Influence of providing objects to piglets before and after weaning on behaviour and weight gain

Inverkan av att erbjuda föremål till smågrisar före och efter avvänjning på beteende och tillväxt

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Contents

Summary

Barren rearing environment and early weaning of piglets can lead to a high level of distress, behavioural disturbances and reduction in weight gain. The main aim of this thesis was to study the effects of potential enrichment objects on piglet's behaviour and weight gain during the pre- and post-weaning period. The second aim was to examine what type of object stimulated the highest frequency of interaction.

The study was carried out at the Swedish Livestock Research Centre in Lövsta where a batch of litters from 10 first-parity Yorkshire sows were used. Sow and piglets were housed in individual farrowing pens and were provided with approximately 1 kg of chopped straw each day. Weaning was performed at the mean age of 33 days by removing the sow from the pen. The 10 litters were randomly assigned to two treatments. Five litters were provided with objects (object litters) whereas the remaining five were not provided with objects (control litters). Objects selected for the study were a knotted rope, a vanilla scented rubber ball and a rubber tire. The study was divided into two periods, the pre-weaning period and the post-weaning period. During the pre-weaning period, the object litters received two objects of the same type at three different ages (13-16, 20-23 and 27-30 days). A new type of object was provided during each age so that at the end of the pre-weaning period, piglets had been given access to all three types of objects. Each day, objects were provided at 9.00 and taken out at 15.00. During the post-weaning period, piglets had access to all three types of objects simultaneously. The objects were introduced on the first day after weaning and then they had 6 days of continuous access to them. The behaviours of four focal piglets from each litter were observed with direct observations (n=20 piglets/treatment). Observations were performed from 10.00-15.00 during the same days that piglets had access to the objects. Piglets were weighed within 24 h of birth, at weaning and at 11 days post-weaning and the average daily pre- and post-weaning weight gains (ADG) were calculated. Statistical analysis was done with Generalized Linear Models.

During the pre-weaning period, piglets in the object litters performed less behaviours directed at the pen fixtures ($P<0.05$), the floor ($P<0.01$), the litter mates ($P<0.001$) and the sow ($P<0.01$) and performed more udder manipulation ($P<0.01$) than piglets in the control litters. Piglets performed less litter mate manipulation when having access to the rope than when having access to the ball ($P<0.01$), more social play when having access to the ball than when having access to the tire ($P<0.05$) and less exploration of floor and manipulation of the udder when having access to the rope than when having access to the tire ($P<0.05$ and $P<0.001$, respectively) and the ball ($P<0.001$ and $P<0.001$, respectively). There were no differences in the frequency of interaction with the different types of objects during the pre-weaning period. During the post-weaning period, piglets in the object litters were manipulating litter mates ($P<0.05$) and exploring pen fixtures ($P<0.05$) less than piglets in the control litters. Piglets in litters with objects interacted more with the rope than with the tire ($P<0.05$) and the ball ($P<0.001$), and more with the tire than with the ball ($P<0.05$) post-weaning. The pre-weaning weigh gain was higher in control litters than in object litters ($P<0.05$) but there was no effect of treatment on the post-weaning weight gain (n.s.). The results suggest that providing objects to piglets before and after weaning could be used as an enrichment strategy to reduce manipulation of other pigs, the sow and pen fixtures. Access to the objects affected weight gain negatively before weaning but piglets may have compensated for this after weaning. As the rope stimulated the highest frequency of object interaction after weaning, a rope is probably better suited for piglets than a tire or a ball from the animal welfare point of view.

Sammanfattning

En karg miljö och tidig avvänjning av smågrisar kan leda till höga nivåer av lidande, beteendestörningar och viktminskning. Det huvudsakliga syftet med detta examensarbete var att studera effekterna av potentiella berikningsföremål på smågrisars beteende och tillväxt under tiden före och efter avvänjning. Det andra syftet var att undersöka vilken typ av föremål som stimulerade den högsta frekvensen av interaktion.

Studien genomfördes på det Nationella forskningscentrumet för lantbrukets djur i Lövsta där en omgång bestående av kullar från 10 förstagångsgrisande Yorkshire-suggor användes. Suggor med deras smågrisar inhystes i indviduella grisningsboxar och försågs med cirka 1 kg hackad halm varje dag. Avvänjning utfördes vid en medelålder på 33 dagar genom att ta bort suggan från boxen. De tio kullarna tilldelades slumpvis två behandlingar. Fem kullar försågs med föremål (försökskullar) medan de återstående fem inte tillhandahölls föremål (kontrollkullar). De föremål som valdes ut för studien var ett knutet rep, en vaniljdoftande gummiboll och ett gummidäck. Studien delades upp i två perioder, före avvänjning och efter avvänjning. Före avvänjning fick försökskullarna två föremål av samma typ vid tre olika åldrar (13-16, 20-23 och 27-30 dagar). Smågrisarna erhöll en ny typ av föremål under varje ålder så att vid slutet av den första perioden (före avvänjning) hade smågrisarna haft tillgång till alla tre föremålstyperna. Varje dag hängdes föremål en in i boxen kl. 9.00 och togs ut kl. 15.00. Efter avvänjning erhölls alla tre föremålen till försökskullarna. Förmålen hängdes in i boxen den första dagen efter avvänjning och sedan hade de 6 dagars kontinuerlig tillgång till dem. Beteendena hos fyra fokaldjur från varje kull observerades med direkta observationer (n=20 smågrisar/ behandling). Observationer utfördes mellan kl. 10.00 och 15.00 under samma dagar som smågrisarna hade tillgång till föremålen. Dessutom registrerades smågrisarnas vikt inom 24 timmar efter födseln, vid avvänjning och 11 dagar efter avvänjning och smågrisarnas tillväxt före och efter avvänjning beräknades. Den statistska analysen gjordes med Generalized Linear Models.

Före anvvänjning, utförde smågrisarna i försökskullarna mindre beteenden riktade mot boxinredning ($P<0.05$), golvet ($P<0.01$), kullsyskon ($P<0,001$) och suggan ($P<0,01$) och mer manipulation av juvret ($P<0.01$) än vad smågrisarna i kontrollkullarna gjorde. Smågrisarna i försökskullarna utförde mindre manipulation av kullsyskon när de hade repet jämfört med när de hade bollen ($P<0.01$), mer social lek när de hade bollen än när de hade däcket ($P<0.05$) och mindre utforskning av golv och manipulering av juvret när de hade repet jämfört med när de hade däcket ($P<0.05$ och $P<0.01$, respektive) och bollen ($P<0.001$ och $P<0.01$, respektive). Det fanns inga skillnader i hur mycket smågrisarna interagerade med de olika föremålen före avvänjning. Efter avvänjning utförde smågrisarna i försökskullarna betydligt mindre beteenden riktade mot kullsyskon ($P<0.05$) och boxinredning ($P<0.05$) än smågrisarna i kontrollkullarna. Smågrisar i kullar med föremål interagerade mer med repet än med däcket ($P<0.05$) och bollen ($P<0.001$), och mer med däcket än med bollen ($P<0.05$) efter avvänjning. Före avvänjning var tillväxten högre i kontrollkullarna än i föremålskullarna ($P<0.05$) men det var ingen effekt av behandlingen på tillväxt efter avvänjning (n.s.). Resultaten tyder på att föremål till smågrisar före och efter avvänjning skulle kunna användas som en berikning för att minska manipulering andra grisar, suggan och boxinredning. Tillgång till föremål påverkade tillväxten negativt före avvänjning men smågrisarna kan ha kompenserat för detta efter avvänjning. Eftersom smågrisarna interagerade mer med repet efter avvänjning, är ett rep förmodligen bättre lämpade för smågrisar än ett däck och en boll sett ur ett djurvälfärdsperspektiv.

Introduction

The commercial nursing and weaning conditions in which piglets are reared greatly differ from more natural conditions (Jensen & Recén, 1989; de Jonge *et al*., 1996; Cox & Cooper, 2001; Johnson *et al*., 2001). Indoor housing systems generally lack the number and diversity of stimuli that can be offered in environments that are more natural. This may hinder animals from performing highly motivated behaviours (Lawrence & Terlouw, 1993) and can lead to boredom (Wiepkema & Koolhaas, 1993). The barren environment, in which piglets are often reared, has been associated with several behavioural disturbances such as belly nosing, tail biting and other manipulative behaviours directed toward litter mates, sow and pen fixtures (Petersen *et al*., 1995; Beattie *et al.*, 2000; Bench & Gonyou, 2006). It has been suggested that many of these behaviours are derived from the inability to perform exploratory and foraging behaviours (Lawrence & Terlouw, 1993). Barren environments have also been observed to be accompanied with higher levels of sitting, standing or lying inactive compared to an environment enriched with larger space and a rack containing peat and straw (Beattie *et al.*, 2000). It has been suggested that this inactivity is a strategy that pigs employ in order to deal with stressful situations (Pearce *et al*., 1989), inadequate stimulation or boredom (Piggins & Phillips, 1998).

In addition to barren and monotonous environments, pigs in the intensive commercial housing systems are often exposed to stressful management routines. For piglets, weaning is a major stressor as it usually involves several challenges such as early and abrupt loss of the sow and their main feeding source (i.e. milk), plus a shift in the social and the physical environment. Weaning causes a high level of distress in piglets as indicated by depressed immune system, elevated plasma cortisol concentrations, increased aggression, distress calling, manipulation of pen mates (including belly nosing and tail biting), set-backs in growth, low food intake and depression in play (Fraser, 1978; Worsaae & Schmidt, 1980; Dybkjaer, 1992; Fraser *et al*., 1994; Weary & Fraser, 1997; Worobec *et al*., 1999; Donaldson *et al*., 2002).

The science of animal welfare no longer focuses only on the absence of negative experiences but also on how to promote positive ones (reviewed by Yeates & Main, 2008). Play is considered as a sensitive indicator of positive welfare in captive animals (Newberry *et al*, 1988; Boissy *et al*., 2007; Held & Spinka, 2011). The argument for this is that it has been shown that juveniles are highly motivated to play when their primary needs have been met (Jensen & Kyhn, 2000), whereas individuals who suffer from environmental and physical stress are not motivated to play (Müller-Schwartze *et al*., 1982; Siviy & Panksepp, 1985). In addition, play is often reflective of "having fun" (Spinká *et al*., 2001) and there is evidence that the performance of play is rewarding (Calcagnetti & Schechter, 1992). Thus, performance of play may not only indicate absence of bad welfare but also indicate the presence of good welfare and positive feelings (Boissly *et al*., 2007). An important aspect of the welfare of captive animals is that individuals, which have their primary needs met and are motivated to play, may not be able to do so due to lack of sufficient space, lack of play partners or lack of appropriate objects to play with (Jensen *et al*., 1998).

Background

Environmental enrichment

Definition

The term "environmental enrichment" is used very inconsistently by different authors in the scientific literature and therefore has no clear definition (Newberry, 1995; Toth *et al*., 2011). It is, however, generally accepted that the major goal of providing enrichment is to increase the welfare of captive animals (Young, 2003). Even so, "enrichment" is often used in a careless manner to refer to objects or materials provided rather than to the desired outcome. Further, there is no established method for assessing that enrichment has occurred (Newberry, 1995; Toth *et al*., 2011). According to Newberry (1995) evidence of enrichment must include improvements in biological functioning such as increased lifetime reproductive success, increased fitness or improved health. In addition, Van de Weerd & Day (2009) suggested that environmental enrichment also should improve the economy from the production and be practical to employ. According to other authors the benefits of providing environmental enrichment for pigs reach beyond biological functioning. Environmental enrichment can improve animal welfare in commercial farming conditions by providing more opportunities to perform behaviours that the animals like such as exploration, forage and play (Bracke *et al*., 2006; Van de Weerd *et al*., 2006; Chaloupková *et al*., 2007; Studnitz *et al*., 2007; Van de Weerd & Day, 2009). Environmental enrichment can thus function as a way to fulfill psychological and emotional needs (Poole, 1992) and thereby promoting more positive emotional states (Douglas *et al*., 2012). Further, environmental enrichment can improve the welfare of animals by increasing the ability to cope with stressors and/or to decrease the number of behavioural disturbances (Young, 2003).

Early experience of environmental enrichment

Behaviour

Providing piglets with adequate environmental enrichment already during the first few weeks of life may be crucial for the development of certain behavioural patterns. This since the socialization period of piglets occur during this time (Schouten, 1986). During the socialization period, piglets will learn appropriate ways of interacting with their physical and social environment (Schouten, 1986). Research indicates that rearing piglets in an enriched pre-weaning environment may reduce their reactivity toward novel environments and stimulus (Beattie *et al.*, 2000; Lewis *et al.*, 2006), possibly leading to enhanced ability to cope with weaning and other stressors (Hillmann *et al*., 2003). Further, a more complex pre-weaning environment may influence the development of social skills as it has been shown that piglets in enriched environments play more (Chaloupková *et al*., 2007) and engage less in agonistic interactions later in life (Chaloupková *et al*., 2007; Munsterhjelm *et al*., 2009). Dudink *et al*. (2006) found that environmental enrichment decreased aggression both before and after weaning and decreased the amount of injuries after weaning. They also found that effects were more pronounced if the arrival of enrichment was announced. In addition, environmental enrichment seems to affect the development of exploratory behaviours. It has been shown that piglets in enriched environments spend less time directing exploratory behaviours toward pen fixtures, litter mates and sow compared to piglets reared in barren environments (Petersen *et al*., 1995; Beattie *et al.*, 2000; Bench & Gonyou, 2006; Lewis *et al*., 2006).

Similarly, environmental enrichment after weaning has the potential to make the weaning process easier for piglets by providing distraction and serve as an outlet for manipulative

and exploratory behaviours (Oostindjer *et al*., 2011). It has also been suggested that providing enrichment at later age can reverse or compensate for the effects of early life trauma (Francis *et al*., 2002). However, maladaptive behaviours such as tail biting and stereotypies have been shown to increase as a response to loss of enrichment (Munsterhjelm *et al*., 2009; Latham & Mason, 2010; Vanheukelom *et al*., 2011) and may cause frustration (Latham & Mason, 2010). This implies that once enrichments have been introduced, it should continued to be provided throughout the pig's life in order to avoid detrimental effects to their welfare.

