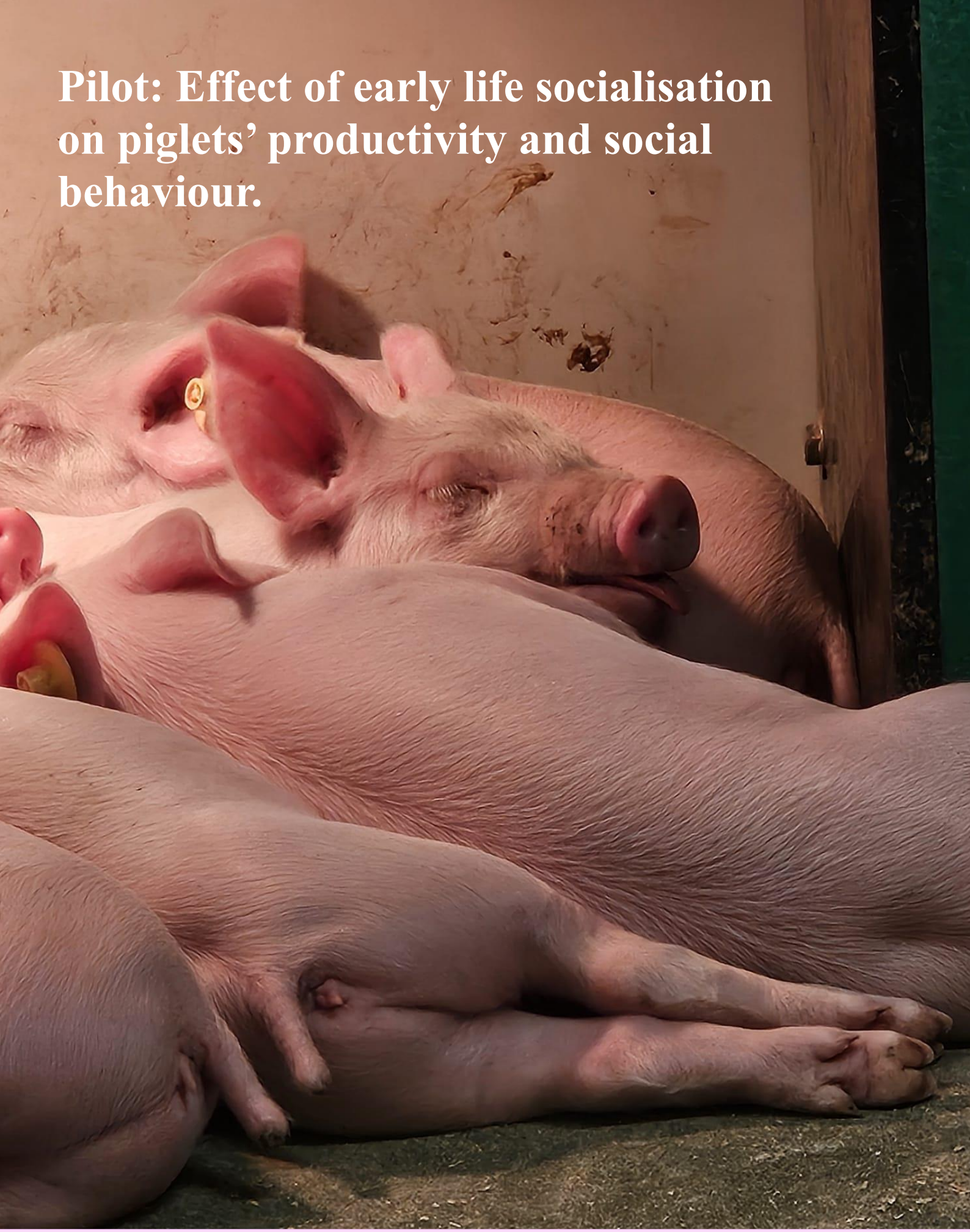
Pilot: Effect of early life socialisation on piglets' productivity and social behaviour.



Author: Chaneequa Langermans
Supervisor: Ellen Meijer
Department of Population Health sciences – Animals in Science and Society
Master Thesis Veterinary Medicine
11-04-2025, Utrecht University

Contents

Abstract
Animal welfare becomes increasingly important in today's society. One of the animals often discussed in welfare debates are pigs. Partly due to the fact that, on most commercial farms, piglets have no contact with piglets from other litters before weaning, which often leads to increased aggression and stress during the weaning period. In contrary to the natural situation, where pigs live in social groups called sounders and piglets interact with each other from about day ten onward. To increase the social skills of the piglets on a commercial farm, early life socialisation can be used. To enable this process the barrier between the farrowing crates of two or more litters can be removed whilst the sows remain in their crates. This enables the piglets to freely co-mingle. Previous studies have shown that it not only increases the social skills of the piglets, but also decreases aggression overtime because of a more quickly establishing of a hierarchy, while maintaining the weight gain of the piglets.
The aim of this pilot study is to investigate a research question about early life socialisation of piglets from the Tolakker farm, whereby a small group of animals were used as a first step to investigate which methods and materials work best in a commercial environment and make recommendations for future studies. The research is based on the question what the effect of early life socialisation on the piglets' productivity and positive social behaviour is.
Sixty-five piglets from six litters were divided into two groups, Socialised (S) consisting of 40 animals and Unsocialised (US) consisting of 25 animals. The socialised group was mixed on day 14. Four piglets in each group were selected as the focal animals. Behavioural observation (2-min focal scan sampling) using an ethogram took place on 17 different days between day 6 and 57. The skin lesions score was measured pre- and post-mixing, including weaning, and just before leaving the farm. Weight of all piglets was recorded on day 3, 13, 27 and 55.
Results showed that socialisation does not significantly affect the amount of social behaviour or the number of lesions. Bodyweight on the other hand was lower in the socialised group compared to the unsocialised group, especially at the end of the weaning period. Unfortunately, because of the small number of healthy animals and the practical issues of the farm environment, no solid conclusions could be drawn from the results. More research is needed, taking the many recommendations into consideration.

Key words
Social behaviour, piglets, early life, socialisation, animal welfare

1. Introduction

Animal welfare becomes increasingly important in today's society. People express their ethical concerns about the quality-of-life animals have, especially farm animals. However, animal welfare cannot be described and studied as a purely technical and scientific concept without involving values (Fraser, 1995; Duncan, 2005; Benson & Rollin, 2008). Despite the fact that science can provide many options to measure physical and physiological ways that can identify, solve, and prevent animal welfare problems, it cannot really measure the overall welfare of animals. This is because there is not one single measurement, or any correct way to combine different measurements, that fully removes all disagreements (Fraser, 1995). As a result, there are various definitions of the concept of animal welfare (Duncan, 2005). One of the definitions used to describe animal welfare is; '*An individual is in a positive welfare state when it has the freedom adequately to react to hunger, thirst or incorrect food; thermal and physical discomfort; injuries or diseases; fear and chronic stress, and thus, the freedom to display normal behavioural patterns that allow the animal to adapt to the demands of the prevailing environmental circumstances and enable it to reach a state that it perceives as positive".* (Ohl & Van der Staay, 2012). An important factor for the animal to experience a positive well-being is the possibility to show natural behaviour and to use natural behaviour as a tool to adapt to the living conditions (Fraser, 2008).

One of the animal species that are often discussed in debates about welfare, are pigs. There is a lot of discussion about the extent to which these animals can exhibit their natural and adaptive behaviours in commercial farming. In nature, pigs spend 75% of their active time on foraging-related behaviour and feeding (D'Eath & Turner, 2009). Exploration is closely related to foraging and even when there are no external stimuli, pigs appear to be strongly motivated to carry out this behaviour (Jensen, 2002). Another important natural behaviour of the pig is wallowing in the wet mud for their thermoregulation, removal of ectoparasites and protection from sunburn (Bracke, 2011). Pigs are highly social animals at nature and social behaviour, especially positive social interactions but also agonistic behaviour are therefore particularly important. Feral pigs live in small social groups called 'sounders', which include two to four adult sows and their piglets from last breeding season (D'Eath & Turner, 2009). In this sounder a stable hierarchy is developed and mostly maintained through active submission and avoidance behaviour by the animals that are lower in the social order (Jensen, 2002).
One to 3 days before parturition the sow separates from the group to seek a secluded farrowing site to build a nest. The nest building behaviour is initiated after a rise in Prostaglandin F2α (Burne, Murfitt & Johnston, 2001). During the first 2 weeks the sow stays close to the nest with her litter and suckling bouts occur about 30 times a day. At around 10 to 12 days of age the sow and her litter leave the nest and rejoins the other sows and piglets at the sounder (Weary & Hotzel, 2008; D'Eath & Turner, 2009). At the age of 4 to 5 weeks old, the piglets start to ingest larger quantities of solid food and this increases significantly over the next few weeks. The sow also spends more of the time apart from her piglets, gradually reducing the frequency of the suckling bouts (Weary & Hotzel, 2008; Jensen & Recén 1989; Jensen & Redbo, 1987; D'Eath & Turner, 2009). After 4 to 5 months the nursing has stopped completely and the piglets are fully weaned (Jensen & Recén, 1989).

In contrast to the natural situation, at most commercial pig farms piglets have no contact with piglets from other litters during the lactation period. Most piglets are abruptly weaned between 21 and 28 days old and then regrouped (Ji et al., 2021; Salazar et al., 2018). Weaning is one of the most stressful periods in a pig's life. Piglets are subjected to several stressors, such as an abrupt separation from the sow, stress during transportation and handling, a new food source, an unfamiliar environment and also social hierarchy stress and stress from co-mingling with piglets from other litters. This stress not only contributes to intestinal and immune system disfunctions but also leads to more aggression between the piglets (Campbell, Crenshaw, & Polo, 2013). Aggression between pigs is an important welfare issue in the pig sector in general (Camerlink et al., 2018).

Early life socialisation, sometimes also called co-mingling, can be used to increase the social skills of the piglets, and reduce aggression between them. To enable the process of early life socialisation the barrier between the farrowing crates of two or more litters can be removed whilst the sows remain in their crates. That way the piglets can freely co-mingle. The mixing of the piglets is best done somewhere between the 10^{th} and the 14^{th} day post-partum to closely resemble the natural social environment (Camerlink et al., 2018; Ji et al., 2021; Salazar et al., 2018; Weller et al., 2019).

Previous studies show, in experimental settings, that early socialisation increases social skills and maintain weight gain as normal or result in an increased growth (Hessel et al., 2006). The early socialisation environment also affects piglets' fighting behaviour, enabling piglets to quickly establish their position in a new hierarchy, and reducing fighting among weaned piglets (D'Eath, 2005; Weller et al., 2019). The study of Salazar et al. (2018) confirms those beneficial results of socialisation on a large-scale commercial pig farm.

