The effects of freedom of choice on behavioural development and welfare in piglets

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Abstract

One of the major animal welfare issues that exist in current pig production is the early and abrupt weaning of piglets, where a significant stressor is that they have not learned how to eat solid feed and thus have a decreased feed intake post-weaning. Research has found that providing piglets with a diverse feeding experience can mitigate food neophobia post-weaning as well as that providing animals with the opportunity to choose between resources makes them engage in activities that are rewarding for themselves. The aim of this study was thus to investigate how providing piglets with the freedom of choice affects their welfare, behavioural development, feed intake and enrichment usage. This was accomplished by performing a behavioural study, involving observation of piglets subjected to either a control or choice treatment. Both treatments consisted of the piglets being housed in enriched environments, but choice differed from control by also having the opportunity to freely choose between different feedstuffs. Providing piglets with the freedom of choice resulted in increased activity levels, feed intake as well as enrichment usage. Therefore, providing freedom of choice may be a promising approach to increase pig welfare.

Keywords: Pig, freedom of choice, welfare, feed intake, enrichment

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1. Introduction

1.1 Modern pig farming and its issues

Today's commercial pig production is highly intensive, with a focus on efficiency (Pedersen 2024). The reason for this is the strong global demand for pork, where the global pork consumption has increased from 63,5 million tons up to 113 million tons between 1990 and 2022 (Kim et al. 2024). This increase in demand has resulted in an intensified pig production with larger industrialised production units and a higher number of pigs needed for production (Pedersen 2024). The shift in efficiency has led to several changes compared to the 1960s where the farms were small, family-run and the pigs were housed extensively (Pedersen 2024). In modern pig production, the pigs are housed in economically efficient units with, for instance, low space allowance, slatted floor systems and no or a scarce amount of enrichment (de Jong et al. 1998; Temple et al. 2012). These housing conditions along with other management actions such as early weaning has led to rising animal welfare concerns from consumers and scientists (Colson et al. 2006; Temple et al. 2012).

One of the most major animal welfare issues that exist in pig production is the early weaning (Colson et al. 2006). Under semi-natural conditions, the weaning process would be gradual where the sow's motivation to nurse would start to decrease from the second week of lactation, and the piglets would be fully weaned before the 17th week of lactation (Jensen & Recén 1989). However, according to the European Union Council Directive 120/2008/EC, that lays down minimum standards for the protection of pigs, piglets are abruptly weaned at 28 days of age, which results in them being subjected to many stressors (Colson et al. 2006). These stressors include, among other things, abrupt dietary change, separation from the sow and social stress due to mixing with unfamiliar piglets (Dybkjær 1992; Weary et al. 2008). Exposure to this combination of stressors results in welfare complications, such as post-weaning diarrhoea, which often results in extensive use of antibiotics after weaning (Gresse et al. 2017; Pedersen 2024).

In addition to this, the current housing conditions on conventional pig farms does not adequately meet the pigs' need for expressing species-specific behaviours (Bolhuis et al. 2005). In intensive pig production, growing pigs are generally housed in stimulus-poor and barren environments that lack enough space for every individual (de Jong et al. 1998). This is viewed as a major welfare concern (Bolhuis et al. 2006). When pigs are housed in barren environments, injurious behaviours, such as manipulative oral behaviours directed at conspecifics, may

appear (Beattie et al. 1995). This behavioural development is suggested to arise from frustration over being unable to adequately satisfy highly motivated behaviours, such as rooting and foraging (Kelly et al. 2000).

1.2 Foraging behaviour

Pigs are omnivorous animals that, under natural conditions, forage sporadically within a large home range area for their food (Studnitz et al. 2007). Under semi-natural conditions it has been found that they spend up to 40-70% of their daily activity budget on foraging behaviours (Gustafsson et al. 1999). These behaviours are crucial for their survival in wild conditions, as it keeps the pigs aware of the availability of resources (Studnitz et al. 2007). During foraging, pigs exhibit behaviours such as biting, sniffing, rooting and chewing various food and indigestible items to become familiar with their environment (Studnitz et al. 2007). However, when kept under intensive production, the opportunities to forage are low and their diet often consists of pellets that they consume within a short period of time (de Jonge et al. 2008).

From an early age, pigs are strongly motivated to forage and perform exploratory behaviours (Stolba & Wood-Gush 1989). Foraging activities is part of appetitive behaviours, that includes behaviours that are motivated by an "appetite" for a certain stimulus (Wood-Gush & Vestergaard 1989; Day et al. 1995), while the action that causes the appetitive behaviour to end (such as food ingestion) are consummatory behaviours (de Jonge et al. 2008). The causal mechanisms that may underlie the rewarding properties of appetitive behaviours in pigs has been difficult to specify, but suggestions include that performing the foraging behaviour may be rewarding in itself (Hughes & Duncan 1988).

1.3 The effect of early life experiences

The environment and experiences during the early life of piglets have long-lasting effects later in life (Edwards & Telkänranta 2024). It has, for example, been shown that it can have permanent effects on their cognitive development (Edwards & Telkänranta 2024) and their behavioural development (Lewis et al. 2006; Vanheukelom et al. 2011; Martin et al. 2015). However, studies that have been performed on investigating the effect of early life conditions have mostly focused on exploring the expression of agonistic behaviours post-weaning (Chaloupková et al. 2007; Ko et al. 2020). This has been shown in several studies, where piglets reared in poorer conditions, such as barren environments, compared to enriched conditions showed significantly more aggression post-weaning (de Jonge et al. 1996; Olsson et al. 1999; Li & Wang 2011). In contrast to this, Chaloupková et al. (2007) found no immediate effect after weaning on agonistic

behaviours, but that pigs reared in enriched farrowing pens performed less agonistic behaviours at 3 and 6 months of age. It is therefore possible to conclude that the effect of pre-weaning housing conditions may not only affect agonistic behaviours in the short-term but also in the long-term (Chaloupková et al. 2007).