It is believed that the effects of early experiences on later behaviours are mediated through play (Olsson *et al*., 1999; Spinká *et al*., 2001). By playing, piglets may learn how to cope emotionally in stressful situations due to enhanced improvisation skills (Spinká *et al*., 2001). Also, it has been suggested that play is important for the development of social skills (Van den Berg *et al*., 1999; Chaloupková *et al*., 2007) and intraspecific communicative signals, which might serve to inhibit aggression and to increase group stability (Van der Schuren *et al*., 1997).

Weight gain

In addition to the behavioural and emotional benefits, experience of environmental enrichment during nursing has been found to improve both pre-weaning weight gain (Oostindjer *et al*., 2011) and post-weaning weight gain (O´Connell *et al*., 2004; Vanheukelom *et al*., 2011). It has been suggested that the effect of enrichment on post-weaning weight gain reflects an improved ability to cope with the weaning process (O´Connell *et al*., 2004). Also the immediate weaning environment has been found to be important for post-weaning weight gain. Rodarte *et al*. (2005) reported that early weaned piglets with access to a hanging rope and rubber tyre tube had a higher weight gain than their counterparts in a barren environment. In an earlier study, Schaefer *et al*. (1990) also found improved weight gains in newly weaned piglets provided with enrichment objects (either a suspended car tire, a sugar-mineral block or a hanging rubber belts). The effects of providing enrichment to pigs from an early age on weight gain are however not consistent. Other studies have reported that the provision of enrichment to piglets during nursing or weaning had no effect on pre- or post-weaning weight gain (Appleby & Wood-Gush, 1988; Beattie *et al*., 2000). Differences in management, breed, type of enrichment provided, housing systems and potential differences in the level of aggression, harmful social behaviours and/or stress may explain the different outcomes from these studies.

Enrichment objects

Most of the studies described above on the effect of early experience of enrichment have modified the early life environment of pigs by adding straw (Beattie *et al.*, 2000; Chaloupková *et al*., 2007; Munsterhjelm *et al*., 2009). In many countries within EU however, piglets are housed in intensive housing systems with slatted floors. In such systems, straw cannot be provided because of the risk of blockage of the manure system by the material. Due to concerns regarding the welfare of pigs in such environments, there is a growing interest for alternative enrichment strategies. A significant amount of research has examined the benefits of enriching the environment of pigs with different kinds of objects (Elkmann & Hoy, 2009; Averós *et al.*, 2010; Van de Perre *et al*., 2011) . However, few of these have evaluated the potential benefits of providing enrichment objects to the nursing and weaning environment.

Effective enrichment objects for pigs

Habituation

The intensity and type of behaviour that pigs direct toward different enrichment objects may reflect key motivational needs, thereby indicating whether these are effective as enrichment for pigs or not (Van de Weerd *et al.*, 2003; Van de Weerd & Day, 2009). However, if the material cannot sustain the pigs' interest for a long period of time, it loses its value as enrichment. Thus, the pigs will again be exposed to barren environments together with its associated threats towards their welfare (Van de Weerd & Day, 2009). Therefore, to evaluate if a material is effective as enrichment, not only the initial level of interest that pigs direct toward the material should be measured but also the rate of habituation (Van de Weerd & Day, 2009). It has been shown that habituation to certain objects can occur very rapidly in pigs (Wood-Gush & Vestergaard, 1991; Gifford *et al.*, 2007; Trickett *et al.*, 2009; Van de Perre *et al*., 2011). Van de Perre *et al.* (2011) investigated the effect of a continuous repeated sequence of seven different objects during the whole fattening period in slaughter pigs. They found that providing a sequence of objects for the first time induced object interaction. However, it was reduced after applying the sequence for the second and the third time. Trickett *et al.* (2009) noted that alternation of objects increased the novelty value, even though habituation still occurred. They also found that newly weaned piglets interacted with ropes at levels comparable to those previously reported for straw. Gifford *et al.* (2007) found that pigs remembered an object that they had been exposed to during two days for at least five days. It can therefore be suggested that an object should not be used again within five days in order to maintain the novelty value.

Type of object

Elkmann & Hoy (2009) compared the relative interest of pigs in three different types of simultaneously offered objects (pendular beam, cross of chains or lifting beam). They found that pigs preferred the cross of chains over the other objects and showed least interest in the pendular beam. They also found that pigs housed in pens with access to straw used the cross of chains and the lifting beam significantly less than pigs housed in pens without straw. Apple & Craig (1992) tested the preference for four different types of objects (knotted rope, rubber hose, hard metal chain and hourglass-shaped rubber dog toy) by 4 weeks old female piglets, housed in two treatments with different pen sizes. They found that piglets preferred the rubber dog toy over the other objects and that pen size did not influence object use. In a literature review, Bracke *et al*. (2006) evaluated the welfare benefits of different enrichment materials for weaner and grower pigs. They concluded, although with caution, that metal objects such as chain are not suitable enrichment materials for pigs; that rubber, rope, roughage and substrates may be sufficient; and that straw and combinations of objects and/or substrates are the best option.

Characteristics

The stronger preference for some forms of enrichment objects over others might be explained by the characteristics of the objects. Van de Weerd *et al*. (2003) developed a systematic methodology for identifying characteristics of enrichment materials that capture and maintain the interest in weaner and grower pigs. They found that the main characteristics of successful enrichments were "ingestible", "odorous", "chewable", "deformable" and "destructible". Rootable substrates such as straw comes close to fit all these criterias, that are probably linked to motivational needs such as exploration and foraging (Van de Weerd & Day, 2009). Also a number of studies confirm that "chewable",

"odorous", "deformable" and "destructible" enrichment objects are valued by pigs (Feddes & Fraiser, 1994; Hill *et al.*, 1998; Nowicki *et al.*, 2007a; Averós *et al.*, 2010). It has also been suggested that the preference for certain objects might be related to texture and to the ability to grab the object (Apple & Craig, 1992). Bracke (2007) found that growing pigs preferred good hygiene and high destructibility more than tinkling sounds of enrichment objects.

Presentation method

Blackshaw *et al.* (1997) investigated whether a fixed or a free object in the pen offered adequate stimulation to weaned piglets. They found that piglets were more interested in the fixed object at first introduction. Also, this higher interest in the fixed object was generally maintained throughout the study. The explanation for this can be that free objects on the floor can get soiled by excreta, which makes objects unattractive to pigs (Bracke, 2007). In addition, free objects on the floor can be caught under the trough or pushed into neighboring pens making them unavailable to the pigs (Blackshaw *et al*., 1997). Also other studies confirm that fixed objects are preferred over free objects on the floor (Scott *et al*., 2009; Averós *et al.*, 2010). Since pigs show behavioural synchronization, also a sufficient number of objects should be provided in order to avoid competition (Docking *et al.*, 2008). Scott *et al*. (2007) did not find any significant difference in the level of object interaction when one object was provided compared to four similar objects. On the contrary, in a meta-analysis using information from 45 experiments, Averós *et al.* (2010) found that the percentage of time spent exploring was affected by the number of objects provided. The effects seemed to be more pronounced when pigs had simultaneous access to different kinds of objects, suggesting that the variety of objects is more important than the number.

Effect of age on the use of enrichment objects

Docking *et al.* (2008) examined how pig's age influenced the use of ten different enrichment objects. The objects were each presented to three replicate litters of three weeks of age (nursing piglets) as well as three replicate groups of three animals of 5 weeks of age (weaned piglets) and 13 weeks of age (growing pigs). The study showed that nursing piglets used the enrichment materials to a much lesser extent than both weaned piglets and growing pigs. It was also shown that growing pigs interacted with objects to a lesser degree than weaned piglets (Docking *et al*., 2008). This is in agreement with the study by Hill *et al*. (1998) who found that interactions with a hose and a chain increased to approximately 15 minutes per day in the growing-finishing period from 12 minutes per day in the pre-weaning period. They also found that finishing pigs interacted more with the hose than the chain whereas nursing piglets interacted at the same level with both objects. Docking *et al*. (2008) also showed that habituation occurred much faster in growing pigs than in weaned piglets or nursing piglets, with object interactions decreasing significantly over five days.

Behaviour before and after weaning

The level of interactions with the objects might not be the only way to determine whether the material or object provided has a high enrichment value. Even though behaviours directed toward the material or object is low, it might stimulate other wanted behaviours such as play or feeding or decrease unwanted behaviours such as litter mate manipulation and aggression. According to Chan & Newberry (2011), in addition to maintaining pig's interest, enrichment should also promote positive behaviours such as play. It has been shown that play behaviour in pigs peak between 2 and 6 weeks of age (Newberry *et al*., 1988) and that exploratory behaviour directed toward inanimate objects and soil increases

with age under semi-natural conditions (Newberry *et al*., 1988). Wood-Gush & Vestergaard (1991) found that interactions with a novel object decreased fast and significantly over 5 minutes in piglets aged 5-6 weeks. However, at the same time play behaviours (scampering and sparring) increased significantly. This indicates that play may be a part of the exploratory behaviour in young pigs (Wood-Gush & Vestergaard, 1991). Successful enrichment objects for young piglets might therefore not only be reflected in the level of interaction with the object but also in how well it stimulates play behaviours.

To the author's knowledge, there is only one study evaluating the behavioural effects of providing enrichment objects to nursing piglets. That study (Lewis *et al.*, 2006) evaluated the effects of providing shredded paper in a rack or a suspended natural fibre rope to piglets in farrowing crates with slatted floors. These two treatments were also compared to a barren control group. They did not find any effects on the play behaviour of piglets but results showed that piglets with access to shredded paper spent less time inactive. In addition, piglets with access to shredded papers spent less time exploring pen fittings and more time interacting with the enrichment compared to piglets in the other two treatments. The study did not measure the piglet's ability to deal with the weaning process. However, they found that compared to the enriched piglets, barren housed piglets were the ones to exhibit freezing behaviour in an open field test, indicating higher levels of fear in novel situations. Also, nursing piglets maintained the interest in the paper until weaning (Lewis *et al.*, 2006).

More studies, although still few, have been performed evaluating the potential use of enrichment object as a way to reduce the weaning-induced stress response in piglets. Trickett *et al*. (2009) found that a suspended rope, compared to a loose wood block, reduced manipulation of pen mates and pen fixtures in weaned piglets. Studies also show that certain objects (sow neck tether covered with hard plastic piping, car tire suspended on a chain, sugar-mineral block in a suspended metal basket, dangling rubber belt) can reduce agonistic interactions among weaned piglets (Schaefer *et al*., 1990; Blackshaw *et al*., 1997). Chan & Newberry (2011) compared the effects of an object that produced barks at unpredictable rates when manipulated by weaned pigs (barking object) with a similar object that did not produce any sound (non-barking object). They did not find any differences in object interaction between the two treatments. However, there was a tendency for more play among pigs that received the barking object. Therefore Chan & Newberry (2011) argued that providing enrichment objects that incorporate some degree of unpredictability, while giving animals control over their degree of exposure to unpredictability may be optimal in order to maximize animal welfare.

Straw in combination with enrichment objects

Compared to straw, different kinds of enrichment objects have been shown to be less effective as enrichment for grower and finisher pigs (de Jong *et al*., 1998; Scott *et al.*, 2006; Van de Weerd *et al.*, 2006; Scott *et al.*, 2007). When straw is combined with enrichment objects, the level of straw directed behaviour does not seem to be influenced (Scott *et al.*, 2006; Scott *et al.*, 2007). These results indicate that when given the choice, pigs prefer straw over enrichment objects. However, providing additional enrichment objects to straw in straw-bedded pens may still have positive influence on pigs' behaviour as shown by Nowicki *et al.* (2007a; 2007b; 2008). Nowicki *et al.* (2007a) found that straw-bedded pens enriched with additional enrichment object in a form of an aromatized or wooden ball reduced fighting and increased time spent eating in newly mixed and weaned piglets. However, for piglets, the aromatized ball was more interesting than the wooden ball. In a subsequent study, Nowicki *et al*. (2007b) compared the behavioural effects of

providing newly mixed and weaned piglets with a chewable, a deformable and a destructible biting object (constructed of ropes and plastic tubes) or a non-destructible wooden ball in straw-bedded pens. Both objects where fixed to the ceiling. They found that both objects reduced aggression and that piglets were more interested in the biting object. Similar findings were also shown when newly mixed and weaned piglets were provided with either a hanging ball or a free ball in a pen (Nowicki *et al*., 2008). Both objects reduced the duration and the frequency of fighting during the first 72 hours after weaning. Piglets were initially more interested in the free ball but changed preference on the second day to the hanging ball.

Aims and questions

The main aim of this thesis was to study the effects of potential enrichment objects (rope, tire and ball) on piglet's behaviour and average daily gain during the pre- and the post-weaning period. The second aim was to examine what type of objects (rope, tire or ball) stimulated the highest frequency of interaction. The study seeked to answer the following questions:

1. Do piglets with access to objects express more locomotor- and social play before and after weaning than piglets without the access to objects?
2. Do piglets without access to objects show more behaviours directed towards pen fixtures, the sow and the other piglets before and after weaning compared to piglets with the access to objects?
3. Do piglets without access to objects have a lower average daily gain before and after weaning than piglets with the access to objects?
4. What type of object, a rope, a ball or a tire, do piglets interact with most frequently before and after weaning?
5. Does a rope influence the behaviour more than a ball or a tire before weaning?