The available research data suggest that co-mingling can increase welfare and productivity of piglets. Existing data mainly focus on piglets' productivity, growth, and aggression before and after weaning under experimental circumstances but data on social behaviours, especially positive social interactions between the piglets are scarce. However, this present study is a pilot study based on the question from the farmer at the Tolakker farm himself; What is the effect of early life socialisation on the piglets' productivity and social behaviour? This question aligns well with the overarching question of whether early life socialisation increases the positive social interaction between the piglets and decreases the aggression and number of lesions after weaning? This pilot study involved only a small group of animals, as an initial step to investigate which materials and methods work best in a commercial environment such as the Tolakker to answer those questions. The most important aim of the study is therefore to provide recommendations for future research.

Although the present study was a pilot study, the conducted measurements related to the following hypotheses: that early life socialisation would increase social (agonistic and play) behaviour in piglets during lactation and weaning and would reduce the number of skin lesions after mixing at weaning compared to unsocialised piglets. Secondly that the piglets that are early socialised maintain weight gain as normal or show an increased weight gain after weaning compared to unsocialised piglets.

For the behavioural observations, an ethogram was used based on the studies from Bolhuis et al., 2005, Cordoni et al., 2021 and Park et al., 2010. The different behaviours are grouped together in seven groups; Social behaviour, Maintenance behaviour, Aggressive behaviour,

Manipulative behaviour, Play behaviour, Chasing and Other. The behaviour chasing was a primary group on its own, because the behaviour can be meant as play behaviour, but also as aggressive behaviour towards the other piglet (Cordoni et al., 2021).

2. Materials and methods

2.1. Ethical note

The study took place from November 2023 till February 2024 on the Tolakker farm, a research farm of the University of Utrecht that also operates as a commercial unit. The study was conducted in accordance with the recommendation in the European Guidelines for the accommodation and care of animals and Dutch Government animal welfare codes and guidelines. The project was reviewed and approved by the ethical committee of the IvD Utrecht. They did not categorize it as an animal experiment because the study included no aversive stimuli or any physical harm to the animals.

2.2. Animals and housing; lactation phase

Sows

Five Hampshire x Large White sows and one Large White x Norsvin Landrace sow selected by the farmer were inseminated with Topigs Norsvin Tempo semen from the same boar. The age of the sows variated between 17 and 42 months. All sows were multiparous (second-sixth parity).

Housing

The separate farrowing pens (242cm x 238cm) contained a conventional farrowing crate for the sows (60cm x 210cm) and a heated creep for the piglets (90cm x 121cm). 50% of the floor of the farrowing pens was solid concrete and the other 50% at the back was slatted. The temperature in the pen varied between 18.2 and 21.9 degrees Celsius. Several types of enrichment were provided in the farrowing pen. The first days there was sawdust in the heated creeps. Also at the back of each farrowing pen was a chain with a plastic stick and a rope for the piglets to play with. The front of each farrowing crate contained a chain with a plastic ball or block and the end of it for the sows. Furthermore, a handful of corn cob mix was thrown on the ground each day.

Feeding

Sows were fed Premium lacto start in the feeding trough at the front of the farrowing crate, from the moment the sows entered the farrowing pens until two days after parturition. All sows received 2x2kg/day. The startup feed was followed by Premium Laction Comfort, three times a day, the amount varied between 2-8 kg/day depending on the genetics and the age of the sow and the number of piglets in the litter. This was fed until the sows left the farrowing pen. The sows had unlimited access to water.

For the first 48 hours, the piglets were not given any additional food to encourage them to ingest the colostrum first. After 2 to 3 days additional artificial nurse milk was provided twice a day until 11 days of age. After 8 days the milk was replaced with nurse pellets twice daily. From the age of 20 days old the nurse pellets were mixed with creep feed in the form of crumble (Prevent 3 crumble) and after 23 days only Prevent 3 was given. All feed was produced by The Heus Voeders B.V., Ede, The Netherlands, see appendix A for the exact composition of the feed.

2.2.1. Experimental design: Lactation phase

Six days before expected parturition, the six gestating sows were showered, weighed, and allocated to separate farrowing pens.
A total of 65 piglets (27 males and 38 females) were born from six litters (2-7) and divided into two groups, Socialised (S) and the control group or Unsocialised (US). Litters 3, 4, 5 and 6 with a total of 40 piglets were socialised at day 14 by removing the barrier between the two farrowing pens while the control litters 2 and 7 with a total of 25 piglets remained in their own farrowing pens.

Three days after birth all piglets were weighed and ear tagged. The ear tag was coloured red, blue, or green to differentiate piglets from different litters. The piglets also received 1 ml of a needle-free iron injection MS FerroSafe (MS Schippers, Bladel The Netherlands), subcutaneously in the neck just behind the ear, their tails were docked, 1 ml of Toltrazuril (Baycox Multi, Bayer Animal Health, Leverkusen Germany), orally to treat coccidia was given and a vaccination Vepured ®(HIPRA, Girona Spain) was given intramuscular in the neck just behind the ear against edema disease. No teeth clipping or castration were performed. At 3 weeks of age an intramuscular vaccination with Porcillis (PCV M. Hyo, MSD Animal Health, Brussel Belgium), was given in the neck just behind the ear against Circo and Mycoplasma hyopneumoniae and Lawsonia intracellularis.

2.2.2. Socialisation

At 14 days of age the barriers between two neighbouring farrowing pens were removed while the sows stayed in the farrowing crates. This allowed the piglets to move freely around the two farrowing pens and interact with the piglets from the other litter. The two remaining control litters were kept isolated within their own farrowing pen as is standard practice on most commercial pig farms.

2.3. Weaning phase

Housing

During the weaning period conventional weaning pens (146cm x 377cm) were used. 47% of the floor of the pen was solid concrete and the other 53% was slatted (dived between front and back). The temperature in the pen varied between 19.4 and 24.5 degrees Celsius during the weeks. Several types of enrichment were provided in the weaning pen. At the front of each pen there was an enrichment station (Figure 1). Also, a handful of lucerne was thrown on the solid part of the floor each day.

Feeding

The piglets had unlimited excess to water and food during the weaning period. Until 10 days after weaning Prevent 3 crumb was mixed with prevent 5 food. Three weeks after weaning only prevent 6 food was given. All feed was produced by The Heus Voeders B.V., Ede, The Netherlands, see appendix B for the exact composition of the feed.

Experimental design

At the mean age of 26 days old the barrier between the farrowing pens was closed again and the sows were removed from the farrowing pens and transported to the insemination stable, leaving the piglets behind. All piglets were then weighed, sorted by sex, assigned to a new group (1-6), and mixed again (see Table 1). The lesion score was also determined for the focal piglets. After this, all the piglets were moved to the new weaning pens per group.

Group	1	2	3	4	5	6
Number of animals	8	12	8	12	11	12
Sex	Boar	Sow	Boar	Sow	Boar	Sow
Socialised (S) / Unsocialised (US)	S	S	S	S	US	US

Table 1. reassignment of the groups during weaning.

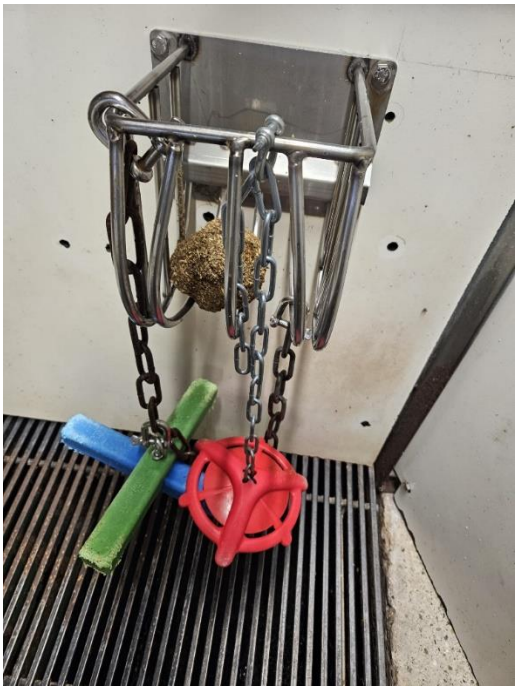


Figure 1. Enrichment station during the weaning phase.

2.4. Behavioural observations

Pre-weaning and post-weaning social behaviour was observed for a total of 20 individuals (10 males and 10 females) from five litters. These were the focal animals. Inclusion criteria: the bodyweight of the piglet had to be within one standard deviation from the mean body weight of the litter and had no visible signs of birth defects. From the piglets that met the inclusion criteria a random selection was made to select the focal animals.

A number was sprayed on the back of the focal animals with a colour stock marker. From the age of 6 to 57 days, behaviour of the piglets was observed using 2-min focal scan sampling with an interval of 20 seconds to write down all the different behaviours. During the lactation period observations were conducted every Monday, Wednesday and Friday and started at approximately 9:00 AM and 3:00 PM. During the weaning period observations were carried out Wednesday and Friday and started at approximately 9:00 AM and 3:00 PM. All observations were performed by the same observer.

The ethogram used for the observations is given in Table 2.

Due to the small number of observation, after the observations were performed, the behaviour patterns were regrouped in the seven primary categories based on Bolhuis et al., 2005,

Cordoni et al., 2021 and Park et al., 2010; Social behaviour, Maintenance behaviour, Aggressive behaviour, Manipulative behaviour, Play behaviour, Chasing and Other. Social behaviour consisted of nuzzling, mounting, grooming, body contact and nosing. Maintenance behaviour consisted of eating, drinking, and sleeping. Aggressive behaviour consisted of head knocking, biting, and fighting. Play behaviour consisted of hopping, rolling, gambolling, and pivoting. Manipulative behaviour of nibbling, sucking, or chewing an ear, tail, or any other part of a pen mate. Chasing and Other behaviour were just on its own.

Behaviour pattern	Description
Nuzzling	Touching of sniffing any part of the head or body of a pen mate
Mounting	Placing both front hoofs on the back of a pen mate
Grooming	Using teeth to carry out hair cleaning on the pen mate
Body contact	Touching by part of the body except for the nose for a minimum of 5 sec.
Nosing	Two piglets tough one another with their noses
Head knocking	Ramming or pushing pen mate with head, without biting
Biting	Ramming or pushing pen mate with head, with biting
Fighting	Mutual pushing or ramming, or lifting pen mate
Chasing	Walking or running after a pen mate
Gambolling	Running across the pen, occasionally accompanied by nudging pen mate gently
Pivoting	Jumping and turning around body axis, usually associated with jumping on the spot
Rolling	Lying on back and moving side to side on the floor
Hopping	Energetic jumping movement where the two front feet or all four feet come off the pen at one time. The piglet continues facing the same direction.
Manipulating	Nibbling, sucking, or chewing an ear, tail, or any other part of a pen mate
Sleeping	Lying on side or belly with eyes closed
Eating	Eating from food trough or chewing food
Drinking	Suckling milk from teat sow
Other	Standing, walking, or lying without performing any other described behaviour

Table 2. Ethogram social behaviour in piglets integrated or modified from (Bolhuis et al., 2005; Cordoni et al., 2021; Park et al., 2010).

2.5. Growth performance

All piglets were weighed individually 3 days after birth, the day before mixing (day 13), the day before weaning (day 27) and 5 days before leaving the farm (day 55). Those measurements were used to calculate the average weight gain per day of each individual.