Moreover, the rearing conditions may impact the development of important social skills (de Jonge et al. 1996). Play behaviour is an important part of social interactions among piglets and is considered as an indicator of welfare (Newberry et al. 1988; Lawrence & Appleby 1996). It has, for instance, been seen that social play enhances social skills that are necessary for conflict resolution and that locomotor play prepares the pig for unexpected situations (Bekoff 1984; Špinka et al. 2001). In addition to this, it has been proposed that piglets reared in a complex environment may cope better with novelty, such as novel environments, and avoid conflicts later in life (Špinka et al. 2001). The social skills developed through play are essential for resolving conflicts, and if they are underdeveloped, this will most likely result in increased aggression in challenging situations, such as when mixing with unfamiliar piglets (Chaloupková et al. 2007). Play behaviour is sensitive to poor environmental and physical conditions and occurs under relatively safe conditions (Špinka et al. 2001). The provision of environmental enrichment might thus promote play behaviour as it contributes to a more complex environment in which the piglets are housed (Yang et al. 2018; van de Weerd & Ison 2019).

1.4 Enrichment

The aim of using enrichment is to enhance the welfare of captive animals (Newberry 1995). This is achieved by providing biologically relevant environmental stimuli that allows animals to exhibit highly motivated species-specific behaviours (Newberry 1995). As pigs are omnivorous, they have a high motivation to gnaw and dig up objects in their surroundings to see if they are edible (Studnitz et al. 2007). Due to this, environmental enrichment for pigs is mostly focused on supplying manipulative materials such as peat, wood shavings and straw (Beattie et al. 1998; Pedersen et al. 2005).

When it comes to physical enrichment for pigs, certain characteristics of the enrichment are more favourable than others (van de Weerd et al. 2003). According to a study by van de Weerd et al. (2003), evaluating species-specific enrichment for pigs, it was found that pigs prefer enrichments that are possible to investigate, manipulate, ingest as well as destroy, which aligns with behaviours they exhibit during foraging. However, the functionality of enrichment might differ depending on which stage of production the enrichment will be applied (Chou et al. 2024). For instance, environmental enrichment for sows has primarily

focused on alleviating hunger-related stereotypic behaviours, while environmental enrichment for growing pigs aims to reduce stress, boredom and prevent damaging behaviours (Chou et al. 2024). Regardless of its function, access to biologically relevant environmental enrichment in commercial pig production is closely linked to the pigs' welfare (Yang et al. 2018). Several studies have demonstrated the benefits of providing enrichment for pigs; for instance, it has been found that enrichment can reduce the incidence of tail biting (D'Eath et al. 2014; Heseker et al. 2024) and that rearing piglets in enriched housing conditions leads to reduced expression of agonistic behaviours and more species-specific behaviours, such as rooting (Beattie et al. 2000; Martin et al. 2015).

1.5 Freedom of choice

Animals held in production are typically provided with one form of each resource, such as a single type of feed, enrichment and bedding (Holt et al. 2024). These monotonous environments give animals little to no opportunity for decision-making or to learn from their consequences and thus develop a sense of agency (Špinka 2019). A way for animals to manage their environment is by having choice, which gives the animals the possibility to choose between alternatives, engage in activities that are rewarding for themselves, exert control over their environment and express individual preferences (Špinka 2019; Hintze & Yee 2023). Thus, providing an environment with the possibility to freely choose between resources could be an important environmental enrichment, by promoting animals' affective states (Holt et al. 2024).

Previous research done by Middelkoop et al. (2020) has shown that a diverse feeding experience early in a piglet's life mitigates food neophobia post-weaning, which is important as it promotes a better welfare due to the piglets eating more post-weaning. Moreover, is has been found that presenting creep feed in a playful way increases early feed intake, as well as post-weaning intake, and reduces the prevalence of post-weaning diarrhoea in piglets (Middelkoop et al. 2019a). Feed choice has also been reported to stimulate positive emotions in piglets' by reaching their agency needs (Špinka 2019). Giving piglets the freedom to choose between different feeds might thus be a promising action to both creating an enriched pre-weaning environment as well as resulting in positive welfare post-weaning.

According to literature animals desire the opportunity to learn, explore and engage in different rewarding experiences (Young et al. 1994; Langbein et al. 2009). Giving animals the opportunity to choose how and when to interact with their environment allows them to engage in activities that are rewarding for themselves and therefore promotes positive welfare (Hintze & Yee 2023).

However, the amount of literature that exists on freedom of choice in piglets is scarce, especially concerning long-term effects on behaviour and if, for instance, agonistic behaviours could be reduced. Agonistic behaviours, such as fighting, is a welfare risk and leads to economic losses for the farmer (Tan et al. 1991). Thus, exploring if creating a more complex pre-weaning environment through, for example, giving piglets feed choices would therefore be of import as it would promote a positive welfare for the pigs.

2. Aim, questions and hypotheses

The purpose of this study is to evaluate the long-term behavioural effects of having the freedom of choice early in life, concerning what to feed and ways to feed piglets, on activity, social behaviour and feed intake later in life.

The following questions will be addressed:

- Does having the freedom of choice affect the piglet's behavioural pattern?
- Does having the freedom of choice increase the piglet's feed intake before and after weaning?
- Does having the freedom of choice affect the usage of enrichment?