Predictions

During both the pre- and the post-weaning period, it was predicted that access to objects would stimulate the piglets to play (locomotor- and social play) more compared to the piglets without the access to objects. It was also predicted that the piglets without the access to objects would perform more manipulatory behaviour directed towards pen fixtures, the sow and the other piglets during both periods. It was predicted that piglets with access to objects would have a higher average daily gain both before and after weaning. Further, it was predicted that the rope would stimulate the highest frequency of object interaction, followed by the tire and the ball respectively. Before weaning, it was predicted that rope, being more popular to interact with, also would stimulate more locomotor- and social play compared to the other objects. Finally, it was predicted that the rope would also be more effective in reducing the frequency of manipulative behaviours directed toward pen fixtures, the other piglets and the sow compared to the other objects.

Material and methods

Animals and housing

The study was performed for four weeks in March-April 2012 at the new pig stable at Swedish Livestock Reasearch Center in Lövsta. It was the first study carried out at the new facility. The construction was not yet fully completed, therefore there were still some construction work carried out in the building. Lövsta has 7 rooms for farrowing sows with 12 farrowing pens, six per side in each room. There are three corridors along the pens were personnel can walk, one corridor behind each side and one corridor in the middle (fig. 1).

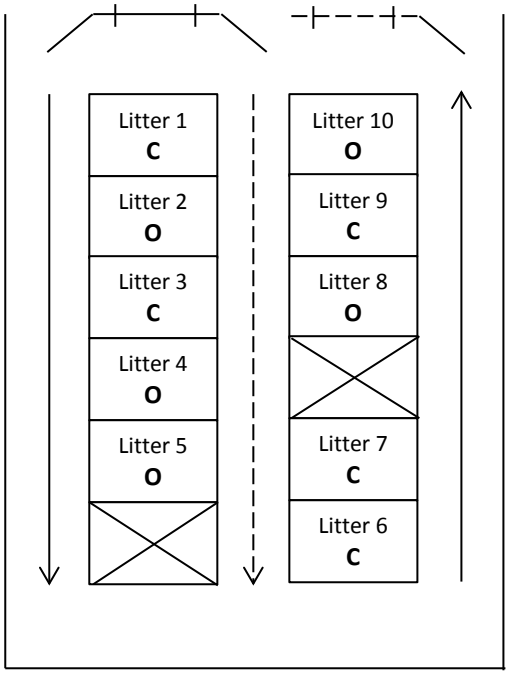

Figure 1. Schematic picture over the farrowing room and the placements of pens with litters of different treatments: object (O) and control (C). ⊢⊣ : window and entrance of strawing maching, ⊢--⊣: window and exit of strawing machine, ⟶ : pre-weaning observation order, --⟶ : post-weaning observation order

For this Master thesis, a batch of specific pathogen free (SPF) pigs consisting of litters from ten first parity pure-bred Yorkshire sows were used. Half of the sows were inseminated with Yorkshire boars wereas the other half were inseminated with Landrace boars. This meant that half of the litters were pure-bred Yorkshire (Y) and half were a hybrid between Yorkshire and Landrace (LxY, table 1). The sows were moved to the farrowing room two weeks before parturition. Prior to parturition, the sows had been in a straw-bedded loose house system.

The sows and piglets were housed in individual farrowing pens with a total area of 6.5 m^2 (3.25 x 2 m). The pens consisted of a lying area (2.8 m^2), a dunging area (2.4 m^2) and a covered creep area (1.3 m^2) with a heat lamp for the piglets (fig. 2). The creep area was separated from the lying area of the pen by a dividing wall with openings that piglets could pass through. During the last week before weaning, heat lamps were turned off in three pens (two object pens and one control pen) because piglet were noted to be lying more in the lying area of the pen than in the creep area. This is a routine procedure done by the barn staff because when piglets grow bigger it gets too hot for them to lie under the heat lamp. Instead, they lie on the open floor where the sow can trample on or lie down on them. Under the floors in the pens there was a heating coil that was on during the whole observation period. Four sows were given piglets from a previous batch since those piglets had lost their mothers shortly after parturition (table 1).

During the study, the sows and the piglets were provided with 1 kg of chopped straw from an automatic strawing machine (JH ministrø, Jørgen Hyldgård Staldservice A/S, Denmark) every day. The strawing machine moved above the pens, from one pen to the next, and had a scale so that the right amount of straw would be delivered. If the strawing machine did not contain enough straw to be delivered to all pens at one occasion, it went to get automatically refilled. Then the strawing machine moved into the room a second time to deliver straw to the remaining pens. If the machine had to be refilled it took about 30 minutes to deliver straw to all pens, otherwise it took about 10 minutes. The straw was provided once in the morning, at the latest 1.5 h before the start of behavioural observations. Sows were fed with commercial complete feed in a feeding trough whereas

piglets were fed with commercial piglet feed in a single feeder from the start of one week before weaning. The lid over the creep area was opened one week before weaning as the single feeder was placed in the creep area at this time. The creep area was from that time on only partially covered. Sow feed was automatically delivered to the stable at 9.00, 12.00 and 15.00 h. Piglet feed was available *ad libitum* and refilled every day at 10.00 h. Both piget feed and sow feed was delivered through pipes to one pen at a time. Water was available *ad libitum* from drinking nipples located in the dunging area for both the sows and the piglets. Cleaning the pens was performed in the morning between 8.00 and 9.00 h. The temperature and ventilation in the stable was thermostatically controlled and temperature was set at 20˚ C. However, the automatic recording of temperature was out of function and therefore temperature was only manually recorded during the last week of observation. The temperature then fluctuated between 18-24˚ C. The lights in the farrowing room were manually turned on at 8.00 h and were automatically turned off at 19.00 h. Between these hours, a night light was on.

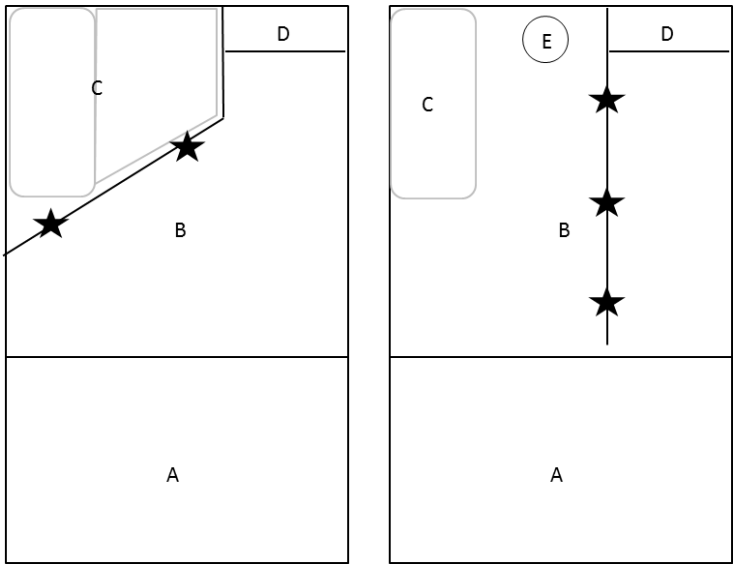

Figure 2. Schematic picture over farrowing pens pre- (left picture) and post-weaning (right picture). A: dunging area, B: lying area, C: covered creep area, D: sow feed through, E: single feeder. ★: marks the places where objects were suspended at the dividing wall.

Study design

The ten litters were randomly assigned to the two treatments (table 1). Treatments were as far as possible balanced among litters with respect to breed (Yorkshire or Yorkshire-Landrace, table 1). Five litters were provided with objects (Object) whereas the remaining five litters were not provided with any objects (Control). The objects were first introduced to the object litters at the mean age of 13 days (table 1). An important note is that the study was initially designed for the use of twelve litters. However, adjustments had to be made since the batch did not have enough animals. Due to this, the pre-weaning design with providing new type of objects each week was unfortunately unbalanced (see table 2).

Before the age of 4 days, piglets were individually marked with an ear tattoo, got their teeth rasped and male piglets were castrated during analgesia. During two days before the start of the study, efforts were made to habituate piglets to the presence of the observer. During the last week before weaning, one focal piglet was found to be lame in its hind legs and was from then on excluded from the study. Weaning was performed at the mean age of 33 days (table 1) by removing the sow from the farrowing pen and placing her in a dry sow stable. Eleven days after weaning, focal piglets were moved to a grower stable where they were used in a subsequent study. The remaining piglets stayed in the farrowing pen until they reached approximately 30 kg (around 12 weeks of age) and were then moved to a slaughter pig unit.

Table 1. Presentation of the treatment, breed of the piglets (Yorkshire: Y, Yorkshire-Landrace: YxL), the number of survived piglets at 4 days of age, the number of adopted piglets from the previous batch, the age of own piglets at the day of first object introduction and the age at weaning for the ten sows used in the study. Adopted piglets were 8-14 days older than the sow's own piglets

Sow	Treatment	Breed	Own piglets	Adopted piglets	Age at object introduction (days)	Weaning age (days)
1	Control	Y	9	0	11	31
2	Object	Y	11	0	13	33
3	Control	Y	8	2	13	33
4	Object	Y	11	0	12	32
5	Object	Y	10	0	10	30
6	Control	YxL	11	0	11	31
7	Control	YxL	7	0	13	33
8	Object	YxL	6	4	15	35
9	Control	YxL	6	4	16	36
10	Object	YxL	8	2	15	35

Objects

Different types of enrichment object were tested in a pilot study in order to select the three most effective and safe objects from the animals point of view. Objects tested in the pilot study included two types of rubber balls, three types of ropes, a chain and two types of rubber dog toys (a tire and a rubber ring). The objects selected for the study were (fig. 3):

- Rubber tire: 20 cm in diameter and 5 cm wide. The tire was cut opened so that piglets or the sow could not get stuck.
- Rubber ball: 10.5 cm in diameter perforated with a hole, vanilla scented.
- Knotted rope: 95 cm with 5 knots and threads hanging out from both ends.

Figure 3. The provision of the three objects and their positions in a pen during the post-weaning period. The placement of the objects on the wall (left, middle or right) was randomized for each pen.

Procedures

Pre-weaning procedures

During the three ages pre-weaning (13-16, 20-23 and 27-30 days), presented as the mean age for all litters, the objects litters received two objects of the same type. The reason for providing two objects was to minimize the risk of competition over objects. The type of object was alternated between the age periods so that all litters at the end of the pre-weaning period would have had access to all three types of objects (table 2). The reason for testing one object at a time was to investigate whether a specific object influenced piglet behaviour more than the others. The order in which objects were provided was randomly selected (table 2). Before and after being used, the objects were thoroughly cleaned with water and disinfectant. By that we minimized the risk of objects having differences in odour between age periods since the objects were used throughout the study. Each day, the objects were provided at 9.00 and taken out at 15.00. The reason for not leaving objects in the pens continuously was that these types of object had not previously been tested with regard to sow safety. However, since a considerable amount of research has been performed providing such objects for weaner-, grower- and finisher pigs, the objects stayed in the pen continuously during the week after weaning (Van de Weerd *et al*., 2003; Docking *et al*., 2008; Trickett *et al*., 2009). The objects were attached with a chain to a dividing wall in front of the creep area (fig. 2), approximately 15 cm above the floor.

Post-weaning procedures

In five litters, i.e. object litters, the enrichment objects were provided the first day after weaning. The animals had continuous and simultaneous access to three objects, one object of each type, for a duration of 6 days (table 2). If the piglets post-weaning would have receive one type of object at a time, as before weaning, piglets would only have access to a type of object for two days before being replaced by a new type of object. As behaviour could change for each day after weaning it would then have been difficult to evaluate the effect of the objects. Therefore it was decided to provide all three types of objects simultaneously after weaning. Objects were attached to the dividing wall, approximately 15 cm above the floor. The dividing wall was opened into the pen in connection with weaning (fig. 2). The placement (left, right or middle) of the objects on the wall was randomised in each pen.

Table 2. Order of providing the objects (rope, tire and ball) in the different ages, presented as the mean age for object piglets

	Age (days)			
	Pre-weaning			Post-weaning
Sow	13-16	20-23	27-30	34-39
2	Tire	Ball	Rope	All three objects
4	Tire	Ball	Rope	All three objects
5	Ball	Rope	Tire	All three objects
8	Rope	Tire	Ball	All three objects
10	Rope	Tire	Ball	All three objects

Observations

The behaviours of four focal piglets per litter were recorded using direct observations. The first criterion when chosing the piglets to observe was to select two males and two females from each litter. The second criterion was to select focals from the sow's own piglet while the third one was to select piglets close to the median birth weight. Where it was possible, focal animals were randomly selected among the piglets that met the criteria. Since there was only one female from the sow's own piglets in one of the control litters (sow number 9, table 1), an adopted female piglet was selected as the second female focal piglet. The adopted focal piglet was 8 days older than the sow's own piglets in that litter. The focal piglets were individually marked with commercial marking spray of different colours. Markings were performed in the morning at the first day of observation and were then re-applied when needed.

Observations were performed during 12 days at three age periods (13-16, 20-23 and 27-30 days) before weaning and the 6 days after weaning. Observations were performed at 10.00-12.00 and 13.00-15.00 by one observer. This meant that the behavioural recordings was performed an hour after the provision of objects. The reason for this was to ensure that the normal behaviour of piglets and the sow was restored. Before weaning, the observer was standing/walking in the corridors behind the pens (fig 1). After weaning, the observer was standing/walking in the corridor in front of the pens (fig 1). This was a practical solution because before weaning, when the creep area was fully covered, the best view over the pens was achieved by standing/walking behind the pens. After weaning, when the creep area was only partially covered, the best view was obtained by standing/walking in front of the pens. All four focal piglets in one litter were observed for one minute per focal piglet before continouing the observations in the next pen. Thereby, every litter was observed for 2x4 minutes in the forenoon and also in the afternoon resulting in a total of 16 minutes of observation per litter per day. Between each pen, the observer waited for 1 minute before the start of observation in order to habituate piglets to the presence of the observer. The order of observations between litters was performed according to a pre-determined schedule so that the observer could walk from one pen to the next (fig. 1). This was done to reduce the disturbance to the animals in that room. Some behaviours were recorded instantaneously at 15 s intervals during one minute (table 3 and 4) whereas other behaviours were recorded continuously within the same minute (table 4 and 5). This resulted in16 instantaneous recordings per pig and day and 4 minutes of continuous recordings per pig and day. During the pilot study, the ethogram was tested in order to decide the method of recording each behaviour. Behaviours that appeared regularly and lasted at least several seconds were recorded instantaneously. These were lying, sitting, standing, being in creep, udder manipulation and exploring floor. Behaviours with shorter duration or that appeared more seldom were recorded continuously. These included feeding, exploring fixtures, manipulation of other piglets and the sow, object interaction, comfort behaviour and the behavioural elements of social- and locomotory play. Feeding was not recorded before weaning because the feeder was obscured by the dividing wall in front of the creep area, where the feeder was situated.

