, with Dom sows showing greater enrichment interaction than Sub sows (Elmore et al. 2011). Stereotypic development in sows has been suggested to be due to feed restriction and frustration from the absence of sufficient foraging substrates (Brouns et al. 1994). In the present study, both Dom and Sub sows showed similar levels of sham chewing behaviour, but Dom sows showed more bar biting than Sub sows. Studies have suggested that stereotypies in sows can be reduced by increasing dietary fibre and providing sufficient foraging substrates (Stewart et al. 2011; Bergeron and Gonyou, 1997). Since stereotypic behaviours were performed more in the morning post feeding than in the afternoon and were negatively correlated with access to loose housing and enrichments in the current study, it can be concluded that the development of the sham chewing and bar biting behaviours of the sows was due more to feeding motivation than the absence of foraging substrates. It is also possible that the methods used in this study were not effective to sustain the interest of the sows since the treatments had no effect on stereotypies.

Previous studies have indicated that a high numbers of skin lesions are correlated to the severity of aggressive interactions in pigs (Barnett et al. 1992; Beattie et al. 1997). Several lesions occur mostly due to factors such as competition over limited resources or the establishment of social hierarchy (Arey and Edwards, 1998; Olsen et al. 2002; Verdon et al. 2015). There was no effect of social status on skin lesions of sows in the present study. This result was possibly due to limited competition over the enrichment materials. Moreover, there was no increase in salivary cortisol level in Sub sows compared to Dom, indicating similar levels of stress in both types of sows in the present study. However, there was an increase in cortisol level at 14 weeks of gestation in the present study. Increase in cortisol level during late gestation has been suggested to occur as animals' approach farrowing (Bronwyn et al. 2015). It is therefore concluded from current study that social status had no effect on the cortisol levels of sows and this is possibly due to less competition in the free-access stalls, but that stage of gestation had greater influence on cortisol level as shown by the increase in cortisol from 6 to 14 weeks of gestation.

4.2. Overall Conclusion

From this study, it was observed that sows made use of all the enrichment materials provided (rope, straw and wood on chains) especially the straw provided on the pen floor. The provision of enrichment objects did not influence the total number of sows in the enriched area compared to the control treatment, although the results indicate that enrichment increased sow activity with a greater percentage of enriched sows standing. No clear effect of habituation was found because the short treatment duration used in this study was not effective to observe sows' response over time. The current findings confirm that novelty is important in enhancing the attractiveness of enrichments and sustaining sows interest. Although, straw produced the greatest response, producers can provide rope and wood on chains for sows, but they should rotate or alternate with different objects to enhance their exploratory value and reduce habituation.

There were similar levels of enrichment use among Dom and Sub sows. However, Dom sows were more active compared to Sub sows. Dom sows also showed more bar biting than Sub sows. There was no difference in skin lesions or cortisol levels among Dom and Sub sows.

Enrichment treatment also had no effect on stereotypic behaviours or skin lesions. Stage of gestation had greater influence on the cortisol level of gestating sows than social status, as cortisol levels rose significantly in late gestation.

The results suggest that there was minimal competition in the group system studied as social status did not significantly affect enrichment use, aggression or stress levels. This could be because the enrichment treatments were not very rewarding, or the housing system may have provided adequate resources to minimize competition (free access stalls).

Future research should examine effects of social status in more competitive housing systems as the effects of social status are more likely when sows actively compete for feed or access to a feeding system. Further research should also examine different methods of presenting object enrichments that would sustain the interest of sows, the best ratio of sows to enrichment objects to limit competition, and the optimal procedure for presenting an associative stimulus before enrichment provision.

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