Giving piglets freedom of choice is hypothesised to influence their behaviour and welfare later in life in a positive way. The piglets are, for instance, expected to be more playful after weaning. This is supported with research by Martin et al. (2015) who found that play behaviour is greater in piglets which have been reared in complex and enriched environments. In addition to this, the provision of freedom of choice is hypothesised to increase the piglet's exploration and reduce their inactivity. Similar findings have been made by Beattie et al. (2000), who investigated how rearing conditions influenced pigs' behaviour from birth to slaughter. In that study it was found that rearing piglets in an enriched environment compared to a barren one resulted in the piglets performing more exploratory behaviours, reduced time spent inactive and reduced time involved in aggressive interactions later in life. Due to this, agonistic behaviours are also expected to decrease by having this access early in life. This hypothesis is also supported with research by Hessel et al. (2006) who found that rearing piglets in a complex pre-weaning environment resulted in piglets engaging in less agonistic behaviours 48 h after weaning. In general, their welfare is expected to be promoted due to them being provided with the freedom of choice. This is supported with research by Holt et al. (2024) who found that laying hens, that had the freedom to choose between different resources early in life, had a positive effect on their affective states and physical condition.

Giving piglets the freedom of choice in terms of what to forage is expected to increase their feed intake post-weaning. This aligns with several studies who have observed a positive relationship between familiarizing piglets with solid feed pre-weaning and their consumption post-weaning (Sulabo et al. 2010; Muns & Magowan 2018; Van Kerschaver et al. 2023). Finally, piglets subjected to the freedom of choice treatment are expected to interact more with the enrichments, since they contain food, compared to the control group.

3. Material and methods

This project was conducted at Lövsta Research Center in Uppsala, Sweden. Data collection took place from February 9th, 2026, to April 29th, 2026. Before the project started an ethical approval of animal experiments was obtained from the Swedish Board of Agriculture (Dnr 5.8.18-10753/2024).

3.1 Animals

A total of six Duroc x Landrace x Yorkshire sows and their respective litters were used for this project. These sows were divided equally into two different batches due to them having different dates for farrowing, where three of the sows were farrowing two weeks before the second batch. For a standardized outcome ten piglets per sow were chosen at random, but balanced for sex and birth weight, when possible, to participate in this project (Tab. 1). They followed the farm's standard procedure concerning ear tagging, iron injection and castration, were weaned at 5 weeks of age, reduced to 10 piglets per pen at 6 weeks of age and moved to the finishing unit at 10 weeks of age.

Table 1. The sex-ratio per treatment.

Sex	**Control**	**Free-choice**
Male	13	16
Female	17	14

3.2 Housing

The piglets were housed in conventional farrowing pens (6,5 m^2) from birth until 10 weeks of age, at which point they were moved to the finishing unit (11,88 m^2). The farrowing pens were furnished according to Swedish standard, with partially slatted and concrete flooring, a piglet corner with a heating lamp, an automatic feeder with creep feed as well as a feed trough for the sow, water nipple and daily supplied straw. The finishing pens also complied with Swedish standard and were equipped with partially slatted and concrete flooring, a feed trough, water nipples, see-through gates to neighbouring pens as well as daily supplied straw. In addition to this, the pigs were given access to a large yellow ball every other day.

3.3 Study design

This thesis is part of a bigger project called “Determining the effects of freedom of choice early in life on resilience and welfare later in life” by Verbeek (2026). Due to this the subjects have been weighed, had their general health and welfare

scored according to the Welfare Quality Protocol every second week, been subjected to different cognitive tests such as novel objects recognition test as well as a problem solving test at 8 and 15 weeks of age and had their blood samples taken. However, since the purpose of this thesis was to investigate the effect of choice on the pigs' behaviour, the study design therefore focuses on all the information relevant to this.

3.3.1 Treatments

Two different treatments were used in this project, a control and a choice treatment. The piglets in the choice treatment were provided with the opportunity to freely choose feed items and feeders from two days of age. The setup was the same for the piglets in the control treatment; however, their diet consisted of standard creep feed (Tab. 2). The feed items that the choice treatment got were ingredients that derived from the creep feed, but it was offered separately and in the same ratio as the creep feed provided to the control treatment. Moreover, the ingredients varied per day and was on a rotational schedule to make sure that all nutritional needs were met. The treatment allocation was such that, in the first batch of piglets, two pens comprised the control treatment, while one pen comprised the choice treatment. For the second batch this arrangement was reversed, meaning that one pen comprised the control and two the choice treatment.

For the experimental setting, each pen was originally supposed to be equipped with special feeders, which were three stainless steel bowls fastened to the wall to keep the feeders in place and to also prevent the sow from gaining access to the feed (Fig. 1). However, due to delayed delivery of these bowls the pigs were fed through other feeders during the start-up of the project. These feeders consisted of cast-iron bowls with a handle and two of these bowls were used for each pen, where one bowl had the wet feed and the other the dry feed (Fig 2). For the control treatment their creep feed was divided and distributed equally to these bowls. Due to the delayed delivery these feeders were used during the first observation for batch 1.

Figure 1. The distribution of the special feeders in the pen. Two of the bowls are fastened to the wall on either side of the creep feed automat, while the third is placed in the corner next to the piglet corner.

Figure 2. A picture showing what the cast-iron bowls looked like.

After the wall-mounted bowls had been installed two of these bowls were used for the two wet feeds while the third bowl was used for the two dry feeds that was given daily in the choice treatment. For the control treatment their creep feed ratio was distributed in equal parts in the three different bowls. However, the older the pigs got, the easier it was for them to pry the bowls off the wall. This resulted in that only the first observation for the piglets in batch 2 and the second observation

for the piglets in batch 1 got their feed presented this way. Thereafter the feed was distributed in the sow trough and an accompanying bowl.