Table 3. Ethogram of body postures of piglets recorded instantaneously during the pre- and post-weaning period

Posture	Description
Lying	Belly or side of body in contact with the floor and feet not in direct contact with the floor with eyes opened or closed
Sitting	Hind part or carpal joints in contact with the floor and only two feet in direct contact with the floor without performing any other described behaviour
Standing	Standing still with all four feet on the floor without performing any other described behaviour
Being in creep	Inside creep area and out of sight for the observer

Table 4. Ethogram of behaviours recorded continuously or instantaneously* during the pre-[1] and/or post-weaning[2] period

Behaviour	Description
Udder manipulation [1] *	Lying perpendicular towards the udder while having the snout in contact with udder or less than 5 cm from udder
Feeding [2]	Head down in feeder or standing close to and with head directed towards the feeder while chewing
Exploring floor [1 + 2] *	Snout within 5 cm (sniffing) in contact with (touching) or moving repeatedly forwards and backwards (rooting) the floor or substrate on the floor
Exploring fixtures [1 + 2]	Snout within 5 cm (sniffing) or manipulating with mouth or tongue (nibbling, biting, licking or sucking) part of the pen above floor level, except objects
Litter mate manipulation	
Body [1 + 2]	Oral manipulation (biting, nibbling, licking or sucking) directed toward the body of another piglet, except the belly or tail. The definition includes single bites, nibbles, licks and suckings as well as longer bouts of manipulation where the piglet alternates between behaviours within the definition. The recepient piglet is relatively inactive (sitting or lying down).
Tail [1 + 2]	Oral manipulation (biting, nibbling or sucking) of another piglet's tail
Belly [1 + 2]	Oral manipulation (biting, nibbling, licking or sucking) or snout moving up and down (massaging) against the belly of another piglet that is lying down on its side
Sow manipulation [1]	Oral manipulation (biting, nibbling, licking or sucking) directed toward any part of the sow's body, except the udder
Object interaction	
Rope [1 + 2]	Manipulating rope with mouth (biting, nibbling, licking or sucking), touching rope with snout or head (nudging or pushing), holding rope in mouth while moving backwards or sideways (pulling) or holding rope in mouth while making rapid side to side movements with the head (shaking)
Ball [1 + 2]	Manipulating ball with mouth (biting, nibbling, licking or sucking), touching ball with snout or head (nudging or pushing), holding ball in mouth while moving backwards or sideways (pulling) or holding ball in mouth while making rapid side to side movements with the head (shaking)
Tire [1 + 2]	Manipulating tire with mouth (biting, nibbling, licking or sucking), touching tire with snout or head (nudging or pushing), holding tire in mouth while moving backwards or sideways (pulling) or holding tire in mouth while making rapid side to side movements with the head (shaking)
Comfort behaviours [1 + 2]	Moving body repeatedly up and down against pen fixtures or pen mates, scratching body with hind leg
Other [1 + 2] *	Behaviours that did not fit into the description of any other instantaneously recorded behaviours

Table 5. Ethogram of social- and locomotor play behaviours recorded continuously during the pre- and post-weaning period

Behaviour	Description
Social play	
Mounting	Standing on back of another piglet with front legs, from behind or from the side of the other piglet that is standing
Head knock	Rapid, lateral movements of the head, once or continuously, against any part of the body of another piglet. If the pig pauses for 2 seconds or longer or switches to another receiver between the same behaviour it is recorded as a new head knock
Nose-to-nose	Gentle nose-to-nose or cheek-to-cheek contact with another pig while rapid movements of the head. If the pig pauses for 2 seconds or longer or switches to another receiver between the same behaviour it is recorded as a new bout
Lever	Attempt to, or successfully, lifting another piglet with snout from under the other piglet's belly or from between its legs
Locomotor play	
Flop	A rapid drop from an upright position to sternal or lateral recumbence. The piglet appears as to have fallen down by itself and not as a result of a slip or being pushed by another piglet
Pivot	Jumping and turning around on spot so that the body is rotated at least 90˚ in the horizontal plane, occasionally accompanied with head toss
Leap	Jumping up and down on spot or with one forward jump, sometimes turning slightly toward a different direction but not as much as during pivot and is occasionally accompanied with head toss
Scamper	Running with vertical and horizontal bouncy movements with at least two forward hops, occasionally accompanied with head toss. Walking with fast speed or running was included in the definition if the piglet ran or walked fast in order to turn to a different direction and then continued to scamper directly after the turn.

Body weight recordings

Focal piglets were weighed within 24 h after birth, at weaning and at 11 days post weaning Piglets were weighed by barn staff in a scale (Profilvågen, Maxicap AB, Sweden) that showed two decimals and was moved to just outside each pen. Before weaning, piglets were picked up and put on the scale whereas at weaning and 11 days post weaning, piglets were prompted to go onto the scale by themselves. From these recordings the average daily gain (ADG) was calculated from birth to weaning (pre-weaning weight gain) and from weaning until 11 days after weaning (post-weaning weight gain).

Statistical analysis

The data were analyzed in SAS Software version 9.3 (Statistical Analysis Systems, SAS Institute, Cary, NC, USA). Recordings of behaviours that occurred at low frequencies were grouped with similar behaviours into new elements (table 6 and 9). Due to a low number of overall recordings, no statistical analysis was performed on separate behaviours belonging to the elements "litter mate manipulation", "social interactions", or "locomotor play". The behaviour "sitting" was rarly recorded and was thus excluded from the analysis. Within each treatment (control and object) and period (pre- and post-weaning), medians and 95 %

confidence intervals (CI) were calculated for the sampled behaviours. For ADG, means and standard error (SE) were calculated within each treatment and period. Behaviours sampled continuously were expressed as the median number of recordings per litter per minute whereas instantaneously sampled behaviours were expressed as median percentage of all recordings per litter. The ADG's were expressed as gram/day (g/day).

Pre-weaning period

Behaviours and ADG were analyzed using the Generalized Linear Model procedure (proc GENMOD) with type 3 Wald statistics. The distribution of instantaneously recorded behaviours was binomial and of the frequency recorded behaviours it was poisson. The statistical model for behaviours included treatment (object and control), sex (female and castrated male) and breed (Y and YxL) as the main factors. ADG from birth to weaning was included in the model as a covariate. A separate analysis was performed for the effect of object type (rope, ball and tire) on behaviours. The statistical model included type of object, breed and sex as the main factors. ADG from birth to weaning was included as a covariate. For object interaction, age period was additionally included in the model. Where significant main effects were found for type of object and age period, a Chi^2-test was used for pair-wise comparisons. The statistical model for ADG included treatment, sex and breed as main factors. Birth weight was included in the model as a covariate. Overall, piglet nested within the sow was included as a repeated factor. The lame piglet was excluded from the analysis for the third age period.

Post-weaning period

Behaviours and ADG were analyzed using the Generalized Linear Model procedure (proc GENMOD) with type 3 Wald statistics. The statistical model for behaviours included treatment (object and control), sex and breed. ADG from weaning to 11 days post weaning was included in the model as a covariate. A separate analysis was performed for object interaction which had seven levels ("rope", "ball", "tire", "rope + ball", "rope + tire", "ball + tire" and "rope + ball + tire"). The statistical model for that analysis included object type (rope, ball and tire), breed and sex as the main factors. When significant main effects were found for type of object, the Chi^2-test was used for pair-wise comparisons between the rope, the ball and the tire. For ADG, the statistical model included treatment, sex and breed. Weaning weight was included in the model as a covariate. Piglet nested within the sow was included as a repeated factor in all the models.

Results

Pre-weaning period

Behaviours

In social play, the most common behaviours observed were nose-to-nose contacts and head knocks for both object litters and control litters (table 6). Litter mate manipulation consisted most frequently of manipulation directed at the body of another piglet for both object litters and control litters (table 6). In locomotor play, the most common behaviours were leaping and scampering for both object litters and control litters (table 6).

Table 6. Median number of recordings per minute (95 % confidence interval (CI)) for behaviours in focal piglets with access to three types of objects (object) or without access to objects (control) and the total number of focal piglets that performed each behaviour during the pre-weaning period (n=20 focal piglets/treatment)

	Object			Control		
Behaviour	Median	CI	No. of piglets	Median	CI	No. of piglets
Social play						
Mounting	0.01	0.00-0.02	5	0.00	0.00-0.01	1
Lever	0.00	0.00-0.00	0	0.00	0.00-0.00	0
Nose-to-nose	0.02	0.01-0.09	13	0.06	0.03-0.08	18
Head knocks	0.02	0.00-0.08	7	0.03	0.02-0.05	13
Litter mate manipulation						
Tail	0.00	0.00-0.02	4	0.02	0.01-0.03	9
Belly	0.00	0.00-0.00	0	0.00	0.00-0.00	0
Body	0.03	0.02-0.06	14	0.12	0.09-0.15	20
Locomotor play						
Leap	0.02	0.00-0.05	9	0.03	0.01-0.07	12
Scamper	0.01	0.00-0.09	9	0.04	0.00-0.09	13
Flop	0.00	0.00-0.02	3	0.01	0.00-0.01	4
Pivot	0.00	0.00-0.01	1	0.00	0.00-0.01	1

Effect of treatment

The control litters performed significantly more manipulation of the sow (Chi^2=11.37; P<0.01) and the other piglets (Chi^2=17.90; P<0.001) compared to the object litters (fig. 4). The control litters also performed more exploration of pen fixtures (Chi^2=4.61; P<0.05) when compared to piglets in litters with objects (fig. 4). Comfort behaviours tended to be performed more by the control litters (0.02 (0.01-0.01 CI)) than by the object litters (0.1 (0.00-0.03 CI), Chi^2=3.43; P<0.1). There was no significant effect of treatment on the performance of social- (Chi^2=0.00; n.s.) and locomotor play (Chi^2=0.00; n.s., fig. 4).

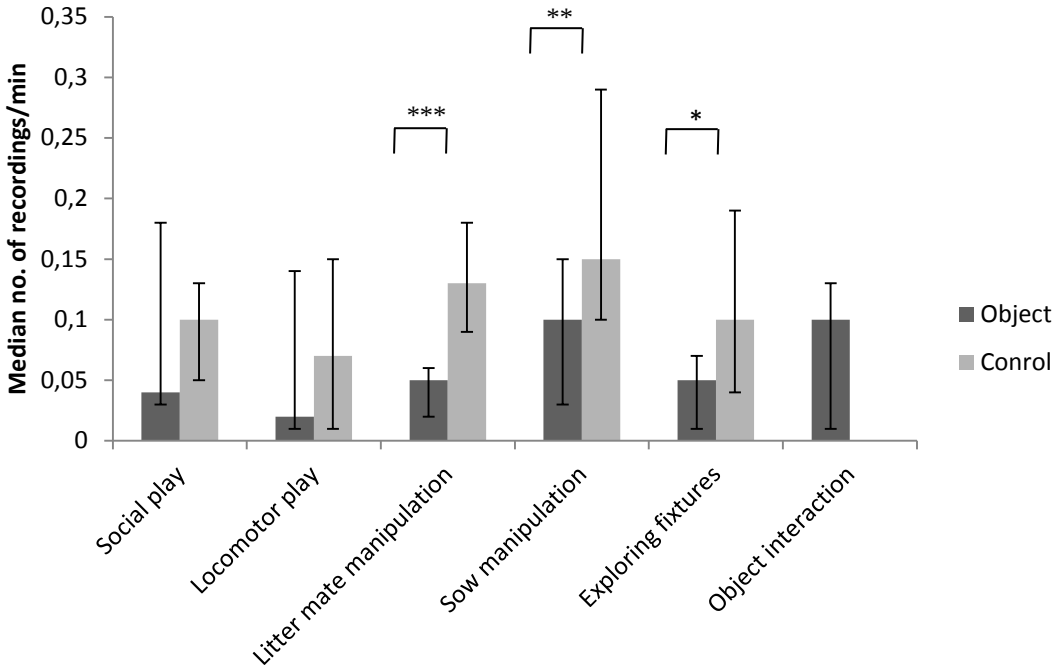

Figure 4. Median number of recordings per minute (95 % confidence interval) of behaviours in focal piglets that had access to two objects of the same type in their pen (object) or not (control) during the pre-weaning period (*P<0.05, **P<0.01, ***P<0.001, n=20 focal piglets/treatment)

Piglets in the control litters explored the floor more when compared to piglets in the object litters (Chi^2=7.40; P<0.01, fig. 5). Manipulation of the udder was performed more by piglets in the object litters than piglets in the control litters (Chi^2=11.92; P<0.01, fig. 5). There were no difference between treatments in the percentage of recordings of lying (Chi^2=2.49; n.s.), standing (Chi^2=0.27; n.s.), being in creep (Chi^2=0.23; n.s.) or performed other behaviours (Chi^2=1.91; n.s., fig. 5).