2.6. Lesion score

On day 13, 15, 27, 29 and 57 the lesion score of the focal animals has been determined using a modified version of the method from the welfare quality assessment protocol (Blokhuis, 2009) for pigs. The piglets were picked up to take a closer look at the lesions and both sides of the body were inspected.

The piglet's body was divided in five separate regions (figure 2) and the tail:

1. Ears
2. Front (head to back of shoulder)
3. Middle (back of shoulder to hind-quarters)
4. Hind quarters
5. Legs (from the accessory digit upwards).
6. Tail

Each region was scored using the following scale:

a. No visible skin injuries, or up to four lesions visible
b. 5 to 10 lesions visible
c. 11 to 15 lesions visible.

Classification on an individual level:

0. All body regions with an individual score 'a'
1. Any body region with an individual score 'b' and/or a maximum of one body region with an individual score 'c'
2. Two or more body regions with an individual score 'c,' or at least one body region that has more than 15 lesions.

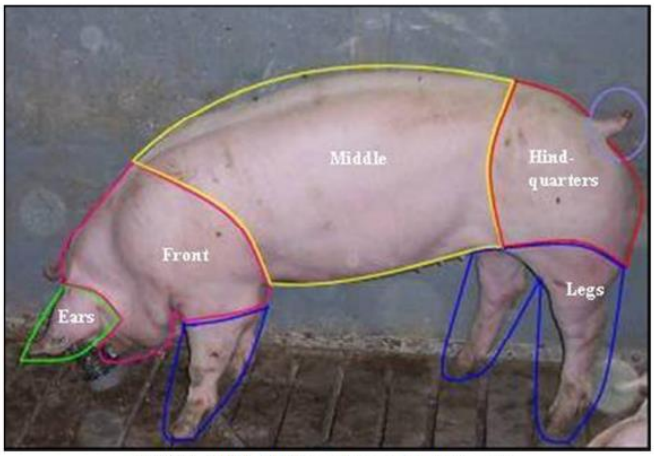


Figure 2. Six separate body regions used in the welfare protocol for pigs (Blokhuis, 2009).

2.7. Statistical analyses

Data were analysed using R-studio version 2023.12.1+402 and the following packages were used for all the analysis: ggplot2, plyr, lme4, ImerTest, Matrix, ggpubr, tidyverse, broom, AICcmodavg. A value of $p < .05$ was considered to be significant. The data of the weight score were analysed using a linear mixed model, with litter and piglet ID as random effects and day and socialised status as fixed effects. The DHARMa nonparametric dispersion test (see appendix C) and the AIC are used to choose the best model. The lesion score was analysed using a two-way factorial (socialised and day) analysis of variance, an ANOVA.

The behavioural observations were divided into seven main groups; Social behaviour, Maintenance behaviour, Aggressive behaviour, Manipulative behaviour, Play behaviour, Chasing and Other behaviour. Both social behaviour, maintenance behaviour and aggressive behaviour were analysed using a linear mixed model, with day as random effect and socialised status as fixed effect. The AIC was used to choose the best model. Also, a boxplot and line chart were made with the observations per day per socialised status. For the other four behaviours no statistical analysis were done, because of the small number of occurrence and the relevance for this study.

3. Results

During the study one sow was treated for clinical mastitis and another sow and two piglets were treated for lameness via an intramuscular injection in the neck, just behind the ears with Procaine benzylpenicillin (Depociline, MSD Animal Health, Brussel Belgium) and Meloxicam (Novem, Boehringer Ingelheim, Ingelheim Germany) following the farm treatment plan. In total four piglets had to be euthanised during the study, due to weakness and anorexia, extreme lameness, or intra-uterine growth retardation. One of those piglets was first included in the experimental group (focal piglet). On the selection day the piglet felt within the inclusion criteria. However, on the first day of the observations the piglet was excluded because of weakness and anorexia and two days later euthanised. After the study two of the six sows were transported to a slaughterhouse due to mastitis and multiple small litters. A third sow was euthanised on the farm due to an extremely low bodyweight (1/5 BCS) and multiple pressure sores.

Litter four was one of the socialised litters. However, only three piglets were born alive and the other ten were mummified. The piglets that lived also showed signs of intra-uterine growth retardation. As a result, a total of seven piglets from five different litters and even from different departments were placed by this sow. This made it impossible to proper select the focus piglets in this group, because older piglets were added and these piglets were essentially already socialised from the moment they were cross-fostered. This together no longer provided a good representation of the group. Therefore, was decided to exclude the litter from the behavioural observations or lesion scoring. The litter was still included for measuring of the weight gain, this because all the piglets were weighed, not only the focal piglets. Furthermore, the piglets from this litter were used to socialise with the piglets from litter three. Otherwise, even less data would be available for the statistical analysis.

3.1. Weight

The litter the piglets were born in influences weight, but the socialisation effect appears to be minimal with the US group having slightly higher weights. Variability in weight is high across all litters. At every measuring point the weight increases in both groups (figure 3). Overall, the US group has a higher mean weight, especially on day 55, suggesting that socialisation has an effect on weight gain over the longer term.
The linear mixed model shows that the weight of the piglets increased significantly at each measuring point (day) with $p < .001$. While the effect of socialisation was minor and not significant, the estimate on day 55 is -.18 which indicates that the S group had a lower weight than the US group. With $p = .09$ on day 55 this was also not significant though.

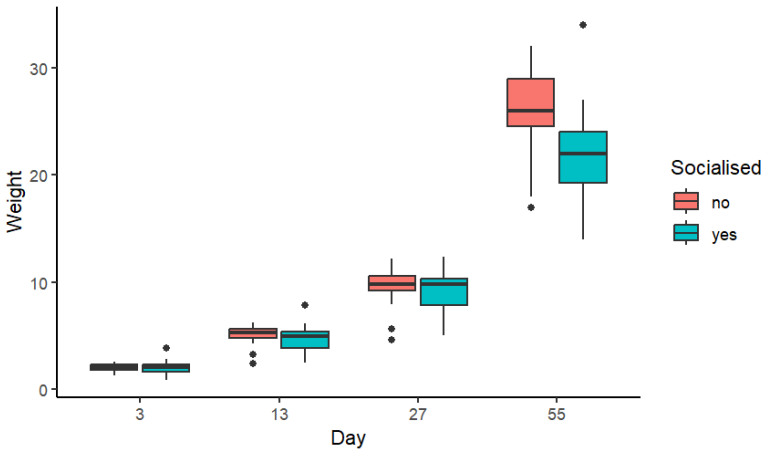


Figure 3. Average weight gain per day per socialised status.

3.2. Lesion score

For the US piglets there was no difference in lesion score between day 13 and 15 (figure 4). The S piglets on the other hand show more of a shift from lesion score 0 to 1. These piglets are mixed on day 14 with piglets in a neighbouring pen.

The p value for socialisation was p = .27, which indicates that there was no significant effect of socialisation on lesion score. On the other hand, the p value for day was p < .001 which indicates that there was a highly significant effect of day on lesion score. In consequence, the number of lesions fluctuated between the days, which was reflected in the highly significant effect on lesion score found in the statistical analysis. The number of lesions was more or less the same if divided across the days (Appendix D). There was however a difference in the moment at which the lesions occur between the groups (S vs US).

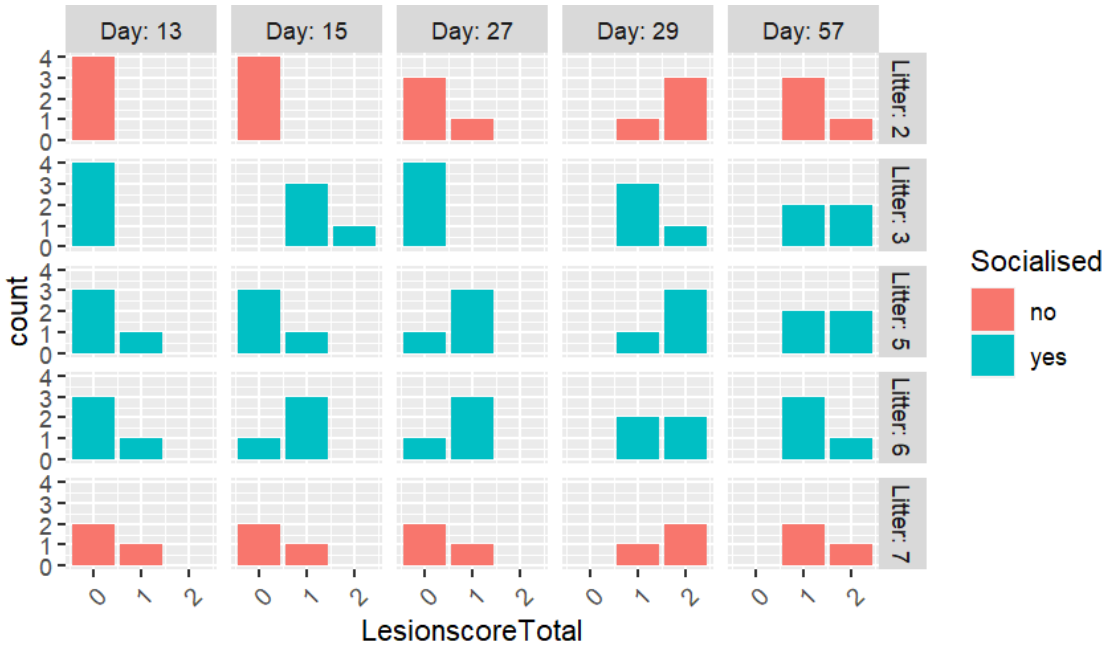


Figure 4. Lesion score per litter per day per socialised status.
Day 14: mixing two neighbouring pens for socialisation
Day 28: weaning
Day 57: leaving farm
Socialised: 16 piglets
Unsocialised: 7 piglets

3.3. Behaviour

3.3.1. Social behaviour

The average amount of social behaviour including nuzzling, body contact, nosing, mounting, and grooming, increased over time. Early on, at day 6 to 15 the median amount of social behaviour observed per group on those days varied between 1-3. From day 18 onward the values significantly increased ($p = .02$) and on day 29 there was a large significant increase +3.58 and $p < .001$. At the end, the values stabilized to an average of 5-7 (figure 5). There was only a decrease in social behaviour noticeable on day 43, indicating an increase in social behaviour as the piglets mature.

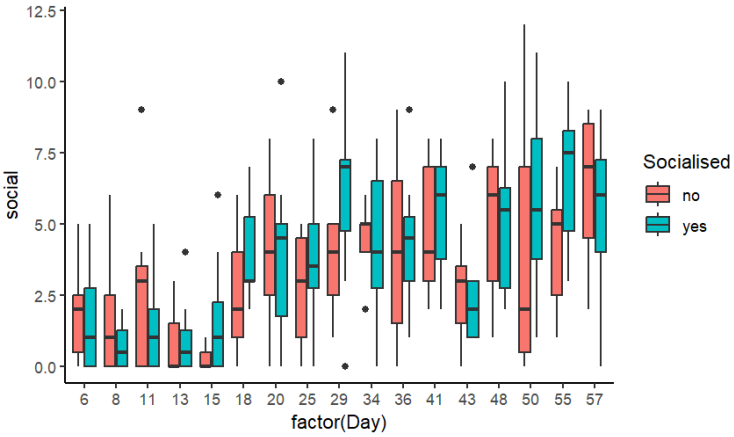


Figure 5. Mean social behaviour per day per socialisation status.