When the piglets in the choice treatment were fed they had access to five out of nine possible feedstuffs daily (Tab. 2). Apart from the special feeders they were also given their feed in a treat ball. During the project two different types of treat balls have been used. Both were made for horses, where one was round and red with holes distributed around it and another was green and shaped like a hexagon but only had one hole. The treat balls were alternated daily, and only dry feed was added to them to make it easier for the pigs to get all the feed out. However, for the control treatment the ball was empty. Other than this a chew toy was hung from the ceiling for them to chew on and a hanging hay ball was added to the pens after weaning, which was filled with straw for all treatments (Fig. 3). The piglets had access to the different enrichments as well as the diverse feeding until they were 10 weeks of age when they were moved to the finishing unit and put on a standardized diet.

Figure 3. All enrichments used during the project. 1 = green hexagon treat ball, 2 = chew toy, 3 = hay ball, 4 = yellow ball, 5 = red treat ball.

Table 2. A table showing how the feeding schedule looked during the project, where the white columns show the feeding schedule for the choice treatment and the red the control treatment.

Day (ball color)	**Bowl 1**	**Bowl 2**	**Bowl 3**	**Treat ball**	**Bowl 1**	**Bowl 2**	**Bowl 3**	**Treat ball**
Mon (green)	Milk replacer powder + Beet fiber pellets	Steel-cut oats + peat	Wheat	Crushed maize kernels	Aqtiv	Aqtiv	Aqtiv	Green: empty
Tue (red)	Milk replacer powder + Wheat bran pellets	Crushed maize kernels + peat	Wheat	Steel-cut oats	Aqtiv	Aqtiv	Aqtiv	Red: empty
Wed (green)	Milk replacer powder + Potato protein	Steel-cut oats + peat	Wheat	Maize flakes	Aqtiv	Aqtiv	Aqtiv	Green: empty
Thu (red)	Milk replacer powder + Beet fiber pellets	Maize flakes + peat	Wheat	Crushed maize kernels	Aqtiv	Aqtiv	Aqtiv	Red: empty
Fri (green)	Milk replacer powder + Wheat bran pellets	Steel-cut oats + peat	Wheat	Crushed maize kernels	Aqtiv	Aqtiv	Aqtiv	Green: empty

Sat (red)	Milk replacer powder + Beet fiber pellets	Steel-cut oats + peat	Wheat	Maize flakes	Aqtiv	Aqtiv	Aqtiv	Red: empty
Sun (green)	Milk replacer powder + Potato protein	Steel-cut oats + peat	Wheat bran pellets	Wheat	Aqtiv	Aqtiv	Aqtiv	Green: empty

Feed amounts were calculated per piglet and based on a sample of average body weight and interpolated for days between data points. Together with the assumption that the net energy need is 10,2 MJ/kg the daily feed amounts were then summed for the week and divided by seven. During pre-weaning, the piglets were fed one week ahead of their curve, meaning that when they were 14 days old, they were fed the ratio they were supposed to be fed at 21 days of age.

3.3.2 Behavioural observations

Behavioural observations were performed in the stables over several occasions during this project. In total five observations per batch were performed, which were when the piglets were 3, 5, 7, 10 and 12 weeks of age. The first observation took place during pre-weaning, the second the day after weaning, the third during the weaning phase, the fourth the day after they had been moved to the finishing unit and the fifth two weeks later. Before any observations took place, a training session was carried out one week before the first observation was performed. During this training session, the observers observed the same pen for four rounds and afterward inter-observer reliability was calculated. As the project progressed, new observers joined the project, which resulted to training sessions being held and calculation of inter-observer reliability becoming a recurring task. Due to the new observers not being familiar with performing behavioural observations, a longer training session was done. This training session involved the new observers observing together with the experienced ones through a complete day of observations.

At least one day before the observation was to take place, the pigs were marked with hair dye, which meant that they were given a number on their backs for

identification purposes. This number was the same throughout the entire project. On an observation day three pens were observed where the observers were responsible for one pen each to observe. The first thing that was done on the days of behavioural observations was to look over the numbers on the pigs and see if they needed to be remarked with a green marker to make their number more visible for the observer. After that, GoPro cameras (model Hero 10 black) were attached to the ceiling so that they filmed down into the pen. These GoPros were used to record the first observation hour and to analyse feed intake as well as enrichment preference, where one GoPro was attached per pen. The GoPros were used during observation 1, 2 and 3, but were removed when the pigs were moved to the finishing unit prior to observation 4. After setting up the GoPros, all the feed to be given to the pigs was prepared. The feed was given to the pigs directly before starting the observation, due to feeding behaviours being of interest and piglets normally starting to eat right away. On a given signal all observers gave the piglets their feed ratio and the observation could start. After an observation was completed, a break was taken before the next observation was performed.

3.3.3 Ethogram

During the course of the project three ethograms adapted to the pigs' different life stages were used, resulting in a pre-weaning, post-weaning and finishing ethogram. The ethogram used during pre-weaning involved behaviours associated with the sow. The post-weaning ethogram included new behaviours connected to the hay ball, while all behaviours related to the sow were removed. The ethogram used during the finishing phase involved interaction with pigs in neighbouring pens as well as interaction with yellow ball, while all behaviours connected to the early enrichments were removed because these were no longer accessible to the piglets. Below is a complete ethogram involving all registered behaviours (Tab. 3).

Table 3. The complete ethogram used for this study. Here the new behaviours that were included for each life-stage are colour coded. The behaviours connected with pre-weaning are coloured green, post-weaning yellow and finishing blue.

Behaviour categories	Behaviour	Definition
Active posture	Standing	Immobile standing with all hooves on the ground.
	Walking	Movement in slow gait, minimum one step.
	Running	Movement in fast gait.
	Teat directed behaviour	Massaging teat or udder area.