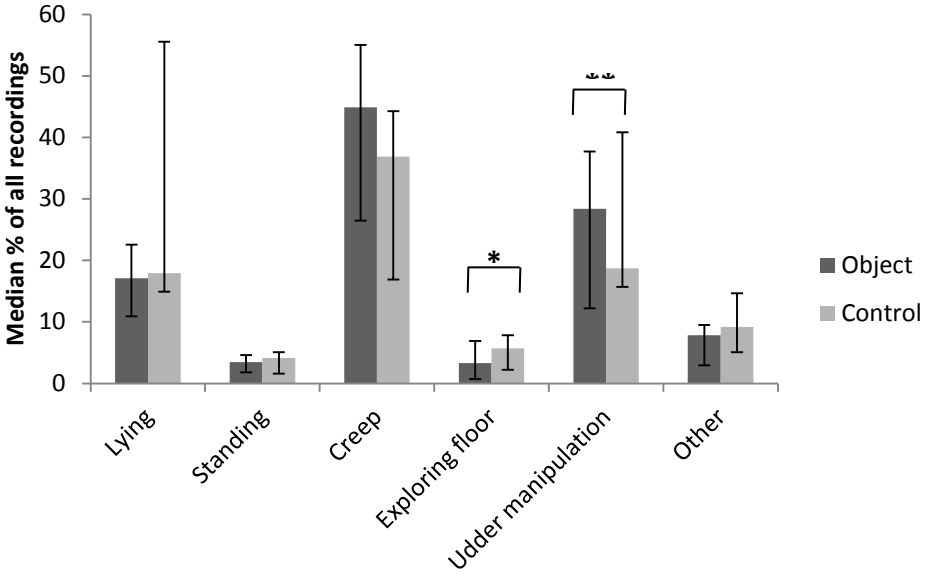

Figure 5. Median percentage (%) of all recordings (95 % confidence interval) that focal piglets performed different behaviours when having access to two objects of the same type (object) or not (controls) during the pre-weaning period (*P<0.05, **P<0.01, n=20 focal piglets/treatment)

During the majority of recordings of being in the creep the observer noted that those piglets that were visable inside the creep area were lying. At some recordings of being in the creep, the sow was lying in front of the creep area, thus obscuring focal piglets being inside of it. It was also noted that piglets could react to the presence of the observer at some times, for example by running away into the creep area or stopping to play. At times when the majority of the litter or just the focal piglets reacted to the presence of the observer, it was recorded as missing data. During the third age period, it was also noted that piglets seemed to be lying more at the udder in those pens where the heating lamp was turned off.

Breed and sex differences

Breed had a significant effect on the median percentage of recordings that a piglet was in the creep, with L being in the creep more than LxY (Chi^2=20.20; P<0.001). There was no significant effect of breed or sex on the performance of the other recorded behaviours (n.s.).

Effect of object type on behaviour

For the litters with objects, there was an effect of type of object on the number of recordings of litter mate manipulation (Chi^2=9.74; P<0.01) and social play (Chi^2=6.02; P<0.05, table 7). When having access to the ball, piglets performed significantly more litter mate manipulation compared to when having access to the rope (z=2.90; P<0.01, table 7). Compared to the ball, the median number of recordings that piglets engaged in social play was higher when piglets had access to the tire compared to when they had access to the ball (z=2.17; P<0.05). There was no significant effect of type of object on the number of recordings of sow manipulation (Chi^2=0.33; n.s.), locomotor play (Chi^2=4.82; n.s.), exploring fixtures (Chi^2=1.05; n.s.) or comfort behaviours (Chi^2=2.95; n.s.).

Table 7. Median number of recordings per minute (95% confidence intervals (CI)) of focal piglet behaviour when having access to different types of objects (rope, ball and tire) during the pre-weaning period (n=20 focal piglets/treatment)

	Rope		Tire		Ball	
Behaviour	Median	CI	Median	CI	Median	CI
Litter mate manipulation	0.02[a]	0.00-0.05	0.03[a, b]	0.00-0.07	0.08[b]	0.00-0.12
Social play	0.05[a, b]	0.00-0.20	0.05[b]	0.00-0.1	0.03[a]	0.02-0.22

Within a row, medians with different superscripts differ significantly

There was an effect of type of object on exploring the floor (Chi^2=12.37; P<0.01), manipulating the udder (Chi^2=15.82; P<0.001) and being in creep (Chi^2=11.82; P<0.01). Piglets explored the floor more when having access to the ball (z=3.51; P<0.001) and the tire (z=2.57; P<0.05) compared to when having access to the rope (table 8). Piglets manipulated the udder more when having access to the ball (z=3.08; P<0.01) and the tire (z=3.22; P<0.01) compared to when having access to the rope (table 8). Piglets were in the creep more when having access to the rope compared to when having access to the ball (z=3.19; P<0.01), and the tire (z=2.53; P<0.05, table 8). There was no effect of type of object on percentage of recordings of lying (Chi^2=0.80; n.s.) or standing (Chi^2=1.04; n.s.).

Table 8. Median percentage of all recordings for piglets with objects (rope, ball or tire) (95 % confidence interval (CI)) that focal piglets performed different behaviours during the pre-weaning period (n=20 focal piglets)

	Rope		Tire		Ball	
Behaviour	Median	CI	Median	CI	Median	CI
Explore	0.83[a]	0.52-4.71	4.30[b]	0.00-6.37	4.30[b]	1.25-9.56
Udder manipulation	23.15[a]	8.23-26.82	23.94[b]	10.50-49.61	26.95[b]	17.66-38.24
Creep	57.29[a]	37.50-63.11	41.80[b]	6.64-55.94	42.19[b]	11.16-64.17

Within a row, medians with different superscripts differ significantly

Object interaction

There was no significant effect of type of object on the frequency of object interactions (Chi^2=0.04; n.s., fig. 6).

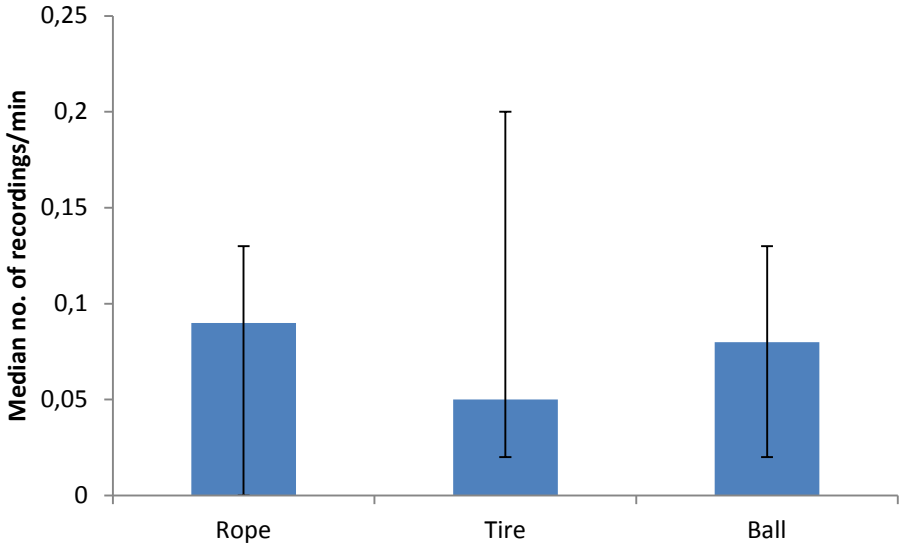

Figure 6. Median number of recordings per minute (95 % confidence interval) of interaction with different objects (rope, ball and tire) in focal piglets during the pre-weaning period (n=20 focal piglets)

There was a significant effect of age on object interaction (Chi^2=25.96; P<0.001, fig. 7). Piglets interacted significantly more with the objects at 27-30 days of age compared to the 20-23 days of age (z=5.08; P<0.001, fig. 7).

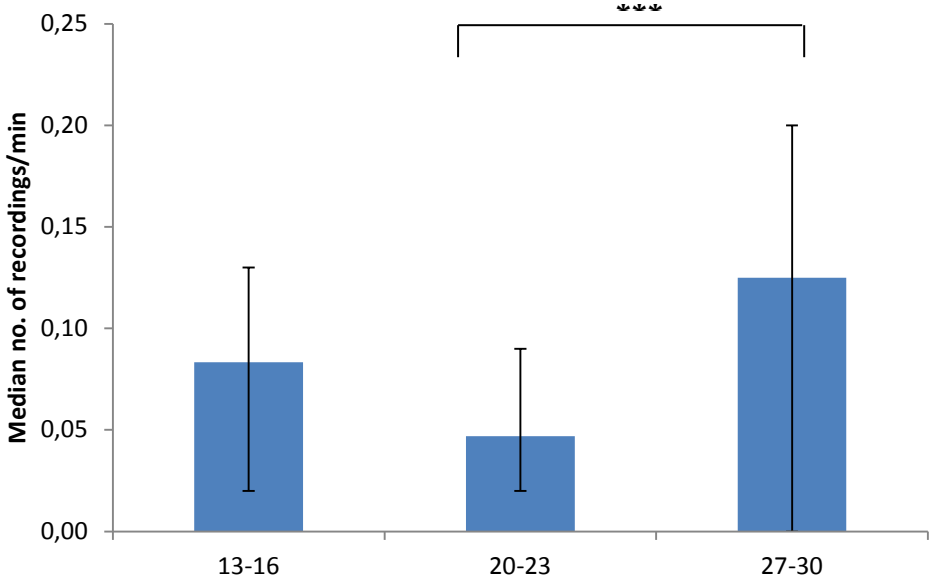

Figure 7- Median number of recordings per minute (95 % confidence interval) of total object interaction at different ages , shown as the mean age (days) for focal piglets, during the pre-weaning period (***P<0.001, n=20 focal piglets)

Weight gain

Piglets from the object litters had a lower body weight at birth and a significantly lower ADG from birth to weaning compared to piglets in the control litters (Chi^2=4.36: P<0.05, table 9). Breed (Chi^2=1.11; n.s.) and sex (Chi^2=0.25; n.s.) had no effect on ADG in the piglets.

Table 9. Body weight (mean ± standard error (SE)) of focal piglets within 24 h after birth (birth weight), at weaning and at 11 days post-weaning. Average daily gain (ADG) (mean ± SE) from birth to weaning (pre-weaning ADG) and ADG from weaning to 11 days post-weaning (post-weaning ADG, n=20 focal piglets/treatment)

	Object	Control
Measures	Mean ± SE	Mean ± SE
Birth weight (kg)	1.5 ± 0.08	1.7 ± 0.08
Wean weight (kg)	11.0 ± 0.59	12.8 ± 1.09
Weight 11 days post-weaning (kg)	14.6 ± 0.81	17.1 ± 1.18
Pre-weaning ADG (g/day)	289.3^a ± 21.99	334.3^b ± 21.62
Post-weaning ADG (g/day)	318.2^a ± 35.65	384.1^a ± 22.21

Within a row, means with different superscripts differ significantly

Post-weaning period

Behaviours

In social play, the most common behaviours were nose-to-nose contacts for both object litters and control litters (table 10). Litter mate manipulation consisted most frequently of manipulation directed at the body of another piglet for both object litters and control litters (table 10). In locomotor play, the most common behaviours were leaping and scampering for both object litters and control litters (table 10).

Table 10. Median number of recordings per minute (95 % confidence interval (CI)) for behaviours in focal piglets with access to three types of objects (object) or without access to objects (control) and the total number of focal piglets that performed each behaviour during the post-weaning period (n=20 focal piglets/treatment)

	Object			Control		
Behaviour	Median	CI	No. of piglets	Median	CI	No. of piglets
Social play						
Mounting	0.00	0.00-0.06	2	0.00	0.00-0.01	1
Lever	0.00	0.00-0.01	1	0.00	0.00-0.01	1
Nose-to-nose	0.05	0.02-0.07	13	0.00	0.00-0.07	4
Head knocks	0.00	0.00-0.04	4	0.00	0.00-0.02	3
Litter mate manipulation						
Tail	0.00	0.00-0.02	2	0.00	0.00-0.04	3
Belly	0.02	0.00-0.02	6	0.00	0.00-0.04	2
Body	0.09	0.07-0.10	18	0.13	0.11-0.22	19
Locomotor play						
Leap	0.02	0.00-0.03	5	0.00	0.00-0.04	3
Scamper	0.02	0.00-0.06	8	0.01	0.00-0.14	7
Flop	0.00	0.00-0.00	0	0.00	0.00-0.01	1
Pivot	0.00	0.00-0.01	0	0.00	0.00-0.01	1

Effect of treatment

Piglets in control litters performed more litter mate manipulation (Chi^2=4.23; P<0.05) and exploration of pen fixtures (Chi^2=4.56; P<0.05) compared to object litters (fig. 8). No difference was found in the performance of comfort behaviours between piglets in control litters (0 (0-0.03 CI)) and object litters (0.02 (0-0.03 CI), Chi^2=1.89; n.s.). Neither was there any effect of treatment on the performance of locomotor- (Chi^2=1.66; n.s.) or social play (Chi^2=1.53; n.s., fig. 8).