3.3.2. Maintenance behaviour

The average maintenance behaviour including; sleeping, eating, and drinking decreases from day 13 on, especially for the S group (figure 6). The value for maintenance behaviour decreases significantly to the lowest point on day 43, with -9.68 and $p < .001$. The US group starts higher and declines slower, with more fluctuations. The US group remains above the S group, except for day 34 and 36.

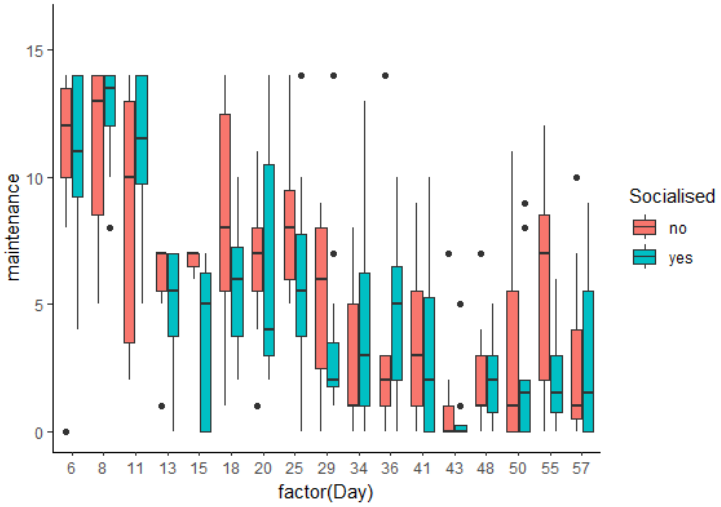


Figure 6. Mean Maintenance behaviour per day per socialisation status.

3.3.3. Aggressive behaviour

The average aggressive behaviour including; head knocking, biting, and fighting was the highest overall in de S group, except for the early days 6, 8 and 11 and days 29 and 34 where the S group declined and the US group peaked (figure 7 and Appendix E). Day 29 was one day after weaning. The aggressive behaviour in the S group was low up to and including day thirteen, after it increases, probably due to the socialisation on day fourteen. However, the p value for socialisation was p = .17 and therefore not significant.

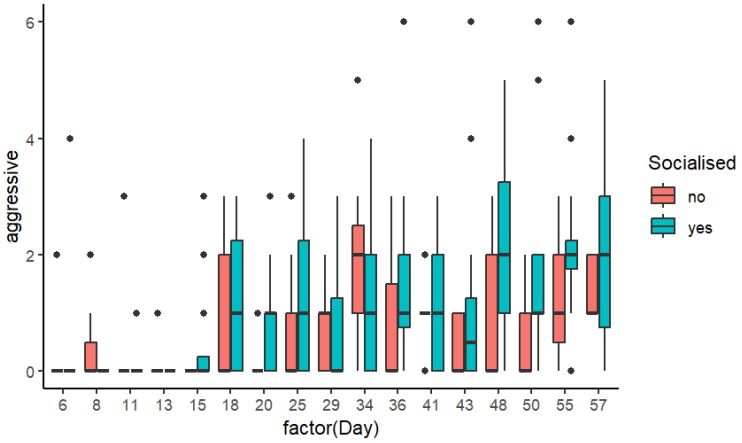


Figure 7. Mean aggressive behaviour per day per socialisation status.

3.3.4. Manipulative behaviour

The average amount of manipulative behaviour consisting of nibbling, sucking, or chewing an ear, tail or any other part of a pen mate was observed 3.4 times per piglet in the S group and 4 times in de US group per piglet. Furthermore, the manipulative behaviour was in both groups highly variable during the different days. There was no clear upward or downward trend. The numbers are very small, and so no definite conclusions could be drawn.

3.3.5. Play behaviour

Play behaviour consisting of hopping, rolling, gambolling, and pivoting was observed 34 times in the S group in comparison with two times in the US group. Suggesting that socialisation has a positive effect on play behaviour, but more data are required.

3.3.6. Chasing

Chasing was only observed three times in total in the S group and not in the US group, therefore no statistical analysis were performed.

3.3.7. Other

The average observed other behaviour including; standing, walking, or lying without performing any other described behaviour, increases over time in both groups. The US group shows more other behaviours than the S group, except on day 13 and 15, where the US group shows a massive dip. On day 43 both groups show a dip in the observed behaviour. The US group also shows more fluctuations than the S group.

4. Discussion

This pilot study explored the effect of early socialisation in piglets on a commercial pig farm without altering any routine management except the treatment. The most important aim of the study was to investigate the materials and methods for the first time and to make recommendations for further studies. Results showed that socialisation does not significantly affect the amount of social behaviour or the number of lesions. Bodyweight on the other hand was lower in the S group, especially at the end of the weaning period.

During this study the behaviour, weight gain and lesion score of six litters of piglets were observed. However, there were some problems with the research groups: (very) small litters, a few deformed or small piglets and some piglets or sows with health problems. This influenced the outcome, because of the small number of animals that could ultimately participate in the experiment. For the behavioural group's manipulative, play and chasing no statistical analysis were performed, due to the small number of observations in those categories.

4.1. Weight

The bodyweight of the piglets increased significantly at each measuring point. Overall, the US group had a higher mean bodyweight, especially towards the end of the study. Although the effect of socialisation on weight gain was not significant ($p = .09$), on day 55 the difference in weight between the two groups was quite large. It is possible if the piglets were followed for a longer amount of time, the effect eventually would become significant. These findings were also in contrast with the hypothesis; the piglets that are early socialised maintain weight gain as normal or show an increased weight gain after weaning compared to unsocialised piglets, and therefor this hypothesis was rejected.

Other studies conducted in controlled experimental environments found the opposite result (D'Eath, 2005, Hessel et al., 2006, Ji et al., 2021, Kanaan et al., 2008, Morgan et al., 2014). These studies showed an increased or no effect of early socialisation on the piglet's bodyweight. However, Salazar et al., 2018 also showed an increased bodyweight in the control group compared to the socialised group. Also, Verdon et al., 2016 showed that piglets in conventional systems grow faster compared to piglets in multi-suckling systems. These authors suggested that the difference in weight gain may be due to the difference in activity during the lactation phase. Due to more social interaction and more space for socialised piglets in those studies there was increased activity and less time for eating and sleeping. Salazar et al., also mentioned less variation in bodyweight in the control group, similar to the results found in the present study. In this study the difference in bodyweight was mainly present towards the end of the weaning period when all the piglets have the same amount of space. Also, the S group did not show significantly more social behaviour than the US group. The S group did however show more play behaviour and more aggressive behaviour, but due to the small number of animals no hard conclusions can be drawn and it may be possible that the S group had an increased activity compared to the US group. In the raw data the US group had an increased maintenance behaviour compared to the S group, whereby the average sleeping behaviour was slightly higher, which corresponds with slightly less observed activity in this group. Another factor that could create a difference in weight gain, especially during the lactation phase, was cross-suckling. However, as expected based on the results from the study by Morgan et al., 2014, the occurrence of cross-suckling was very low and did not influence the weight gain in this study, as the S group had a lower weight as the US group.

For next time, it is important to monitor the piglets for a longer period of time to increase the likelihood of detecting a significant difference in weight gain between the groups.

Additionally, it is better to monitor the difference in weight gain per day than to only monitor the different weights. While a small piglet can gain the same number of grams per day as a larger piglet, the overall weight will still be lower.

4.2. Lesion score

The effect of socialisation on the lesion score was not significant, the effect of day was on the other hand, highly significant. Day was highly significant because, the number of lesion fluctuated between the days and the individual piglets. On the days that de piglets were mixed (day 13 and day 28), the number of lesions increased. The US group did not show a difference between day 13 and 15 in lesion score. The S group on the other hand, showed a shift from 0 to 1. This was expected, due to the mixing of the piglets on day 14. Socialisation was not significant and did not necessarily mean a decrease in lesions. However, after weaning a decrease in the S group was expected as the hierarchy was sooner established (D'Eath, 2005). Nevertheless, the lesion score in the S group did not decline at the end of the study and stayed high. Despite that, due to the small number of animals, these results are purely observational and no definitive conclusions can be drawn. These results did, however, not support the hypothesis for the lesion score: The number of skin lesions of the socialised piglets will be lower at weaning compared to the unsocialised piglets and was therefore rejected.

Contrary to the D'Eath and the current study, Verdon et al., 2016; van Nieuwamerongen et al., 2015 and Parrat et al., 2006 have found that early socialisation of piglets reduced the number of skin lesion from 8 hours to 12 days after weaning. The study from D'Eath, 2005 showed more skin lesions after mixing in the S group compared to the US group, but after day 60 it was the opposite. Suggesting that the aggression declined to a lower level more quickly. In the current study the piglets left the farm on day 57, so there was no observation of the lesion score after that. This suggested that for the next study it is important to follow the piglets to the fattening farm, to monitor the trend of the lesion score for a longer period of time. Another limiting factor was the way the lesion score was measured. A score of 0 does not necessary mean 0 lesions. Sometimes the overall number of lesions of the litter was lower than that in another litter, but the lesion score measured was higher.

4.3. Behaviour

Here again, it is important to keep in mind that the number of observations were too small to draw reliable conclusions. It was more about observing a trend for further studies. Also, the effect of the litter was not included in the statistical analysis, although it likely has an impact on the outcome. For example, at one point, a specific behaviour (Mounting/Head knocking) was frequently observed in one litter and very little in another, this still resulted in a relatively high average across litters.
Also, a decline in Social, Maintenance, and Other behaviour was observed on day 43. However, this was expected, as the behavioural observations were conducted only in the afternoon and not in the morning due to practical constraints.

4.3.1. Social- and Play behaviour

The average amount of social behaviour increased over time. From day 18 onward the values increased significantly, whereas at the end of the weaning period the values stabilized. This indicated that the amount of social behaviour increased as the piglets mature. During the first weeks, most of the day consists of sleeping and suckling. Newberry et al., 1988 also found that the amount of play- and social behaviour towards other piglets increases with age, with a peak in activity at week 2 to 6.

Play behaviour was observed more frequently in the S group than in the US group, suggesting that socialisation has a positive effect on play behaviour. However, due to the limited number of observations, no statistical analysis were conducted and more data are required to draw conclusions.
These findings did not support the hypothesis that early socialisation would increase social (agonistic and play) behaviour in piglets during lactation and weaning, and it was therefore rejected. In contrast to studies from Van Nieuwamerongen et al., 2015, Salazar et al., 2018 and Singh et al., 2017 among others, which did indeed find a significant increase in the amount of social and play behaviour in the socialised piglets compared to the unsocialised piglets. However, they used a much larger group of piglets.

However, it seems that the S group showed more social behaviour over time and more play behaviour. Although, more research is needed with a larger group of animals so more statistical analysis can be done.