Interacting with sow	Touching, sniffing alla areas of the sow excluding udder area.
Interacting with treat ball	Touching, pushing, biting, licking, climbing the treat ball.
Interacting with hay ball	Touching, biting, pushing the hay ball.
Interacting with bite rite	Touching, biting, pushing, licking the bite rite.
Interacting with yellow ball	Touching, pushing, biting, licking, climbing the ball.
Automatic feeder-directed behaviour	Touching, sniffing, licking outside of the automatic feeder.
Special feeder-directed behaviour	Touching, sniffing, licking outside of the special feeders.
Manipulating straw	Pig is chewing straw in mouth above the floor.
Drinking water and drinker related behaviour	Drinker in mouth.
Exploring floor area	Snout movements along the floor.
Exploring home-pen	Sniffing, licking walls and interiors/fixtures.
Exploring conspecifics non-aversive	Touching, licking or sniffing another pig with no aversive reaction from receiver.
Interacting with neighbour	Pig is touching, sniffing, licking, biting another pig in the adjacent pen.
Head shakes	Repeated shakes of the head, often with floor substrates in mouth.

	Other behaviour	Any other behaviour not defined in the ethogram.
Inactive posture	Lying, eyes open	Pig's body is pressed against the ground with eyes open.
	Lying, eyes closed	Pig's body is pressed against the ground with eyes closed.
	Lying, out of sight	Pig's body is pressed against the ground, but the observer cannot see its head.
Total eating	Suckling	Teat in mouth.
	Eating creep feed from automat	Pig's mouth inside the automatic feeder containing creep feed.
	Eating creep feed from special feeder	Pig's mouth inside the special feeder containing creep feed.
	Eating choice feed	Pig's mouth inside the special feeder containing choice feed.
	Eating food from treat ball	Pig is eating food that leaves the treat ball.
	Eating from hay ball	Pig is eating the hay or straw.
	Eating from sow trough	Piglet is eating the sow's feed.
Agonistic behaviours	Mounting	A standing pig lifts its two front legs and puts them or its chest on any part of the body or head of another pig (Hintze et al. 2013).
	Mounting receiver	On the receiving end of mounting behaviour.
	Belly nosing	Repeated nosing or manipulation of a conspecifics belly by the acting pig's snout.

	Belly nosing receiver	Pig is on the receiving end of belly nosing.
	Tail interest	Touching, sniffing or manipulating the tail of a conspecific without taking the tail into its mouth.
	Tail reaction	Having the tail of a conspecific in its mouth resulting in a physical reaction (squealing, grunting, moving away), from the conspecific.
	Tail in mouth	Having the tail of a conspecific in its mouth. May include mastication of the tail.
	Tail manipulation receiver	Pig is on the receiving end of tail interest or tail in mouth, but with no physical reaction.
	Ear manipulation	Chewing, sucking or having conspecifics ear in its mouth.
	Ear manipulation receiver	Pig is on the receiving end of ear manipulation.
	Biting other body parts	Biting another pig in other areas excluding ears or tail.
	Manipulating other body parts receiver	Pig is on the receiving end of biting other body parts.
	Pushing	Pushing resulting in a conspecific moving away.
Fighting	Fighting	Combination of aggressive behaviours (pushing, biting etc.) with at least two pigs engaging.

Play	Non-social playing	Pivoting, rolling, sliding or gambolling alone.
	Social playing	Pivoting, rolling, sliding or gambolling with conspecifics, minimum one other conspecific engaging in the same behaviour at the same time.
Not visible	Out of sight	Pig cannot be seen.

3.3.4 Data collection

The observation method that was used in this project was instantaneous sampling every 15s. This meant that, at 15s-intervals, the behaviour exhibited by one of the 10 subjects were recorded. The piglets were recorded in a sequential order, meaning that piglet 1 was recorded first and piglet 10 last. This was done in 28 rounds, where each of the 10 piglets were recorded once per round, resulting in 28 recordings per piglet per observation session. During each recording, the aim was to record the pigs' locomotor behaviour as well as any non-locomotor behaviours that they were performing. At each observation day, a total of three observation sessions were carried out. Each observation session lasted 70 min, which resulted in a total of 3,5 h of observation and 84 recordings per pig being conducted per observation day. On an observation day, all preparations for the observation began at 09:00 h. As a result, the first observation of the day began around 09:50 h, the second around 12:00 h, and the last around 15:00 h.

3.3.5 Data analysis

Behavioural data was collected on paper out on the farm during observations. After the observations were complete all data was transcribed and compiled in Microsoft Excel. Thereafter the data was exported to R studio for statistical analysis.

In R studio the data set was checked for possible errors. The proportion of behaviours were analysed by a binominal general linear mixed model with treatment, sex and age as fixed effects and piglet ID nested within pen as the random effect. In case of non-convergence of the model, a Wilcoxon rank-sum test was also used to analyse skewed data. For further analysis of significant

results post hoc tests were performed. No statistical method has been used to correct for multiple testing.

4. Results

4.1 Total behaviour

A summary has been compiled for the mean number of recordings observed for each behavioural category and treatment across the entire observation period (Fig. 4). In both the choice and control treatment, inactive posture accounted for the largest proportion of observation (Choice = 301.1 recordings; Control = 319.7 recordings), while play was the category where behaviours occurred less frequently (Choice = 1.4 recordings; Control = 0.4 recordings). In addition to this, the choice treatment seems to eat more frequently (Choice = 52.3 recordings; Control = 30.8 recordings) spend less time inactive and more time active (Choice = 158.4 recordings; Control = 127.6 recordings) compared to the control treatment, however there is a variation within the treatments.