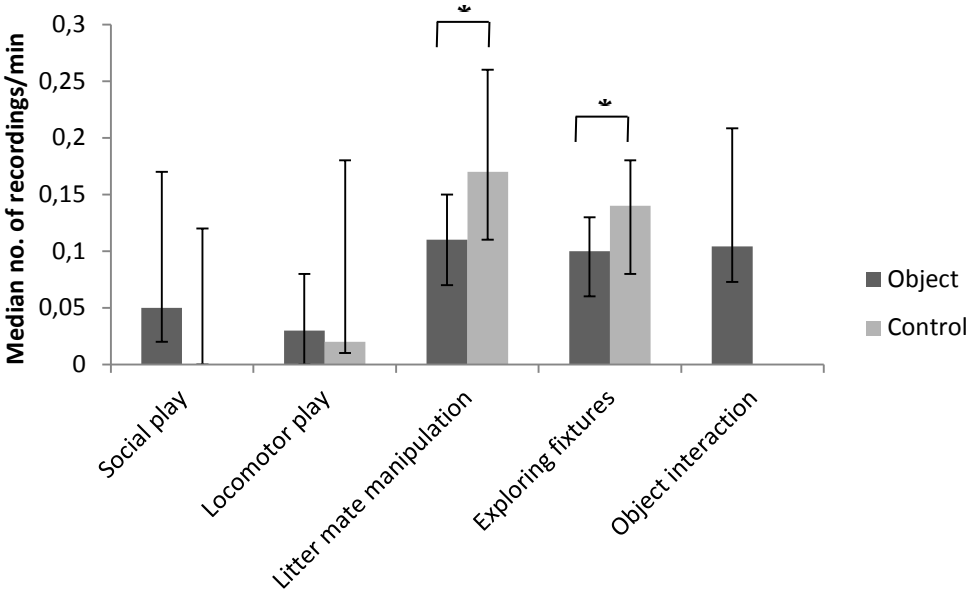

Figure 8. Median number of recordings per minute (95 % confidence interval) of behaviours in focal piglets that had access to three different types of objects (object) or no access to objects (control) during the post-weaning period (*P<0.05, n=20 focal piglets/treatment).

No effect of treatment was found in lying (Chi^2=2.70; n.s.), standing (Chi^2=0.75; n.s.), exploring floor (Chi^2=0.60; n.s.), feeding (Chi^2=0.68; n.s.), being in creep (Chi^2=1.74; n.s.) or performing other behaviours (Chi^2=2.01; n.s., fig. 9).

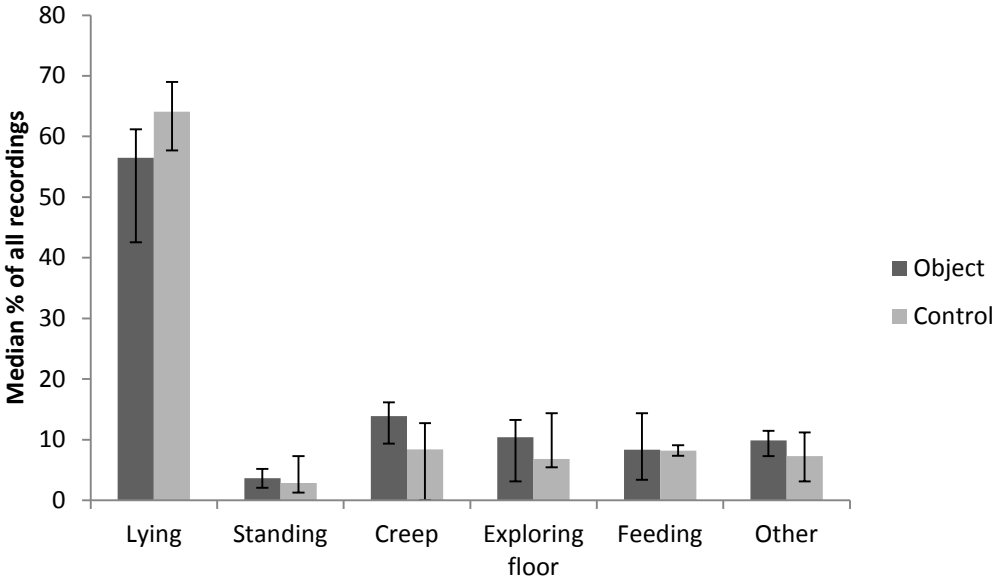

Figure 9. Median percentage (%) of all recordings (95 % confidence interval) that piglets performed different behaviours when having access to three objects of different type (object) or no access to objects (controls) during the post-weaning period (n=20 focal piglets/treatment)

Breed and sex differences

There was no significant effect of breed or sex on the performance of the recorded behaviours (n.s.).

Object interaction

There was a effect of the type of object found on object interactions (Chi^2=125.00; P<0.001, fig. 10). Object piglets interacted significantly more with the rope compared to both the ball (z=4.08; P<0.001) and the tire (z=2.08; P<0.05) and more with the tire compared to the ball (z=2.19; P<0.05, fig 10).

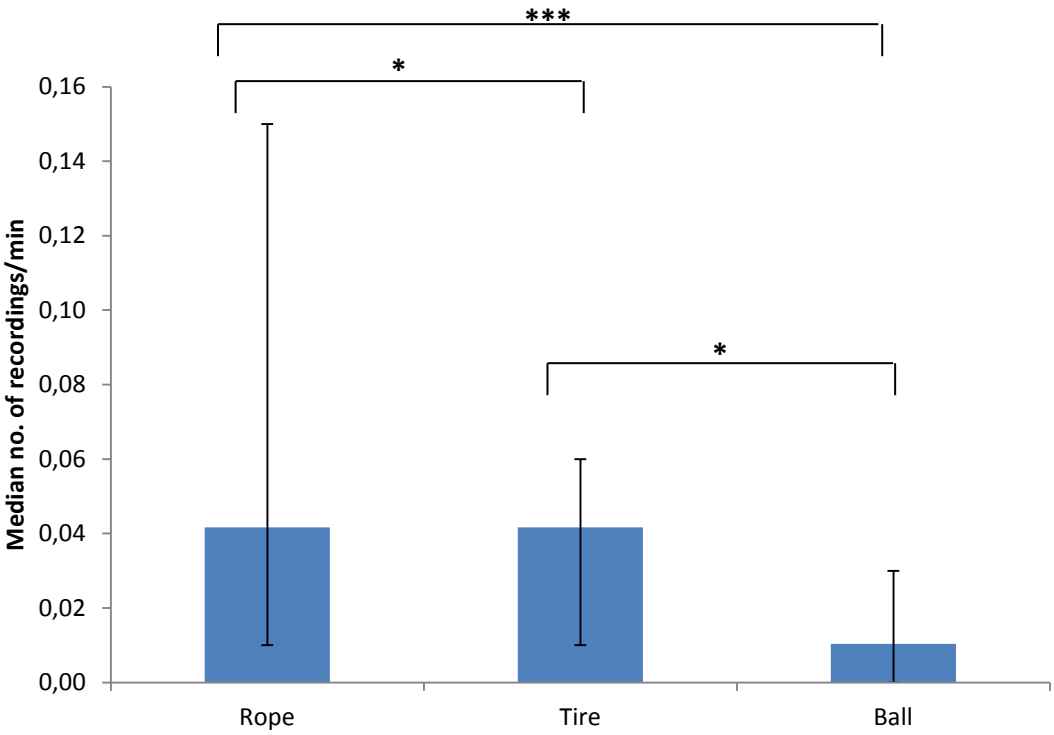

Figure 10. Median number of recordings per minute (95 % confidence interval) of interaction with different objects (rope, ball and tire) in piglets during the post-weaning period (*P<0.05, ***P<0.001, n=20 focal piglets)

Weight gain

Piglets in the control litters had a higher body weight at weaning and 11 days post-weaning compared to piglets in the object litters (table 9). There was however no significant effect of treatment on ADG during 11 days post-weaning (Chi^2-value=2.23; n.s.,). Neither breed (Chi^2=1.95; n.s.) nor sex (Chi^2=0.21; n.s.) had an effect on post-weaning ADG in the piglets.

Discussion

During the period before weaning piglets with objects explored pen fixtures and the floor and manipulated the sow and litter mates less than piglets without objects. Also after weaning, piglets with objects manipulated litter mates and explored pen fixtures less than piglets without objects. However, there were no differences in play between treatments during pre- and post-weaning, but piglets with objects interacted with them quite a lot. Piglets with objects had a lower weight gain pre-weaning but not after weaning compared to piglets without objects. This suggest that, during post-weaning, piglets with objects may have compensated for the lower weight gain that occurred pre-weaning.

Behaviours

Pre-weaning period

Studies have shown that piglets first reaction to novel objects are to investigate them through exploration after which locomotor play shortly follows (Wood-Gush *et al*., 1990; Wood-Gush & Vestergaard, 1991). The authors therefore concluded that play is probably a form of exploration in piglets. Spinká *et al*. (2001) on the other hand mean that, although play is closely related to exploration, play and exploration are motivationally distinct from each other. Environmental change, novel objects and unexpected stimuli have been reported to elicit exploration and locomotor play in piglets (Newberry *et al*., 1988; Wood-Gush & Vestergaard, 1991; Spinká *et al*., 2001; Chan & Newberry, 2011). As an environmental stimulus become familiar, it loses its ability to stimulate exploration as well as play (Wood-Gush & Vestergaard, 1991). Providing piglets with a new type of object at different ages, as well as limiting the accessibility of objects to only a couple of hours per day during four days per week, was believed to induce novelty of the objects. We therefore predicted that piglets in litters with access to the objects would engage more in locomotor play compared to piglets in the control litters. The above mentioned studies on what stimulates play in piglets did not record any social play behaviours. However, in calves, it has been observed that social play often occurred in connection with locomotor play (Jensen *et al*., 1998). Therefore, it was also predicted that frequency of social play would be higher for piglets in litters with access to the objects. It was also predicted that providing piglets with objects would offer a more varied and stimulating environment to interact with, thereby reducing manipulatory activities toward litter mates, the sow and pen fixtures.

The results from the present study confirmed the predictions that piglets with access to objects would perform less manipulatory behaviours directed toward litter mates, the sow and pen fixtures. Most probably, some of these behaviours were instead directed toward the objects. Manipulatory activities toward pen mates can later develop into high levels of harmful social behaviours that are detrimental to the welfare of pigs and bad for the productivity (Beattie *et al*, 2000:2001; Moinard *et al*., 2003; Chaloupková *et al*., 2007; Munsterhjelm *et al*, 2009). It has been shown that enrichment that starts from an early age can prevent such outbreaks (Beattie *et al*., 2000: 2001; Chaloupková *et al*., 2007; Munsterhjelm *et al*, 2009). Further, it has been suggested that manipulatory activities directed at inappropriate objects indicate stress arising from a lack of environmental stimuli (Dybkjaer, 1992; Lawrence & Terlouw, 1993).

In this study, piglets with objects during pre-weaning did not seem to perform more locomotor- or social play compared to those without the objects. A certain level of unpredictability of the environment seems to be important for stimulating play (Chan & Newberry, 2011). A previous study demonstrated higher levels of play in piglets enriched with straw and more space (Chaloupková *et al*., 2007). Straw may add some

unpredictability as it can change in location and structure as a response to piglet´s behaviour (Chaloupková *et al*., 2007). Since both the object litters and the control litters in this study were provided with straw, this might have been sufficient to stimulate equal levels of play in both treatments. Further, behavioural elements of locomotor play such as scampering and pivoting involve a lot of movements and are therefore probably more dependent on available space than materials provided to the pen. If that is the case, piglets, regardless of treatment, could have had equal possibilities to play as space allowances were the same. In dairy calves, it has been demonstrated that space is essential to the expression of locomotor play (Jensen *et al*., 1998). The same authors also found peaks in locomotor play during times of external stimuli, such as feeding, provision of straw and other management routines. Recordings of the behaviour of focal piglets in the present study started at one hour after object introduction each day. The reason for this was to ensure that the normal behaviour of piglets and the sow was restored. The initial reaction to objects was therefore not recorded, although it would have been interesting to include it in the study. It is possible that objects induced a short-term daily novelty, stimulating locomotor play, after which object quickly got familiar to the piglets and play was reduced.

The elements of social play recorded in this study have in previous studies been used as indicators of both play and aggression (Jensen, 1982; Donaldson *et al*., 2002; Chaloupkova *et al*., 2007; Dudink *et al*., 2006; Pitts *et al*., 2000). In the present study, piglets were kept with their litter mates throughout the study and a dominance hierarchy might most likely have already been established and stable. Therefore, the elements of social play recorded in this study are more likely to represent play behaviours than aggression. In piglets, it has been observed that elements of agonistic behaviours sometimes occured in playful contexts (Newberry & Wood-Gush, 1986; Newberry *et al*., 1988). Also in other species, elements of agonistic behaviours have been observed in connection with locomotor play (Reinhardt & Reinardt, 1982). Indeed, the observer noted that head knocks and nose-to-nose contacts were often performed in association with locomotor play and rarely appeared aggressive. As stated earlier, there were no differences in social play between treatments. Providing objects in piglet's home environment may thus not be relevant for social play. Instead, the social environment is probably more important for this type of play as demonstrated by Donaldsson *et al*. (2002).

Scientists have stated that it is difficult to distinguish serious exploration of objects from object play in piglets. It has been suggested that both play and exploration is a part of the investigatory behaviours directed toward inanimate objects in young pigs (Blackshaw *et al*., 1997). It is possible that some interactions with the objects were indeed playful but this can only be speculated since the present study, unfortunately, did not distinguish between different types of object interaction. For example, carrying and shaking objects has previously been defined as play (i.e. object play) (Newberry *et al*., 1988).

If characteristics that maintain novelty are inherent within the material, for example flexibility and chewability (Van de Weerd *et al*., 2003), that material might stimulate exploration and play for a long time (Jensen & Pedersen, 2007). A rope have been demonstrated to induce high levels of interaction in a previous study (Trickett *et al*., 2009). Therefore it was predicted that the rope, compared to the tire and the ball, would stimulate a higher frequency of interaction. Because of this, it was further predicted that the rope would stimulate locomotor- and social play as well as reduce manipulatory activities toward litter mates, the sow and pen fixtures more efficiently compared to the tire and the ball. Although there were no differences in frequency of interaction with the three objects, the rope seemed to affect the piglets exploratory and manipulatory activities to a larger extent than the other two objects. This assumption is based on the result from present study

showing that piglets manipulated litter mates less with the rope than with the ball and manipulated the udder and explored the floor less with the rope than when they had the other two objects. Thus, the rope seemed to be more effective in terms of redirecting the piglets attention away from the litter mates, the udder and the floor compared to the tire and the ball. However, social play was perfomed more when piglets had the tire than when they had the ball, altough the difference was small.