4.3.2. Maintenance behaviour
The average maintenance behaviour decreased from day 13 onwards, especially in the S group. This was expected, as from two weeks of age more social and play behaviour could be seen and there was less time left for the maintenance behaviour. The older the piglets get, the less time they spent on sleeping, and more time on social behaviour and exploring (Newberry et al., 1988). The US group spent more time on maintenance behaviour compared to the S group, however the difference was not significant. This was also because the S group spent more time on other behaviours, like social behaviour.

This was also in line with the study from Bolhuis et al., 2005, where the maintenance behaviour decreased significantly with age, but the type of housing (socialised/unsocialised) had no significant effect on the maintenance behaviour.

4.3.3. Aggressive behaviour
The average aggressive behaviour was the highest overall in de S group, except for the early days and day 29. Day 29 was one day after weaning which can explain the spike in the US group, because this was the first time those piglets encountered piglets from other litters. The aggressive behaviour in the S group increased from day 13 onward. This can be explained because the piglets were mixed on day 14. Even though there were differences in the amount of aggressive behaviour between the groups, again it was not significant.

After mixing an increase in aggression was expected as the piglets fought for dominance and a new hierarchy. According to the study from D'Eath, 2005, this aggression was helpful to increase the social skills and therefor reduce the amount of aggression during weaning, because of a more stable hierarchy formation. Camerlink et al., 2018 also suggested that early socialisation had an influence on the piglet's perception when meeting unfamiliar individuals after weaning and that less fighting would occur. However, the results of this study did not align with these findings. Aggression in the S group did not stabilise faster than in the US group after weaning. This was also reflected in the lesion score, which showed no significant difference between the groups at day 29 or 57. This could be due to the fact that litter four (from the S group) was already mixed at day 0, then mixed again at day 14 and then after weaning at day 28 again.

4.3.4. Manipulative behaviour

The US group shows a bit more manipulative behaviour compared to the S group. However, the manipulative behaviour was in both groups highly variable over the days. There was no clear upward or downward trend. The numbers are small, and so no definite conclusions can be drawn. Nevertheless, it is important to observe this behaviour, as it can be quite harmful. This is because of the fact that, manipulative behaviour consists of nibbling, sucking, or chewing an ear, tail or any other part of a pen mate and it can be connected to tail biting. Sometimes it is even considered as the initial phase of it (Hakansson & Bolhuis, 2021).

4.3.5. Other behaviour

The US group showed more other behaviour than the S group, but since this category was so diverse no conclusions can be drawn from it. For next time it is important to breakdown 'Other behaviour' into more different behaviours in the ethogram. All the behaviours in this group had quite different internal motivations and it was not possible to find one suitable explanation for all. Pen exploring is also an important behaviour, which was observed multiple times, but was not included in the ethogram during this study because it did not seem particularly important at the start. In the future studies, it is important to include this behaviour, as it seemed that the S piglets showed the behaviour more, being more curious than the US piglets.

4.4. Recommendations

This study was performed on a commercial farm where nothing in the daily management was changed, expect for the experimental design. There were a lot of things that could not be influenced, such as the condition of the sows, the size of the litters, the pens, and surroundings and so on. This was vastly different to controlled experimental environments. Also, mistakes were possible, for example one of the sows had the wrong feeding schedule. It is important to make clear instructions and agreement at the beginning of the study. So, when any issues arise, there can be anticipated immediately, because even little mistakes can influence the study outcome. It is also important to establish clear in- and exclusion criteria and to make sure that those can be ensured throughout the study, enough animals must be included at the start. In the lactation pens, the sows were not placed randomly, but in the order the animal caretaker had decided to. Ideally, the sows would be assigned randomly next time and blindly observed, but this will not be possible because of the colours on the bag of the animals.

From day three on, the piglets had their own ID because they were eartagged. The bodyweight was therefore measured from day three onward. For next time it is recommended to eartag the piglets on the day they are born, so. the birth weight of every piglet is known and can be used as the starting point. Also, when piglets are transferred to another litter and sow, due to a small number of piglets in a litter, it is possible to identify in what litter they were born

In this study a lot of older piglets were cross-fostered in pen four from other litters, and therefore no focal piglets were determined from this litter. Another piglet was already included to determine the average weight of the litter and then moved to another litter. This should be avoided in the next study.
In the study from Camerlink et al., 2018, the piglets were regrouped based on their weight. This resulted in more uniform litters, making the average weight of the litters more representative of the actual weight gain of the piglets. In this study, the average weight of the litter could be high, even though some piglets were not growing well. For future studies, this approach could be considered or alternatively, the average daily weight gain per piglet could be monitored to better determine the growth rate.

During the study observations were done at 9:00 AM and 3:00 PM due to practical reasons. Especially the first weeks the piglets were asleep during most of the observations. The study of (Besteiro et al., 2018) shows that activity of the piglets spikes at 10:00 AM and 6:00 PM. The study was conducted by only one student and therefore the observations were done on slightly various times, where the order of scoring was always the same. This was however based on the number of the pens, not randomly chosen. Also, before the observations could be performed, a number was sprayed on the back of the focal piglets. This had to be repeated at the beginning of every morning, what resulted in stress just before the observation.

Often directly after the scoring of the behaviour a lot of activity was observed. Therefore, we recommend placing cameras in the pens next time, so a lot more social behaviour can be observed afterwards. This can also help to observe more play and chasing behaviour, which was very limited observed during this study. What is also important is to let the piglets get used to the observer being in the room. After approximately 10 minutes the piglets are calmer and observations can be made.
The ethogram was designed based on literature and deliberations with the animal caretakers on the farm. For example, belly nosing was left out because it was never observed on the farm before by the animal caretaker. Despite this fact, belly nosing was observed quite a few times during the observations and therefore it is recommended to include it to the ethogram next time. Additionally, pen exploring and interaction with the enrichment materials could be included as separate behaviours in the ethogram, as there appears to be a slight difference between the two groups. Currently, these behaviours were in the group 'Other behaviour,' however laying and staying were also in this group and have quite different internal motivations. Therefor it is better to make the ethogram more extensive next time.

For further studies it is also important to follow the piglets for a longer period of time. So, the long-term effects of early socialisation on the pigs can also be followed and the social skills of the piglets on the finishing farm can be observed. Also, it is important to include enough animals at the start of the next study, so more definite conclusions can be drawn and more statistical analysis are possible to perform. Furthermore, when the animals do not meet the inclusion criteria anymore during the study, the whole litter can be excluded and there are still enough animals for the observations.

Finally, focus more on the effect of early life socialisation on the health and welfare of the sows. During this study, some cross-suckling was observed and some sows were treated for mastitis. For next study it is important to find out if those two events are connected. In addition, the behaviour of the sows towards unfamiliar piglets, during the study some sows were aggressive towards piglets from the other litter during the socialisation period. This can be stressful for the sow and for the piglets.

5. Conclusion

The most important aim of this study was to evaluate which materials and methods work best within the commercial environment of the Tolakker farm and to provide recommendations for future research on the effects of early socialisation in piglets. Unfortunately, due to the limited number of healthy animals and the practical constraints of the farm environment, as well as the challenges of working independently, no definite conclusions can be drawn from the results. Further research is needed, taking into consideration the many recommendations proposed throughout the study.

6. Acknowledgements

I would like to thank my supervisor Ellen Meijer for all the help and support over the past period. Additionally, I want to thank everyone at the Tolakker farm, with special thanks to Evelien and Jan, for all their help and hospitality. I have genuinely enjoyed my time with the pigs!

References

Benson, G. J., & Rollin, B. E. (2008). *The well-being of farm animals: challenges and solutions*. John Wiley & Sons.

Besteiro, R., Arango, T., Rodríguez, M. R., Fernández, M. D., & Velo, R. (2018). Estimation of patterns in weaned piglets' activity using spectral analysis. *Biosystems Engineering*, *173*, 85-92.

Blokhuis, H. J. (2009). Welfare quality assessment protocol for pigs. Retrieved from

https://www.welfarequalitynetwork.net/media/1018/pig_protocol.pdf

Bolhuis, J. E., Schouten, W. G., Schrama, J. W., & Wiegant, V. M. (2005). Behavioural development of pigs with different coping characteristics in barren and substrate-enriched housing conditions. *Applied Animal Behaviour Science*, *93*(3-4), 213-228.

Bracke, M. B. (2011). Review of wallowing in pigs: Description of the behaviour and its motivational basis. Applied Animal Behaviour Science, 132(1-2), 1-13.

Burne, T. H., Murfitt, P. J., & Johnston, A. N. (2001). PGF2α-induced nest building and choice behaviour in female domestic pigs. *Applied Animal Behaviour Science*, *73*(4), 267-279.

Camerlink, I., Farish, M., D'Eath, R. B., Arnott, G., & Turner, S. P. (2018). Long term benefits on social behaviour after early life socialization of piglets. *Animals*, *8*(11), 192.

Campbell, J. M., Crenshaw, J. D., & Polo, J. (2013). The biological stress of early weaned piglets. *Journal of animal science and biotechnology*, *4*(1), 19.

Cordoni, G., Gioia, M., Demuru, E., & Norscia, I. (2021). The dark side of play: play fighting as a substitute for real fighting in domestic pigs, Sus scrofa. *Animal Behaviour*, *175*, 21-31.

D'Eath, R. B. (2005). Socialising piglets before weaning improves social hierarchy formation when pigs are mixed post-weaning. *Applied Animal Behaviour Science*, *93*(3-4), 199-211.

D'Eath, R. B., & Turner, S. P. (2009). The natural behaviour of the pig. In *The welfare of pigs* (pp. 13-45). Dordrecht: Springer Netherlands.

Duncan, I. J. (2005). Science-based assessment of animal welfare: farm animals. Revue scientifique et technique-Office international des epizooties, 24(2), 483.

Fraser, D. (1995). Science, values and animal welfare: exploring the 'inextricable connection'. *Animal welfare*, *4*(2), 103-117.

Fraser, D. (2008). The role of the veterinarian in animal welfare. Animal welfare: too much or too little? The 21st Symposium of the Nordic Committee for Veterinary Scientific Cooperation (NKVet)-Verlose, Denmark. 24-25 September 2007-Abstracts. *ACTA VETERINARIA SCANDINAVICA*, *50*.

Hakansson, F., & Bolhuis, J. E. (2021). Tail-biting behaviour pre-weaning: Association between other pig-directed and general behaviour in piglets. *Applied Animal Behaviour Science*, *241*, 105385.

Hessel, E. F., Reiners, K., & Van den Weghe, H. F. A. (2006). Socializing piglets before weaning: Effects on behavior of lactating sows, pre-and postweaning behavior, and performance of piglets. *Journal of Animal Science*, *84*(10), 2847-2855.

Jensen, P. (2002). Behaviour of pigs. *The ethology of domestic animals ().*

Jensen, P., & Recén, B. (1989). When to wean—observations from free-ranging domestic pigs. *Applied animal behaviour science*, *23*(1-2), 49-60.

Jensen, P., & Redbo, I. (1987). Behaviour during nest leaving in free-ranging domestic pigs. *Applied Animal Behaviour Science*, *18*(3-4), 355-362.