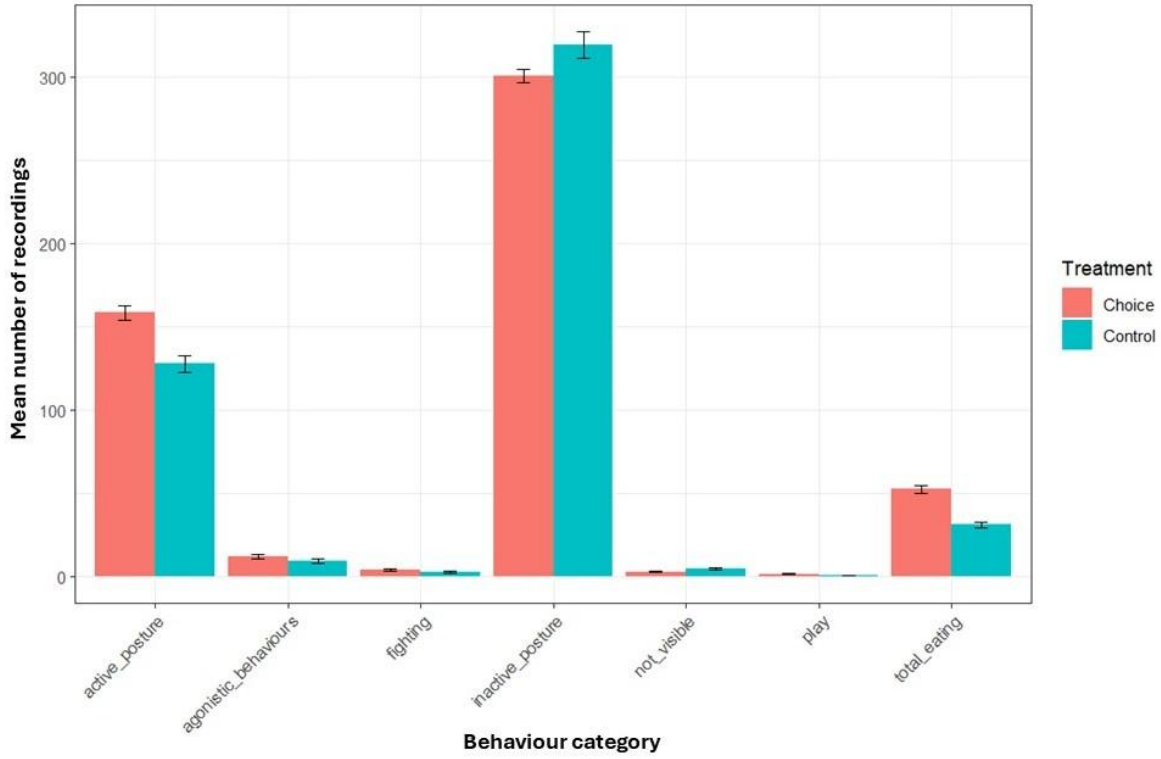

Figure 4. The mean ± SE number of recordings presented for each behavioural category for the choice and control groups.

4.2 Behavioural pattern

Inactive postures were the most common behaviours, regardless of treatment group (Fig. 5). To analyse if there was a significant difference in inactive posture

between the treatments a binominal general linear mixed model was used (Tab. 4). A significant interaction was found between treatment and age ($\chi^2 = 130.44$, df =4, $p < 0.001$), which indicates that the effect of treatment varied over the different ages. To further analyse this, a post hoc test was performed. Here no significant difference was found between treatments for 3 and 12 weeks of age ($p > 0.05$). However, significant results were found for 5 ($p < 0.001$), 7 ($p < 0.007$) and 10 weeks of age ($p < 0.041$), which means that the pigs in the choice treatment showed significantly lower levels of inactive posture compared to the control treatment during these ages.

Moreover, active posture was the second most common behaviour that occurred. When analysing this a significant interaction was found between treatment and age ($\chi^2 = 135.91$, df =4, $p < 0.001$). The post hoc test found that the age of 5 weeks was significant ($p < 0.001$), meaning that the pigs in the choice treatment showed significantly higher levels of active posture compared to the pigs in the control treatment during this age. However, no significant treatment differences were found for the other ages ($p > 0.05$).

Agonistic behaviours were observed at a low frequency during 3 and 5 weeks of age but tended to increase from the age of 7 weeks for both treatments. The binominal general linear mixed model found a significant three-way interaction between treatment, age and sex ($\chi^2 = 12.74$, df =4, $p = 0.013$). When performing the post hoc analysis significant results were found for 7 weeks of age for females ($p = 0.003$), which means that females in the control treatment showed significantly more agonistic behaviours than the females in the choice treatment during this age. Moreover, significant results were also found for 12 weeks of age for females ($p = 0.007$), which in turn means that the females in the choice treatment performed significantly more agonistic behaviours than the females in the control group during this age. No significant results were found for males.

The mean proportion of recordings where the pigs were not visible was observed to a limited extent and tended to decrease after the age of 3 weeks, however, an increase was seen during the age of 10 weeks for the control treatment. When analysing this a significant three-way interaction between treatment, age and sex was found ($\chi^2 = 12.80$, df =4, $p = 0.012$). Significant differences were found for 10 weeks of age for females ($p = 0.017$), meaning that the females in the control treatment were out of sight in higher frequencies than the females in the choice treatment during this age. Other than this, significant differences were also found for 3 weeks of age for males ($p = 0.023$), which means that the males in the control treatment were out of sight in higher frequencies than the males in the choice treatment during this age.

Fighting, occurred at a low frequency throughout the project, but tended to increase during the age of 12 weeks for the pigs in the choice treatment. However, when performing the binominal general linear mixed model analysis no significant results were found.

Play was observed to a limited extent and tended to decrease for both treatments with time. It was not possible to use the binominal general linear mixed model to analyze the behavioural category play, as the data for this category was skewly distributed. Therefore, a non-parametric test called Wilcoxon test was used (Tab. 5). However, no significant difference was found between treatments for play behaviour for any age ($p > 0.05$).