When it comes to behaviours directed at the sow's udder, a previous study has shown that piglets reared in barren environments are manipulating the udder to a larger extent than piglets reared in a more enriched environment (Petersen *et al*., 1995). The same authors suggested that piglets in barren environments use their mothers as a target for manipulating activities that in enriched environments are directed to the physical environment. Surprisingly, the results from the present study indicate the opposite. Our piglets from the object litters manipulated the udder more often than piglets from the control litters. This may be related to a higher demand for energy due to a lower weight gain in the piglets with objects. Previous research has found that piglets with relatively low weight gains spent more time actively manipulating the udder (Weary *et al*., 1996). The same authors suggested that this activity was performed in an effort to receive more milk. Since the present study was performed on relatively few litters, it is also possible that by chance, the litters receiving objects would still have been the ones with general lower weight gains.

The impact of the sow on her piglet's milk intake should not be ignored as she probably is the main factor for determining the piglet's intake (Arellano *et al*., 1992). Previous research has found that offspring of mothers with less milk production suckle the udder more frequently (reviewed by Cameron, 1998). It can be speculated that the sows from the object litters got disturbed by the daily provision and removal of the objects. It is however likely that the sows got habituated to the routine, but that initially this may have led to a drop in milk production. In order to avoid this possible effect, the same treatment, i.e. entering the pen before and after the observations each day, should have been made. Piglets in the object litters, being less nutritionally satisfied, may thus have stimulated the udder more frequently in an effort to receive more milk compared to the control piglets. This would also explain why object piglets had a lower growth rate from birth until weaning than control piglets. As argued before, due to a low number of litters, it is also possible that by chance the sows that would otherwise also produce less milk were allotted into the object treatment. Results from the present study also showed that when piglets had access to the rope, they performed less manipulation of the udder and the litter mates than when they had access to the other objects. It is possible that the rope, being more chewable and manipulable than the tire and the ball, were partly used as an output for the need to explore and forage (i.e. nursing or searching for other feed sources).

It should also be mentioned that it was sometimes difficult to tell whether a piglet was actually manipulating the udder with the snout or not. Therefore, the definition of udder manipulation also included recordings when piglets were lying perpendicular toward and with snout close to the udder. During the age of 27-30 days, it was noted that piglets were often lying at the udder in the pens where the heating lamp was turned off. Because of that, they may have been lying at the sow's udder more frequently in an attempt to keep their body temperature. Since there were more pens from the object treatment compared to the control treatment (i.e. two vs one pen respectively) that had the lamps turned off, this might have partly been confounded with the effects of treatment.

Post-weaning period

Increased manipulation of penmates and pen fixtures as well as decreased play behaviour has been shown to be reliable behavioural indicators of the stressfulness of early weaning (Dybkjaer, 1992). Play is believed to be under the influence of a variety of different stressors and may therefore be a general indicator of the stress level (Dykjaer, 1992). The occurrence of pen mate- and pen fixture manipulation, deriving from explorational needs, on the other hand is believed to reflect stress arising from a lack of appropriate environmental stimuli (Dybkjaer, 1992). Oostindjer *et al*. (2011) suggested that decreased pen mate- and pen fixture manipulation, due to increased environmental complixity, may also indicate a reduced stress response to weaning. In this study, it was therefore predicted that piglets in litters with objects would engage more in play and less in manipulatory acitivies directed at litter mates and pen fixtures.

In the present study, the access to objects reduced some of the piglet's manipulatory activities toward litter mates and pen fixtures also after weaning. This is in agreement with previous studies (Petersen *et al*., 1995; Beattie *et al.*, 2000; 2001; Bench & Gonyou, 2006; Lewis *et al*., 2006; Oostindjer *et al*., 2011). It thus seems as objects after weaning can add a certain degree of distraction to weaning and serve as an outlet for manipulation and exploratory behaviours. Thus, the enrichment objects may have reduced some of the immediate stress response to weaning (Oostindjer *et al*., 2011). Belly nosing and tail biting usually starts to appear a couple of weeks after weaning (Dybkjaer, 1992) which could explain why manipulation targeted toward the tail and belly was more or less absent for both treatments in the present study.

No effect of treatment was seen in locomotor- or social play, indicating that the general welfare level was similar for piglets in both treatments (Dybkjaer, 1992). The reason for this has partly been discussed in the previous section (pre-weaning behaviour). Also, it is possible that the stress induced by the abrupt loss of the sow and their main feeding source (milk) overshadowed any differences arrived from the environment (Chaloupkova *et al*., 2007).

No difference was found between treatments on the frequency of feeding which is in line with the results of Dudnik *et al*. (2006). Other studies have also investigated the effect of post-weaning environment on feed intake of newly weaned piglets (Dudnik *et al*., 2006; Oostindjer *et al*., 2011). Results are however not unanimous. The reason for this may lie in differences in feed, feeding method, type of enrichment, breed selection and method of weaning.

Object interaction

Before weaning, when having no choice in which object to interact with, there were no differences in the frequency of interaction with the different types of objects. However, after weaning, when all three objects were presented simultaneously, piglets seemed to prefer to interact with the rope over the other two objects whereas the tire was preferred over the ball. This confirms the hypothesis of ropes being most popular to interact with, followed by the tire and the ball. Ropes have previously been reported to be very effective in occupying pig's time (Trickett *et al*., 2009). Pigs prefer objects that are chewable, deformable, destructible, odorous and ingestible (e.g. Van de Weerd *et al*., 2003). The reason for the rope being more interesting for pigs to interact with is probably that the rope was more flexible and chewable than the tire and the ball. Further, compared to the other objects, the rope was relatively large and had two endings making more piglets able to interact with it simultaneously. The tire was also chewable and to a certain extent deformable but probably less than the rope whereas the ball was odorous but could not be

chewed nor changed. Out of this, it seems as if chewability and deformability is more important than odor and that the texture, size and form of the rope was more interesting for piglets than that of the tire.

Before weaning, a difference was found between the ages 27-30 days and 20-23 days in the frequency of object interaction. The reason for this may be that piglets during the third age period were spending more time exploring their surrounding compared to the second age period. This is in agreement with studies showing that exploratory behaviours directed toward inanimate objects increase with age (Newberry & Wood-Gush, 1988; Hill *et al*., 1998; Docking *et al*., 2008).

All the provided objects seemed to withstand piglet's interacting with them without being destroyed. The rope is probably somewhat easier to clean as it can be machine washed, although it requires some more work cleaning by hand. When providing objects in the pre-weaning environment, also the sow needs to be taken into consideration. The present study did not record the sow's interaction with the objects, however, except for when initially introduced, sows were rarely seen interacting with them.

Weight gain

The present study showed that the average daily growth rate of piglets in the control litters was higher compared to piglets in the object litters during the pre-weaning period. This result contradicts with the result of Oostindjer *et al*. (2011). In that study, they found a higher pre-weaning weight gain in piglets housed in enriched pens compared to barren housed piglets. Possible reasons for the different results are differences in the type of enrichment used, the amount of environmental stimuli provided and the presentation method. It is possible that the daily procedure of hanging in and taking out the objects initially disturbed the sows, leading to reduced milk production. As discussed earlier, this may have affected ADG in piglets from object litters negatively. Assuming that objects used in the present study had an enriching effect and were valuable for piglets, it is also possible that piglets may have become frustrated during times that enrichment was not present (Latham & Mason, 2010). This could thereby have caused piglets in object litters to have a reduced weight gain before weaning. However, this can only be speculated since no behavioural recordings were performed when piglets did not have access to the objects. Whatever the cause, negative effects on productivity may hamper the implementation of providing objects to piglets on commercial farms.

Set-back in growth has been demonstrated as one of many stress reactions to early weaning (Worobec *et al*., 1999). After weaning, the difference in ADG found during the pre-weaning period was no longer significant. The change from ADG being significantly different before weaning to being not significant after weaning may have meant that piglets in the object treatment started to grow faster. If this is true, it is possible that weaning was less stressful for piglets with access to the objects than for the controls (O´Connell *et al*., 2004).

It should be mentioned that litter size could have affected the behaviour and weight gain in the piglets. However, due to the small data set, it was not possible to run the statistical analysis when litter size was included in the model. Even so, litter sizes in the present study was quite similar and therefore is unlikely to have affected behaviour and weight gain.

Future studies

During the study, there were some disturbances that could have affected the behaviour and weight gain of the piglets. This is not desirable and in a larger study, the experiment would probably have been remade at a later stage. Even so, the results obtained from this study still points to potential welfare benefits of providing objects additional to small amounts of straw during the early life of pigs. The effects of providing objects as a complement to straw in the pre- and post-weaning environment of piglets therefore deserve further investigation.

Since early and abrupt weaning is common practice in modern pig production, measures should be taken to alleviate the stress at weaning. Evidence suggests that the environment both before and after weaning can be important (Chaloupková *et al*., 2007; Munsterhjelm *et al*., 2009; Oostindjer *et al*., 2011). However, it was not possible from the current study to judge which aspect, pre- or post-weaning environment, that was responsible for the effects after weaning. Therefore, it would be interesting to design a two-by-two factorial design to test this whereby pre-weaning piglets are housed in either barren pens or pens enriched with objects, and relocated to a barren or enriched pen post-weaning. In this way, piglets that did not have objects pre-weaning will have objects post-weaning and vice versa.

The reason for piglets not having continuous access to objects during the pre-weaning period was mainly because of safety reasons for the sow. In addition, for enrichment objects being implemented on commercial farms, the objects should be practical. Providing and taking out enrichment objects on a daily basis is time consuming and probably will not be applied. Further efforts should therefore be made to find relevant objects that are suitable for piglets and safe for both sows and piglets for continuous access in the pre-weaning environment. It would also be interesting to further test these objects, for example when pigs are moved between different stages of production with mixing of unfamiliar pigs in new environments.

Play involves a lot of movements and fast switches between different behavioural elements. It is therefore difficult to record reliably using direct observations. This difficulty may be overcome by the use of video cameras to record the behaviours of piglets. Further, play is a complex concept that is yet not fully understood. A consequence of this is that play is difficult to define and scientists dispute about how related to play some behaviours are (Newberry *et al*., 1988; Blackshaw *et al*., 1997; Donaldson *et al*., 2002). For example, behaviours that have been used to describe social play (Donaldson *et al*., 2002; Chaloupková *et al*., 2007) can also occur during serious fighting (Pitts *et al*., 2000). Further, play covers many behavioural categories (i.e. social play, locomotor play and object play) that are probably controlled by different motivational systems (Pellis, 1991). Different types of play may thus be stimulated by different types of environmental stimuli. Further efforts should therefore be made in order to disentangle the complex concept of play and to figure out relevant features of materials that stimulate play in piglets.

Conclusions

The main finding of this study was that the access to objects directed piglets attention away from litter mates, the sow and pen fixtures. On the other hand, the access to objects affected growth negatively before weaning but piglets seemed to compensate for this after weaning. Play was not affected by access to the objects and therefore, the object did not seem to serve as a stimuli relevant for eliciting play. Rope stimulated the highest frequency of object interaction after weaning and was more effective in reducing manipulation of litter mates, the udder and exploration of floor before weaning compared to the tire and the ball. Therefore, a rope is probably a better suited object for piglets than a tire and a ball.

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References

Apple, J.K., Craig, J.V. 1992. The influence of pen size on toy preference of growing pigs. Applied Animal Behaviour Science 35, 149-155.

Appleby, M.C., Wood-Gush, D.G.M. 1988. Effect of earth as an additional stimulus on the behaviour of confined piglets. Behavioural Processes 17, 83-91.

Arellano, P.E., Pijoan, C., Jacobson, L.D., Algers, B. 1992. Stereotyped behaviour, social interactions and suckling pattern of pigs housed in groups or in single crates. Applied Animal Behaviour Science 35, 157-166.

Averós, X., Brossard, L., Dourmad, J.Y., de Greef, K.H., Edge, H.L., Edwards, S.A., Meunier-Salaün, M.C. 2010. A meta-analysis of the combined effect of housing and environmental enrichment characteristics on the behaviour and performance of pigs. Applied Animal Behaviour Science 127, 73-85.

Beattie, V.E., O'Connell, N.E., Moss, B.W. 2000. Influence of environmental enrichment on the behaviour, performance and meat quality of domestic pigs. Livestock Production Science 65, 71-79.

Beattie, V.E., Sneddon, I.A., Walker, N., Weatherup, R.N. 2001. Environmental enrichment of intensive pig housing using spent mushroom compost. Animal Science 72, 35–42.

Bench, C.J., Gonyou, H.W. 2006. Effect of environmental enrichment at two stages of development on belly nosing in piglets weaned at fourteen days. Journal of Animal Science 84, 3397-3403.

Blackshaw, J.K., Thomas, F.J., Lee, J.A. 1997. The effect of a fixed or free toy on the growth rate and aggressive behaviour of weaned pigs and the influence of hierarchy on initial investigation of the toys. Applied Animal Behaviour Science 53, 203-212.

Boissy, A., Manteuffel, G., Jensen, M.B., Moe, R.O., Sprujit, B., Keeling, L.J., Winckler, C., Forkman, B., Dimitrov, I., Langbein, J., Bakken, M., Veissier, I., Aubert, A. 2007. Assessment of positive emotions in animals to improve their welfare. Physiology & Behaviour 92, 375-397.

Bracke, M.B.M. 2007. Multifactorial testing of enrichment criteria: Pigs 'demand' hygiene and destructibility more than sound. Applied Animal Behaviour Science 107, 218-232.

Bracke, M.B.M., Zonderland, J.J., Lenskens, P., Schouten, W.G.P., Vermeer, H., Spoodler, H.A.M., Hendriks, H.J.M., Hopster, H. 2006. Formalised review of environmental enrichment for pigs in relation to political decision making. Applied Animal Behaviour Science 98, 165-182.

Cameron, E.Z. 1998. Is suckling behaviour a useful predictor of milk intake? A review. Animal Behaviour 56, 521-532.