Ji, W., Bi, Y., Cheng, Z., Liu, R., Zhang, X., Shu, Y., ... & Liu, H. (2021). Impact of early socialization environment on social behavior, physiology and growth performance of weaned piglets. *Applied Animal Behaviour Science*, *238*, 105314.

Kanaan, V. T., Pajor, E. A., Lay Jr, D. C., Richert, B. T., & Garner, J. P. (2008). A note on the effects of co-mingling piglet litters on pre-weaning growth, injuries and responses to behavioural tests. *Applied Animal Behaviour Science*, *110*(3-4), 386-391.

Morgan, T., Pluske, J., Miller, D., Collins, T., Barnes, A. L., Wemelsfelder, F., & Fleming, P. A. (2014). Socialising piglets in lactation positively affects their post-weaning behaviour. *Applied Animal Behaviour Science*, *158*, 23-33.

Newberry, R. C., Wood-Gush, D. G. M., & Hall, J. W. (1988). Playful behaviour of piglets. *Behavioural Processes*, *17*(3), 205-216.

Ohl, F., & Van der Staay, F. J. (2012). Animal welfare: At the interface between science and society. *The Veterinary Journal*, *192*(1), 13-19.

Park, S. Y., Oord, R. V., van der Staay, F. J., & Nordquist, R. E. (2010). Social behavior of

pigs. Retrieved from

https://dspace.library.uu.nl/bitstream/handle/1874/204302/SYPark_pig_socia_%20behavior_research_report.pdf?sequence=1&isAllowed=y

Parratt, C.A., Chapman, K.J., Turner, C., Jones, P.H., Mendl, M.T., Miller, B.G., 2006. The fighting behaviour of piglets mixed before and after weaning in the presence or absence of a sow. Appl. Anim. Behav. Sci. 101, 54–67.

Salazar, L. C., Ko, H. L., Yang, C. H., Llonch, L., Manteca, X., Camerlink, I., & Llonch, P. (2018). Early socialisation as a strategy to increase piglets' social skills in intensive farming conditions. *Applied Animal Behaviour Science*, *206*, 25-31.

Singh, C., Verdon, M., Cronin, G. M., & Hemsworth, P. H. (2017). The behaviour and welfare of sows and piglets in farrowing crates or lactation pens. *Animal*, *11*(7), 1210-1221.

Van Nieuwamerongen, S. E., Soede, N. M., Van der Peet-Schwering, C. M. C., Kemp, B., & Bolhuis, J. E. (2015). Development of piglets raised in a new multi-litter housing system vs. conventional single-litter housing until 9 weeks of age. *Journal of animal science*, *93*(11), 5442-5454.

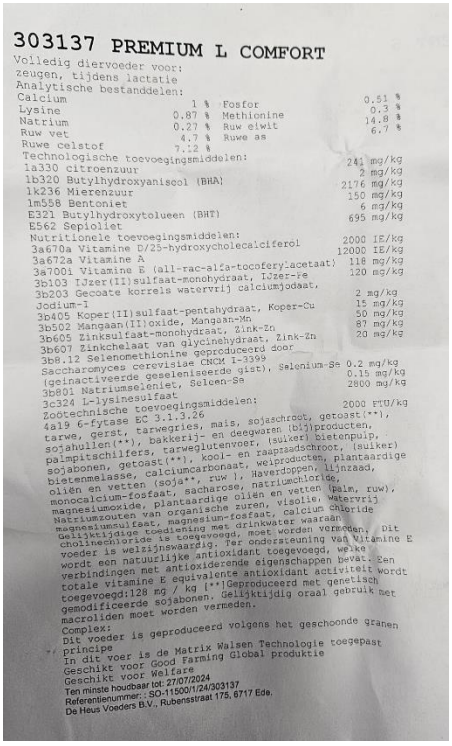
Verdon, M., Morrison, R. S., & Hemsworth, P. H. (2016). Rearing piglets in multi-litter group lactation systems: effects on piglet aggression and injuries post-weaning. *Applied Animal Behaviour Science*, *183*, 35-41.

Weary, D. M., Jasper, J., & Hötzel, M. J. (2008). Understanding weaning distress. *Applied Animal Behaviour Science*, *110*(1-2), 24-41.

Weller, J. E., Camerlink, I., Turner, S. P., Farish, M., & Arnott, G. (2019). Socialisation and its effect on play behaviour and aggression in the domestic pig (Sus scrofa). *Scientific Reports*, *9*(1), 4180.

Appendix A

Compounds feed lactation phase.



303137 PREMIUM L COMFORT

Volledig diervoeder voor:
zeugen, tijdens lactatie
Analytische bestanddelen:

Calcium	1 %	Fosfor	0.51 %
Lysine	0.87 %	Methionine	0.3 %
Natrium	0.27 %	Ruw eiwit	14.8 %
Ruw vet	4.7 %	Ruwe as	6.7 %
Ruwe celstof	7.12 %		

Technologische toevoegingsmiddelen:

1a330 citroenzuur	241 mg/kg
1b320 Butylhydroxyanisool (BHA)	2 mg/kg
1k236 Mierenzuur	2176 mg/kg
1m558 Bentoniet	150 mg/kg
E321 Butylhydroxytolueen (BHT)	6 mg/kg
E562 Sepioliet	695 mg/kg

Nutritionele toevoegingsmiddelen:

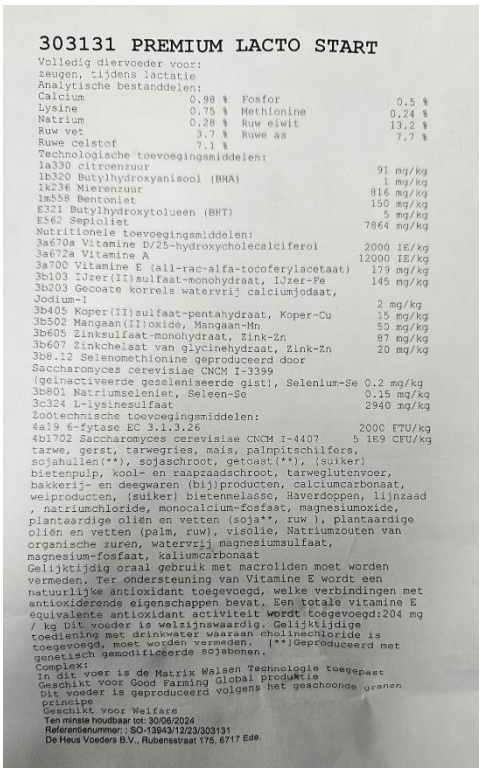
3a670a Vitamine D/25-hydroxycholecalciferol	2000 IE/kg
3a672a Vitamine A	12000 IE/kg
3a700l Vitamine E (all-rac-alfa-tocoferylacetaat)	118 mg/kg
3b103 IJzer(II)sulfaat-monohydraat, IJzer-Fe	120 mg/kg
3b203 Gecoate korrels watervrij calciumjodaat, Jodium-I	2 mg/kg
3b405 Koper(II)sulfaat-pentahydraat, Koper-Cu	15 mg/kg
3b502 Mangaan(II)oxide, Mangaan-Mn	50 mg/kg
3b605 Zinksulfaat-monohydraat, Zink-Zn	87 mg/kg
3b607 Zinkchelaat van glycinehydraat, Zink-Zn	20 mg/kg
3b8.12 Selenomethionine geproduceerd door Saccharomyces cerevisiae CNCM I-3399 (geinactiveerde geseleniseerde gist), Selenium-Se	0.2 mg/kg
3b801 Natriumseleniet, Seleen-Se	0.15 mg/kg
3c324 L-lysinesulfaat	2800 mg/kg

Zootechnische toevoegingsmiddelen:

4a19 6-fytase EC 3.1.3.26	2000 FTU/kg

tarwe, gerst, tarwegries, mais, sojaschroot, getoast(**), sojahullen(**), bakkerij- en deegwaren (bij)producten, palmpitschilfers, tarweglutenvoer, (suiker) bietenpulp, kool- en raapzaadschroot, (suiker) sojabonen, getoast(**), kool- en raapzaadschroot, plantaardige bietenmelasse, calciumcarbonaat, weiproducten, Haverdoppen, lijnzaad, oliën en vetten (soja**, ruw), natriumchloride, monocalcium-fosfaat, sacharose, natriumchloride, monocalcium-fosfaat, magnesiumoxide, plantaardige oliën en vetten (palm, ruw), magnesiumoxide, plantaardige oliën en vetten, visolie, watervrij Natriumzouten van organische zuren, visolie, watervrij magnesiumsulfaat, magnesium-fosfaat, calcium chloride Gelijktijdige toediening met drinkwater waaraan cholinechloride is toegevoegd, moet worden vermeden. Dit voeder is welzijnswaardig. Ter ondersteuning van Vitamine E wordt een natuurlijke antioxidant toegevoegd, welke verbindingen met antioxiderende eigenschappen bevat. Een totale vitamine E equivalente antioxidant activiteit wordt toegevoegd:128 mg / kg [**]Geproduceerd met genetisch gemodificeerde sojabonen. Gelijktijdig oraal gebruik met macroliden moet worden vermeden.

Complex:
Dit voeder is geproduceerd volgens het geschoonde graanen principe
In dit voer is de Matrix Walsen Technologie toegepast
Geschikt voor Good Farming Global produktie
Geschikt voor Welfare
Ten minste houdbaar tot: 27/07/2024
Referentienummer: : SO-11500/1/24/303137
De Heus Voeders B.V., Rubensstraat 175, 6717 Ede.