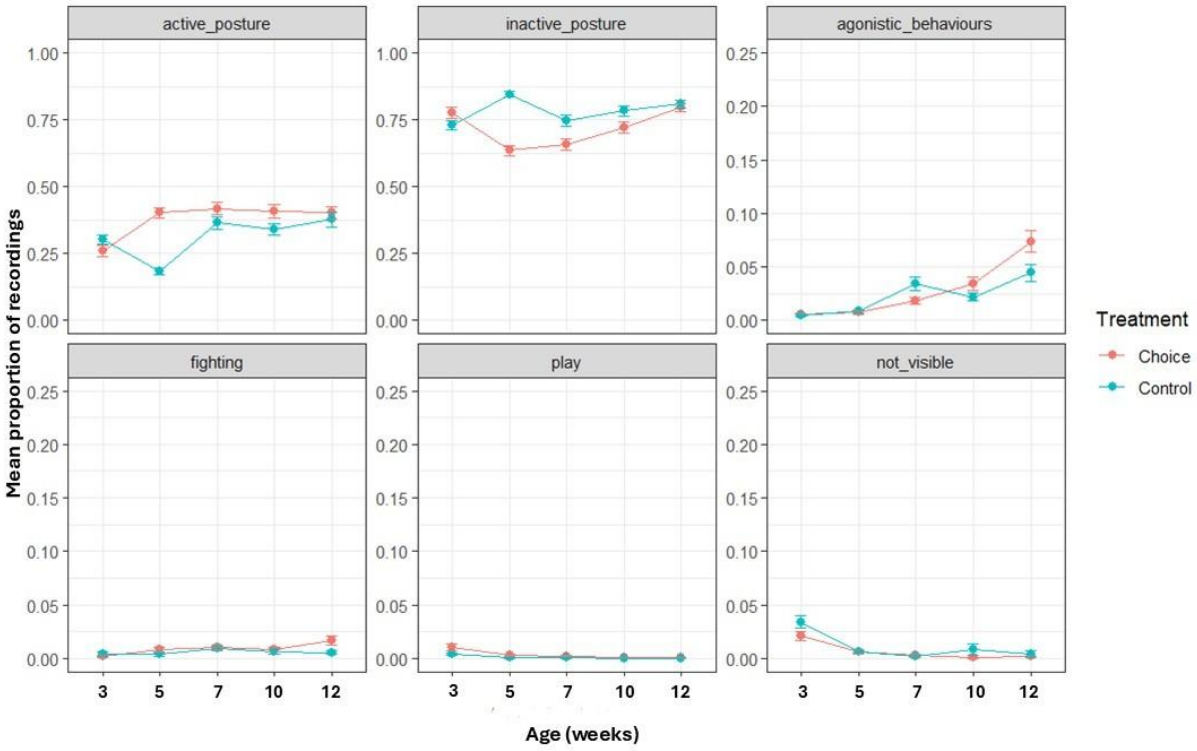

Figure 5. The mean ± SE proportion of recordings presented for each behavioural category divided over treatment (choice and control) and the different ages they had during observations. The scale differs between the categories from either 0-1 or 0-0.25 on the y-axle depending on the frequency of the performed behaviours.

Table 4. Results from the binominal general linear mixed model analysis for all behavioural categories, except play, investigating the effect of factors.

Category	Factors	χ^2	df	p-value formatted
Active posture	age	85.825	4	**<0.001**
	age:sex	5.215	4	0.266
	sex	0.177	1	0.674

	treatment	3.142	1	0.076
	treatment:age	135.910	4	**<0.001**
	treatment:age:sex	3.345	4	0.502
	treatment:sex	1.980	1	0.159
Agonistic behaviours	age	111.688	4	**<0.001**
	age:sex	6.360	4	0.174
	sex	0.011	1	0.917
	treatment	0.090	1	0.764
	treatment:age	32.600	4	**<0.001**
	treatment:age:sex	12.743	4	**0.013**
	treatment:sex	0.034	1	0.854
Fighting	age	0.855	4	0.931
	age:sex	6.720	4	0.151
	sex	2.180e-5	1	0.996
	treatment	0.400	1	0.527
	treatment:age	2.030	4	0.730
	treatment:age:sex	7.536	4	0.110
	treatment:sex	2.464	1	0.117
Inactive posture	age	123.884	4	**<0.001**
	age:sex	3.949	4	0.413
	sex	0.001	1	0.974
	treatment	3.064	1	0.080
	treatment:age	130.435	4	**<0.001**
	treatment:age:sex	2.932	4	0.569
	treatment:sex	0.224	1	0.636
Not visible	age	53.572	4	**<0.001**
	age:sex	8.762	4	0.067
	sex	8.043	1	**0.005**
	treatment	0.033	1	0.857
	treatment:age	9.490	4	**0.050**
	treatment:age:sex	12.796	4	**0.012**
	treatment:sex	8.131	1	**0.004**

Table 5. Results from a Wilcoxon test for play.

Age (weeks)	**p-value**
3	0.699
5	1
7	0.699
10	0.617
12	0.617

4.3 Feed intake

Suckling, eating creep feed from automat and eating from sow trough were the only individual feeding behaviours that could occur in both treatments, while eating creep feed special only could occur in the control treatment and eating choice feed only could occur in the choice treatment (Fig. 6). Due to this there is no response from the choice treatment for eating creep feed special and no response from the control treatment for eating choice feed.

Both suckling and eating from sow trough were only possible to observe during the age of 3 weeks, where a high level of suckling behaviour can be seen for both treatments, while eating from sow trough occurred at a much lower level compared to suckling. To analyse these behaviours Wilcoxon tests were performed, however, no significant difference was found for either suckling ($p > 0.05$) or eating from sow trough ($p > 0.05$).