Chaloupková, H., Illmann, G., Bartos, L., Spinká, M. 2007. The effect of pre-weaning housing on the play and agonistic behaviour of domestic pigs. Applied Animal Behaviour Science 130, 25-34.

Chan, W.Y., Newberry, R.C. 2011. The object that barked: A novel enrichment item for domestic pigs. In: The meaning of barks: vocal communication of fearful and playful affective states in pigs. Chan, W.Y. Ph.D-thesis, Washington State Univeristy.

Cox, L.N., Cooper, J.J. 2001. Observations on the pre- and post-weaning behaviour of piglets reared in commercial indoor and outdoor environments. Animal Science 72, 75-86.

de Jong, I.C., Ekkel, E.D., Van de Burgwal, J.A., Lambooij, E., Korte, S.M., Ruis, M.A.W., Koolhaas, J.M., Blokhuis, H.J. 1998. Effects of strawbedding on physiological responses to stressors and behavior in growing pigs. Physiology and Behaviour 64, 303–310.

de Jonge, F.H., Bokkers, E.A.M., Schouten, W.G.P., Helmond, F.A., 1996. Rearing piglets in a poor environment: developmental aspects of social stress in pigs. Physiology and Behaviour 60, 1–8.

Docking, C.M., Van de Weerd, H.A., Day, J.E.L., Edwards, S.A. 2008. The influence of age on the use of potential enrichment objects and synchronisation of behaviour of pigs. Applied Animal Behaviour Science 110, 244-257.

Donaldson, T.M., Newberry, R.C., Spinká, M., Cloutier, S. 2002. Effects of early play experience on play behaviour of piglets after weaning. Applied Animal Behaviour Science 79, 221-231.

Douglas, C., Bateson, M., Walsh, C., Bédué, A., Edwards, S. 2012. Environmental enrichment induces optimistic cognitive biases in pigs. Applied Animal Behaviour Science 139, 65-73.

Dudink, S., Simonse, H., Marks, I., de Jonge, F.H., Spruijt, B.M. 2006. Announcing the arrival of enrichment increases play behaviour and reduces weaning-stress-induced behaviours of piglets directly after weaning. Applied Animal Behaviour Science 101, 86-101.

Dybkjaer, L. 1992. The identification of behavioural indicators of 'stress' in early weaned piglets. Applied Animal Behaviour Science 35, 135-147.

Elkmann, A., Hoy, S. 2009. Frequency of occupation with different simultaneously offered devices by fattening pigs kept in pens with or without straw. Livestock Science 124, 330-334.

Feddes, J.J.R., Fraser, D. 1994. Nonnutritive chewing by pigs – implications for tail-biting and behavioral enrichment. Transactions of the Asae 37, 947-950.

Francis, D.D., Diorio, J., Plotsky, P.M., Meaney, M.J. 2002. Environmental enrichment reverses the effects of maternal separation on stress reactivity. The Journal of Neuroscience 15, 7840-7843.

Fraser, D. 1978. Observations on the behavioural development of suckling and early-weaned piglets during the first six weeks after birth. Animal Behaviour 26, 22-30.

Fraser, D., Feddes, J. J. R., Pajor, E. A. 1994. The relationship between creep feeding behaviour of piglets and adaptation to weaning: effect of diet quality. Canadian Journal of Animal Science 74, 1–6.

Gifford, A.K., Cloutier, S., Newberry, R.C. 2007. Objects as enrichment: Effects of object exposure time and delay interval on object recognition memory of the domestic pig. Applied Animal Behaviour Science 107, 206-217.

Held, S.D.E., Spinka, M. 2011. Animal play and animal welfare. Animal Behviour 81, 891-899.

Hill, J.D., McGlone, J.J., Fullwood, S.D., Miller, M.F. 1998. Environmental enrichment influences on pig behaviour performance and meat quality. Applied Animal Behaviour Science 57, 51-68.

Hillmann, E., von Hollen, F., Bünger, B., Todt, D., Schrader, L. 2003. Farrowing conditions affect the reactions of piglets toward novel environment and social confrontation at weaning. Applied Animal Behaviour Science 81, 99-109.

Jensen, M.B., Kyhn, R. 2000. Play behaviour in group-housed dairy calves, the effect of space allowance. Applied Animal Behaviour Science 67, 35-46.

Jensen, M.B., Vestergaard, K.S., Krohn, C.C. 1998. Play behaviour in dairy calves kept in pens: the effect of social contact and space allowance. Applied Animal Behaviour Science 56, 97-108.

Jensen, M.P., Pedersen, L.J. 2007. The value assigned to six different rooting materials by growing pigs. Applied Animal Behaviours Science 108, 31-44.

Jensen, P. 1982. An analysis of agonistic interaction patterns in group-housed dry sows - aggression regulation through an “avoidance order”. Applied Animal Ethology 9, 47-61.

Jensen, P., Recén, B. 1989. When to wean – Observations from free-ranging domestic pigs. Applied Animal Behviour Science 23, 49-60.

Johnson, A.K., Morrow-Tesch, J.L., McGlone, J.J. 2001. Behaviour and performance of lactating sows and piglets reared indoors or outdoors. Journal of Animal Science 79, 2571-2579.

Lawrence, A.B., Terlouw, E.M.C. 1993. A review of behavioral factors involved in the devolpement and continued performance of stereotypic behaviors in pigs. Journal of Animal Science 71, 2815-2825.

Lewis, E., Boyle, L.A., O’Doherty, J.V., Lynch, P.B., Brophy, P. 2006. The effect of providing shredded paper or ropes to piglets in farrowing crates on their behaviour and health and the behaviour and health of their dams. Applied Animal Behaviour Science 96, 1-17.

Moinard, C., Mendi, M., Nicol, C.J., Green, L.E. 2003. A case study control of on-farm risk factors for tail biting in pigs. Applied Animal Behaviour Science 81, 333-355.

Müller-Schwartze, D., Stagge, B., Müller-Schwartze, C. 1982. Play behaviour: persistence, decrease and energetic compensation during food shortage in deer fawns. Science 215, 85-87.

Munsterhjelm, C., Peltoniemi, O.A.T., Heinonen, M., Hälli, O., Karhapää, M., Valros, A. 2009. Experience of moderate bedding affects behaviour of growing pigs. Applied Animal Behaviour Science 118, 42-53.

Newberry, R.C. 1995. Environmental enrichment: increasing the biological relevance of captive environments. Applied Animal Behaviour Science 44, 229-243.

Newberry, R.C., Wood-Gush, D.G.M. 1986. Social relationships of piglets in a semi-natural enrivonrment. Animal Behaviour 34, 1311-1318.

Newberry, R.C., Wood-Gush, D.G.M., Hall, J.W. 1988. Playful behaviour in piglets. Behavioural Processes 17, 205-216.

Nowicki, J., Kopyra, M., Klocek, C. 2007a. The behavioural reaction of weaners to hanging toys: wooden ball and aromatized wooden ball – way to decrease aggression after mixing. Journal of Central European Agriculture 8, 447-452.

Nowicki, J., Kopyra, M., Moskala, E. 2007b. The comparison of weaners housed after mixing in pen equipped with a hanging toys: object for biting and wooden ball. Journal of Central European Agriculture 8, 153-158.

Nowicki, J., Moskala, E., Kopyra, M. 2008. Behavioural response of newly mixed weaners to a hanging wooden ball and a free ball in the pen. Annals of Animal Science 8, 63-69.

O´Connell, N.E., Beattie, V.E., Sneddon, I.A., Breuer, K., Mercer, J.T., Rance, K.A., Sutcliffe, M.E.M., Edwards, S.A. 2005. Influence of individual predisposition, maternal experience and lactation environment on the responses of pigs to weaning at two different ages. Applied Animal Behaviour Science 90, 219-232.

Olsson, I.A.S., de Jonge, F.H., Schuurman, T., Helmond, F.A. 1999. Poor rearing conditions and social stress in pigs: repeated social challenge and the effect on behavioural and physiological responses to stressors. Behavioural Processes 46, 201-215.

Oostindjer, M., van den Brand, H., Kemp, B., Bolhuis, J.E. 2011. Effect of environmental enrichment and loose housing of lactation sows on piglet behaviour before and after weaning. Applied Animal Behaviour Science 134, 31-41.

Pearce, G.P., Paterson, A.M., Pearce, A.N. 1989. The influence of pleasant and unpleasant handling and the provision of toys on the growth and behaviour of male pigs. Applied Animal Behaviour Science 23, 27-37.

Pellis, M.S. 1991. How motivationally distinct is play? A preliminary case study. Animal Behaviour 42, 851-853.

Petersen, V., Simonsen, H.B., Lawson, L.G. 1995. The effect of environmental stimulation on the development of behaviour in pigs. Applied Animal Behaviour Science 45, 215-224.

Piggins, D., Phillips, C.J.C. 1998. Awareness in domesticated animals—concepts and definitions. Applied Animal Behaviour Science 57, 181-200.

Pitts, A.D., Weary, D.M., Pajor, E.A., Fraser, D. 2000. Mixing at young ages reduces fighting unacquainted domestic pigs. Applied Animal Behaviour Science 68, 191-197.

Poole, T.B. 1992. The nature and evolution of behavioural needs in mammals. Animal Welfare 1, 203-220.

Reinhardt, V., Reinhardt A.. 1982. Mock fighting in cattle. Behaviour 81, 1-13.

Schaefer, A.L., Salomons, M.O., Tong, A.K.W., Sather, A.P., Lepage, P. 1990. The effect of environmental enrichment on aggression in newly weaned pigs. Applied Animal Behaviour Science 27, 41-52.

Schouten, W.G.P., 1986. Rearing conditions and behaviour in pigs. Ph.D-thesis, Wageningen, The Netherlands.

Scott, K., Taylor, L., Gill, B.P., Edwards, S.A. 2006. Influence of different types of environmental enrichment on the behaviour of finishing pigs in two different housing systems: 1. Hanging toy versus rootable substrate. Applied Animal Behaviour Science 99, 222–229.

Scott, K., Taylor, L., Gill, B.P., Edwards, S.A. 2009. Influence of different types of environmental enrichment on the behaviour of finishing pigs in two different housing systems: 3. Hanging toy versus rootable substrate of the same material. Applied Animal Behaviour Science 116, 186-190.

Scott, K., Taylor, L., Gill, B.P., Edwards, S.A., 2007. Influence of different types of environmental enrichment on the behaviour of finishing pigs in two different housing systems: 2. Ratio of pigs to enrichment. Applied Animal Behaviour Science 105, 51–58.

Siviy, S., Panksepp, J.1985. Energy balance at play in juvenile rats. Physiology and Behaviour 35, 435-441.

Spinká, M., Newberry, R.C., Bekoff, M. 2001. Mammalian play: training for the unexpected. The Quarterly Review of Biology 76, 141-168.

Studnitz, M., Jensen, M.B., Pedersen, L.J. 2007. Why do pigs root and in what will they root? A review on the exploratory behaviour of pigs in relation to environmental enrichment. Applied Animal Behaviour Science 107, 183-197.

Toth, L.A., Kregel, K., Leon, L., Much, T.I. 2011. Environmental enrichment of laboratory rodents: the answear depends on the question. Comparative Medicine 61, 314-321.

Trickett, S.L., Guy, J.H., Edwards, S.A. 2009. The role of novelty in environmental enrichment for the weaned pig. Applied Animal Behaviour Science 116, 45-51.

Van de Weerd, H.A., Day, J.E.L. 2009. A review of environmental enrichment for pigs housed in intensive housing systems. Applied Animal Behaviour Science 116, 1-20.

Van de Weerd, H.A., Docking, C.M., Day, J.E.L., Avery, P.J., Edwards, S.A. 2003. A systematic approach towards developing environmental enrichment for pigs. Applied Animal Behaviour Science 84, 101-118.

Van de Weerd, H.A., Docking, C.M., Day, J.E.L., Breuer, K., Edwards, S.A. 2006. Effects of species-relevant environmental enrichment on the behaviour and productivity of finishing pigs. Applied Animal Behaviour Science 99, 230–247.

Van den Berg, C.L., Van Ree, J.M., Spruijt, B.M. 1999. Sequential analysis of juvenile isolation-induced decreased social behavior in the adult rat. Physiology & Behaviour 67, 483-488.

Van der Schuren, L.J.M.J., Niesink, J.M., Van Ree, J.M. 1997. The neurobiology of social play in rats. Neuroscience & Biobehavioural Reviews 21, 309-326.

Vanheukelom, V., Driessen, B., Maenhout, D., Geers, R. 2011. Peat as environmental enrichment for piglets: the effect on behaviours, skin lesions and production results. Applied Animal Behaviour Science 134, 42-47.

Weary, D.M., Fraser, D. 1997. Vocal response of piglets to weaning: effect of piglet age. Applied Animal Behaviour Science 54, 153-160.

Weary, D.M., Pajor, E.A., Thompson, B.K., Fraser, D. 1996. Risky behaviour of piglets: a trade off between feeding and risk of mortality by maternal crushing? Animal Behaviour 51, 619-624.

Wiepkema, P.R., Koolhaas, J.M. 1993. Stress and animal welfare. Animal Welfare 2, 195-218.

Wood-Gush, D.G.M, Vestergaard, K. 1991. The seeking of novelty and its relation to play. Animal Behaviour 42, 599-606.

Worobec, E.K., Duncan, I.J.H., Widowski, T.M. 1999. The effects of weaning at 7, 14, and 28 days on piglet behaviour. Applied Animal Behaviour Science 62, 173-182.

Worsaae, H., Schmidt, M. 1980. Plasma cortisol and behaviour in early weaned piglets. Acta Veterinaria Scandinavica 21, 640-657.

Yeates, J.W., Main, D.C.J. 2008. Assessment of positive welfare: a review. The Veterinary Journal 175, 293–300.

Young, R.J. 2003. Environmental enrichment for captive animals. Blackwell Publishing, Oxford, United Kingdom.

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