303131 PREMIUM LACTO START

Volledig diervoeder voor:
zeugen, tijdens lactatie
Analytische bestanddelen:

Calcium	0.98 %	Fosfor	0.5 %
Lysine	0.75 %	Methionine	0.24 %
Natrium	0.28 %	Ruw eiwit	13.2 %
Ruw vet	3.7 %	Ruwe as	7.7 %
Ruwe celstof	7.1 %		

Technologische toevoegingsmiddelen:

1a330 citroenzuur	91 mg/kg
1b320 Butylhydroxyanisool (BHA)	1 mg/kg
1k236 Mierenzuur	816 mg/kg
1m558 Bentoniet	150 mg/kg
E321 Butylhydroxytolueen (BHT)	5 mg/kg
E562 Sepioliet	7864 mg/kg

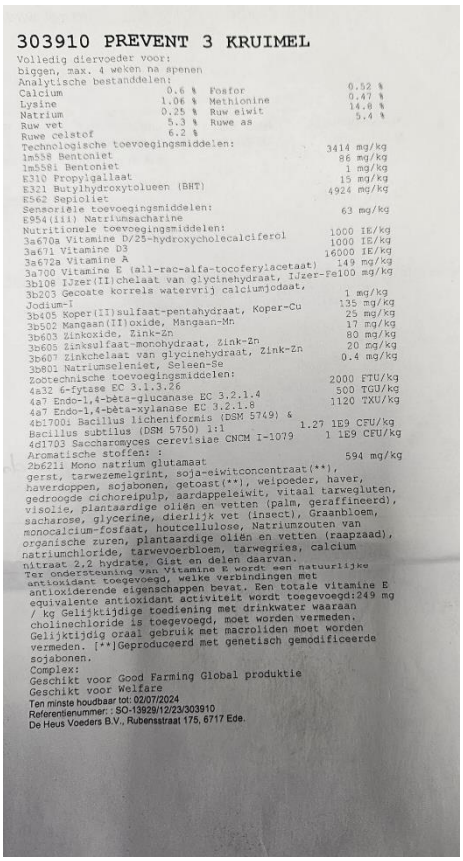
Nutritionele toevoegingsmiddelen:

3a670a Vitamine D/25-hydroxycholecalciferol	2000 IE/kg
3a672a Vitamine A	12000 IE/kg
3a700 Vitamine E (all-rac-alfa-tocoferylacetaat)	179 mg/kg
3b103 IJzer(II)sulfaat-monohydraat, IJzer-Fe	145 mg/kg
3b203 Gecoate korrels watervrij calciumjodaat, Jodium-I	2 mg/kg
3b405 Koper(II)sulfaat-pentahydraat, Koper-Cu	15 mg/kg
3b502 Mangaan(II)oxide, Mangaan-Mn	50 mg/kg
3b605 Zinksulfaat-monohydraat, Zink-Zn	87 mg/kg
3b607 Zinkchelaat van glycinehydraat, Zink-Zn	20 mg/kg
3b8.12 Selenomethionine geproduceerd door Saccharomyces cerevisiae CNCM I-3399 (geinactiveerde geseleniseerde gist), Selenium-Se	0.2 mg/kg
3b801 Natriumseleniet, Seleen-Se	0.15 mg/kg
3c324 L-lysinesulfaat	2940 mg/kg

Zootechnische toevoegingsmiddelen:

4a19 6-fytase EC 3.1.3.26	2000 FTU/kg
4b1702 Saccharomyces cerevisiae CNCM I-4407	5 1E9 CFU/kg

tarwe, gerst, tarwegries, mais, palmpitschilfers, sojahullen(**), sojaschroot, getoast(**), (suiker) bietenpulp, kool- en raapzaadschroot, tarweglutenvoer, bakkerij- en deegwaren (bij)producten, calciumcarbonaat, weiproducten, (suiker) bietenmelasse, Haverdoppen, lijnzaad , natriumchloride, monocalcium-fosfaat, magnesiumoxide, plantaardige oliën en vetten (soja**, ruw), plantaardige oliën en vetten (palm, ruw), visolie, Natriumzouten van organische zuren, watervrij magnesiumsulfaat, magnesium-fosfaat, kaliumcarbonaat
Gelijktijdig oraal gebruik met macroliden moet worden vermeden. Ter ondersteuning van Vitamine E wordt een natuurlijke antioxidant toegevoegd, welke verbindingen met antioxiderende eigenschappen bevat. Een totale vitamine E equivalente antioxidant activiteit wordt toegevoegd:204 mg / kg Dit voeder is welzijnswaardig. Gelijktijdige toediening met drinkwater waaraan cholinechloride is toegevoegd, moet worden vermeden. [**]Geproduceerd met genetisch gemodificeerde sojabonen.
Complex:
In dit voer is de Matrix Walsen Technologie toegepast
Geschikt voor Good Farming Global produktie
Dit voeder is geproduceerd volgens het geschoonde graanen principe
Geschikt voor Welfare
Ten minste houdbaar tot: 30/06/2024
Referentienummer: : SO-13943/12/23/303131
De Heus Voeders B.V., Rubensstraat 175, 6717 Ede.



303910 PREVENT 3 KRUIMEL

Volledig diervoeder voor:
biggen, max. 4 weken na spenen
Analytische bestanddelen:

Calcium	0.6 %	Fosfor	0.52 %
Lysine	1.06 %	Methionine	0.47 %
Natrium	0.25 %	Ruw eiwit	14.8 %
Ruw vet	5.3 %	Ruwe as	5.4 %
Ruwe celstof	6.2 %		

Technologische toevoegingsmiddelen:

1m558 Bentoniet	3414 mg/kg
1m5581 Bentoniet	86 mg/kg
E310 Propylgallaat	1 mg/kg
E321 Butylhydroxytolueen (BHT)	15 mg/kg
E562 Sepioliet	4924 mg/kg

Sensorische toevoegingsmiddelen:

E954(iii) Natriumsacharine	63 mg/kg

Nutritionele toevoegingsmiddelen:

3a670a Vitamine D/25-hydroxycholecalciferol	1000 IE/kg
3a671 Vitamine D3	1000 IE/kg
3a672a Vitamine A	16000 IE/kg
3a700 Vitamine E (all-rac-alfa-tocoferylacetaat)	149 mg/kg
3b108 IJzer(II)chelaat van glycinehydraat, IJzer-Fe	100 mg/kg
3b203 Gecoate korrels watervrij calciumjodaat, Jodium-I	1 mg/kg
3b405 Koper(II)sulfaat-pentahydraat, Koper-Cu	135 mg/kg
3b502 Mangaan(II)oxide, Mangaan-Mn	25 mg/kg
3b603 Zinkoxide, Zink-Zn	17 mg/kg
3b605 Zinksulfaat-monohydraat, Zink-Zn	80 mg/kg
3b607 Zinkchelaat van glycinehydraat, Zink-Zn	20 mg/kg
3b801 Natriumseleniet, Seleen-Se	0.4 mg/kg

Zootechnische toevoegingsmiddelen:

4a32 6-fytase EC 3.1.3.26	2000 FTU/kg
4a7 Endo-1,4-bèta-glucanase EC 3.2.1.4	500 TGU/kg
4a7 Endo-1,4-bèta-xylanase EC 3.2.1.8	1120 TXU/kg
4d1700i Bacillus licheniformis (DSM 5749) & Bacillus subtilus (DSM 5750) 1:1	1.27 1E9 CFU/kg
4d1703 Saccharomyces cerevisiae CNCM I-1079	1 1E9 CFU/kg

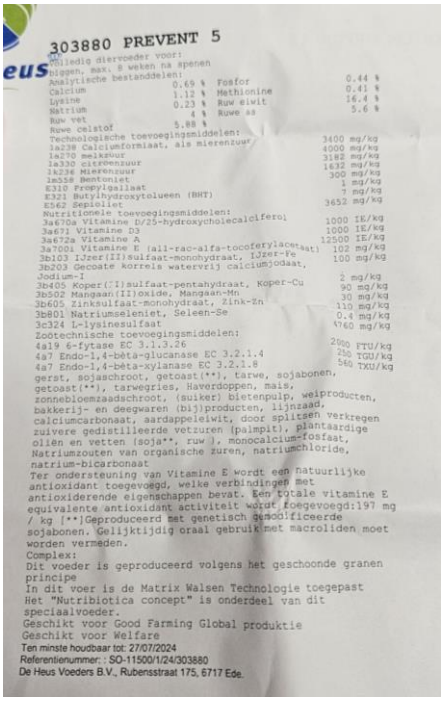
Aromatische stoffen: i

2b621i Mono natrium glutamaat	594 mg/kg

gerst, tarwezemelgrint, soja-eiwitconcentraat(**), haverdoppen, sojabonen, getoast(**), weipoeder, haver, gedroogde cichoreipulp, aardappeleiwit, vitaal tarwegluten, visolie, plantaardige oliën en vetten (palm, geraffineerd), sacharose, glycerine, dierlijk vet (insect), Graanbloem, monocalcium-fosfaat, houtcellulose, Natriumzouten van organische zuren, plantaardige oliën en vetten (raapzaad), natriumchloride, tarwevoerbloem, tarwegries, calcium nitraat 2,2 hydraat. Gist en delen daarvan.
Ter ondersteuning van Vitamine E wordt een natuurlijke antioxidant toegevoegd, welke verbindingen met antioxiderende eigenschappen bevat. Een totale vitamine E equivalente antioxidant activiteit wordt toegevoegd:249 mg / kg Gelijktijdige toediening met drinkwater waaraan cholinechloride is toegevoegd, moet worden vermeden. Gelijktijdig oraal gebruik met macroliden moet worden vermeden. [**]Geproduceerd met genetisch gemodificeerde sojabonen.
Complex:
Geschikt voor Good Farming Global produktie
Geschikt voor Welfare
Ten minste houdbaar tot: 02/07/2024
Referentienummer: : SO-13929/12/23/303910
De Heus Voeders B.V., Rubensstraat 175, 6717 Ede.

Appendix B

Compounds feed weaning phase.



303880 PREVENT 5

Volledig diervoeder voor:
biggen, max. 8 weken na spenen

Analytische bestanddelen:

Calcium	0.69 %	Fosfor	0.44 %
Lysine	1.12 %	Methionine	0.41 %
Natrium	0.23 %	Ruw eiwit	16.4 %
Ruw vet	4 %	Ruwe as	5.6 %
Ruwe celstof	5.88 %		

Technologische toevoegingsmiddelen:

1a238 Calciumformiaat, als mierenzuur	3400 mg/kg
1a270 melkzuur	4000 mg/kg
1a330 citroenzuur	3182 mg/kg
1k236 Mierenzuur	1632 mg/kg
1m558 Bentoniet	300 mg/kg
E310 Propylgallaat	1 mg/kg
E321 Butylhydroxytolueen (BHT)	7 mg/kg
E562 Sepioliet	3652 mg/kg

Nutritionele toevoegingsmiddelen:

3a670a Vitamine D/25-hydroxycholecalciferol	1000 IE/kg
3a671 Vitamine D3	1000 IE/kg
3a672a Vitamine A	12500 IE/kg
3a700i Vitamine E (all-rac-alfa-tocoferylacetaat)	102 mg/kg
3b103 IJzer(II)sulfaat-monohydraat, IJzer-Fe	100 mg/kg
3b203 Gecoate korrels watervrij calciumjodaat, Jodium-I	2 mg/kg
3b405 Koper(II)sulfaat-pentahydraat, Koper-Cu	90 mg/kg
3b502 Mangaan(II)oxide, Mangaan-Mn	30 mg/kg
3b605 Zinksulfaat-monohydraat, Zink-Zn	110 mg/kg
3b801 Natriumseleniet, Seleen-Se	0.4 mg/kg
3c324 L-lysinesulfaat	4760 mg/kg

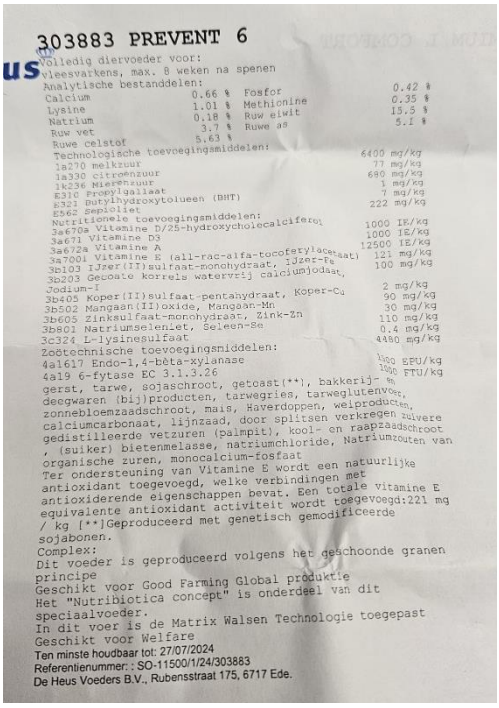
Zootechnische toevoegingsmiddelen:

4a19 6-fytase EC 3.1.3.26	2000 FTU/kg
4a7 Endo-1,4-bèta-glucanase EC 3.2.1.4	250 TGU/kg
4a7 Endo-1,4-bèta-xylanase EC 3.2.1.8	540 TXU/kg

gerst, sojaschroot, getoast(**), tarwe, sojabonen, getoast(**), tarwegries, Haverdoppen, mais, zonnebloemzaadschroot, (suiker) bietenpulp, weiproducten, bakkerij- en deegwaren (bij)producten, lijnzaad, calciumcarbonaat, aardappeleiwit, door splitsen verkregen zuivere gedistilleerde vetzuren (palmpit), plantaardige oliën en vetten (soja**, ruw), monocalcium-fosfaat, Natriumzouten van organische zuren, natriumchloride, natrium-bicarbonaat

Ter ondersteuning van Vitamine E wordt een natuurlijke antioxidant toegevoegd, welke verbindingen met antioxiderende eigenschappen bevat. Een totale vitamine E equivalente antioxidant activiteit wordt toegevoegd:197 mg / kg [**]Geproduceerd met genetisch gemodificeerde sojabonen. Gelijktijdig oraal gebruik met macroliden moet worden vermeden.

Complex:
Dit voeder is geproduceerd volgens het geschoonde granen principe
In dit voer is de Matrix Walsen Technologie toegepast
Het "Nutribiotica concept" is onderdeel van dit speciaalvoeder.
Geschikt voor Good Farming Global produktie
Geschikt voor Welfare
Ten minste houdbaar tot: 27/07/2024
Referentienummer: : SO-11500/1/24/303880
De Heus Voeders B.V., Rubensstraat 175, 6717 Ede.



303883 PREVENT 6

Volledig diervoeder voor:
vleesvarkens, max. 8 weken na spenen

Analytische bestanddelen:

Calcium	0.66 %	Fosfor	0.42 %
Lysine	1.01 %	Methionine	0.35 %
Natrium	0.18 %	Ruw eiwit	15.5 %
Ruw vet	3.7 %	Ruwe as	5.1 %
Ruwe celstof	5.63 %		

Technologische toevoegingsmiddelen:

1a270 melkzuur	6400 mg/kg
1a330 citroenzuur	77 mg/kg
1k236 Mierenzuur	680 mg/kg
E310 Propylgallaat	1 mg/kg
E321 Butylhydroxytolueen (BHT)	7 mg/kg
E562 Sepioliet	222 mg/kg

Nutritionele toevoegingsmiddelen:

3a670a Vitamine D/25-hydroxycholecalciferol	1000 IE/kg
3a671 Vitamine D3	1000 IE/kg
3a672a Vitamine A	12500 IE/kg
3a700i Vitamine E (all-rac-alfa-tocoferylacetaat)	121 mg/kg
3b103 IJzer(II)sulfaat-monohydraat, IJzer-Fe	100 mg/kg
3b203 Gecoate korrels watervrij calciumjodaat, Jodium-I	2 mg/kg
3b405 Koper(II)sulfaat-pentahydraat, Koper-Cu	90 mg/kg
3b502 Mangaan(II)oxide, Mangaan-Mn	30 mg/kg
3b605 Zinksulfaat-monohydraat, Zink-Zn	110 mg/kg
3b801 Natriumseleniet, Seleen-Se	0.4 mg/kg
3c324 L-lysinesulfaat	4480 mg/kg

Zootechnische toevoegingsmiddelen:

4a1617 Endo-1,4-bèta-xylanase	1000 EPU/kg
4a19 6-fytase EC 3.1.3.26	2000 FTU/kg

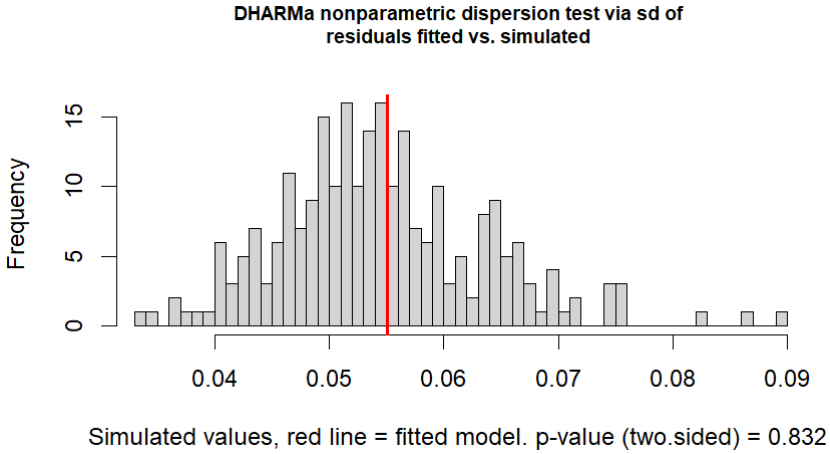
gerst, tarwe, sojaschroot, getoast(**), bakkerij- en deegwaren (bij)producten, tarwegries, tarweglutenvoer, zonnebloemzaadschroot, mais, Haverdoppen, weiproducten, calciumcarbonaat, lijnzaad, door splitsen verkregen zuivere gedistilleerde vetzuren (palmpit), kool- en raapzaadschroot , (suiker) bietenmelasse, natriumchloride, Natriumzouten van organische zuren, monocalcium-fosfaat

Ter ondersteuning van Vitamine E wordt een natuurlijke antioxidant toegevoegd, welke verbindingen met antioxiderende eigenschappen bevat. Een totale vitamine E equivalente antioxidant activiteit wordt toegevoegd:221 mg / kg [**]Geproduceerd met genetisch gemodificeerde sojabonen.

Complex:
Dit voeder is geproduceerd volgens het geschoonde granen principe
Geschikt voor Good Farming Global produktie
Het "Nutribiotica concept" is onderdeel van dit speciaalvoeder.
In dit voer is de Matrix Walsen Technologie toegepast
Geschikt voor Welfare
Ten minste houdbaar tot: 27/07/2024
Referentienummer: : SO-11500/1/24/303883
De Heus Voeders B.V., Rubensstraat 175, 6717 Ede.

Appendix C

DHARMa nonparametric dispersion test bodyweight.



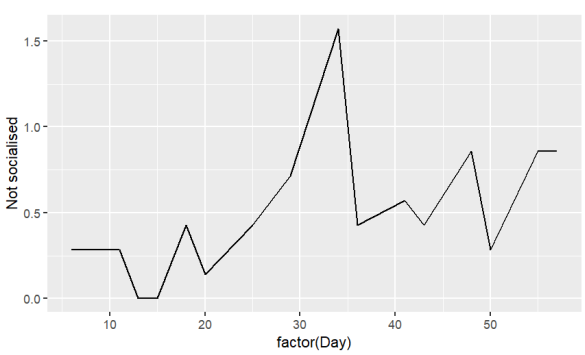
Appendix D

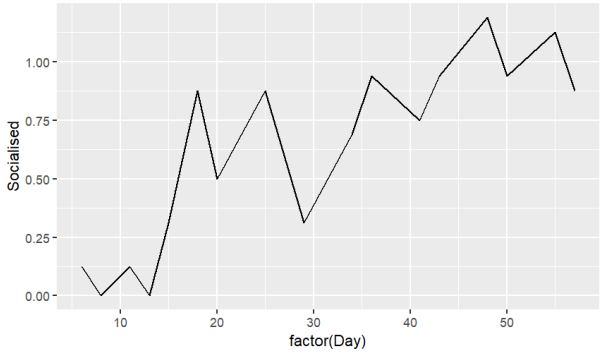
Litter	Day	Lesion score 0	Lesion score 1	Lesion score 2
2	**13**	**4**	**0**	**0**
	15	**4**	**0**	**0**
	27	**3**	**1**	**0**
	29	**0**	**1**	**3**
	57	**0**	**3**	**1**
3	**13**	**4**	**0**	**0**
	15	**0**	**3**	**1**
	27	**4**	**0**	**0**
	29	**0**	**3**	**1**
	57	**0**	**2**	**2**
5	**13**	**3**	**1**	**0**
	15	**3**	**1**	**0**
	27	**1**	**3**	**0**
	29	**0**	**1**	**3**
	57	**0**	**2**	**2**
6	**13**	**3**	**1**	**0**
	15	**1**	**3**	**0**
	27	**1**	**3**	**0**
	29	**0**	**2**	**2**
	57	**0**	**3**	**1**
7	**13**	**2**	**1**	**0**
	15	**2**	**1**	**0**
	27	**2**	**1**	**0**
	29	**0**	**1**	**2**
	57	**0**	**2**	**1**

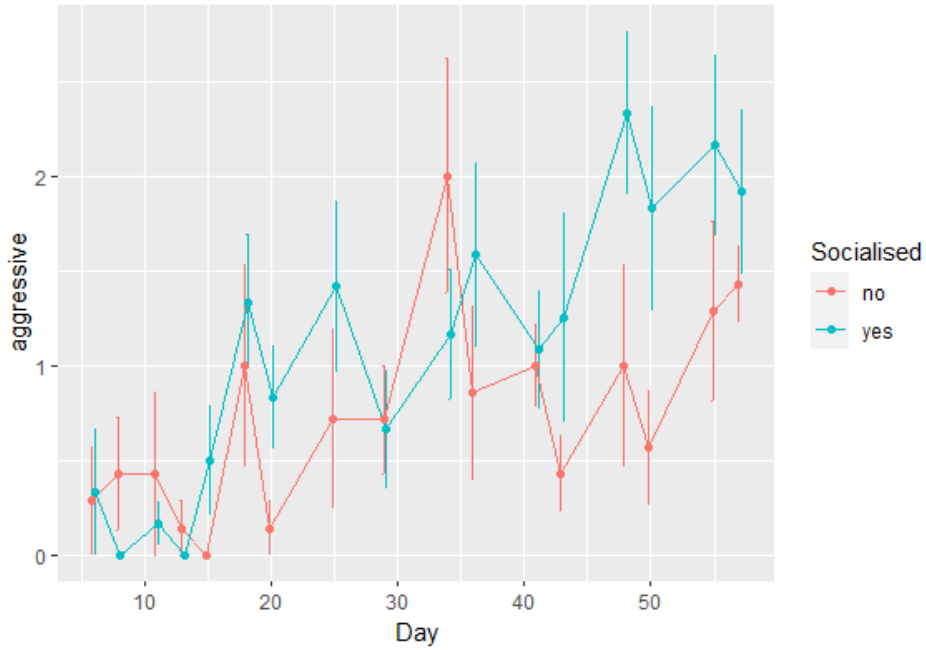
Table 3 Lesionscore per litter per day.

Day 14: mixing two neighbouring pens for socialisation.
Day 28: weaning
Day 57: leaving farm.

Appendix E







Average aggressive behaviour per group.