In addition to this, eating creep feed from automat increased after the age of 3 weeks in both treatments. To analyse this a binominal general linear mixed model was used (Tab. 6). For eating creep feed from automat, a significant interaction was found between treatment and age ($\chi^2 = 26.69$, $df = 4$, $p < 0.001$), which indicates that the effect of treatment differed across the different ages. The post hoc analysis found that the choice treatment showed significantly higher levels of eating creep feed from automat compared to the control treatment for 5 ($p = 0.014$) and 10 weeks of age ($p = 0.006$). In contrast, the control treatment showed significantly higher levels of eating creep feed from automat compared to the choice treatment during the age of 12 weeks ($p = 0.025$).

Moreover, eating choice feed had a considerable increase in frequency and showed a positive trend from 3-7 weeks of age. In contrast to this, eating creep feed special also showed a positive trend from 3-7 weeks of age, but at a lower level compared to eating choice feed.

In conclusion, total eating behaviour was generally higher in the choice treatment compared with the control treatment during the age of 3-10 weeks of age. When analysing this behavioural category, a significant three-way interaction was found between treatment, age and sex ($\chi^2 = 12.15$, $df = 4$, $p = 0.016$) (Tab. 6). Significant results were found for 5-10 weeks of age for females ($p < 0.001$; $p < 0.001$; $p = 0.005$), where the females in the choice treatment showed significantly higher total eating compared to the females in the control treatment during these ages. The age of 12 weeks was also significant for females ($p = 0.027$), however, here the females in the control treatment showed significantly higher total eating compared to the females in the choice treatment. For the male's the ages of 3-10

weeks showed significant results ($p = 0.006$; $p < 0.001$; $p < 0.001$; $p = 0.024$), where the males in the choice treatment showed significantly higher total eating compared to the males in the control treatment.

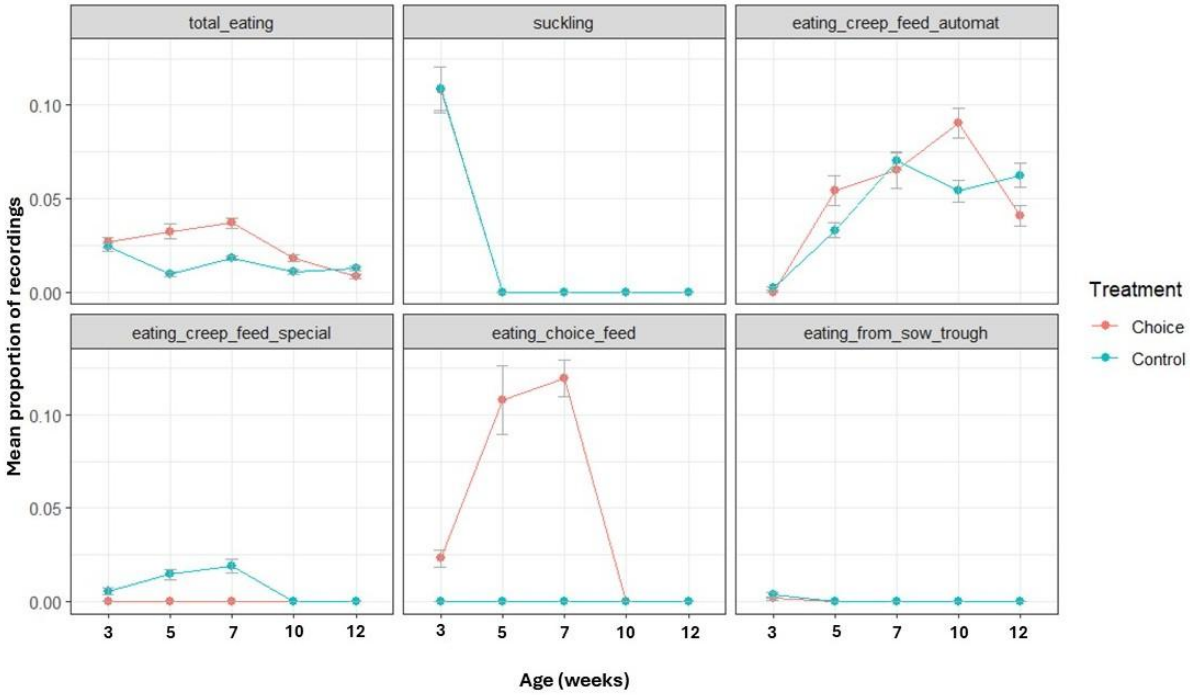

Figure 6. The mean + SE proportion of recordings presented for each feeding behaviour, as well as for the "total eating" category.

Table 6. Results from the binominal general linear mixed model analysis for eating creep feed from automat, along with the "total eating" category, investigating the effect of factors.

Behaviour/category	**Factors**	**χ^2**	**df**	**p-value formatted**
Eating creep feed automat	age	27.788	4	**<0.001**
	age:sex	0.121	4	0.998
	sex	2.322e-8	1	1.000
	treatment	2.189e-5	1	0.996
	treatment:age	26.692	4	**<0.001**
	treatment:age:sex	0.521	4	0.971
	treatment:sex	1.283e-8	1	1.000
Total eating	age	147.068	4	**<0.001**

	age:sex	3.394	4	0.494
	sex	1.475	1	0.225
	treatment	0.874	1	0.350
	treatment:age	109.253	4	**<0.001**
	treatment:age:sex	12.153	4	**0.016**
	treatment:sex	11.892	1	**<0.001**

4.4 Enrichment usage

Usage of the treat ball peaked around the age of 5 and 7 weeks (Fig. 7). However, when analysing the interaction with the treat ball using a binominal general linear mixed model no significant results ($p > 0.05$) were found (Tab. 7). The hay ball enrichment was first possible to observe during the age of 5 weeks, which was also the age when most interaction occurred. To analyse if there was a significant difference in usage between the treatments a Wilcoxon test was performed, but no significant difference was found ($p > 0.05$). Interactions with the chew toy and the yellow ball occurred at low frequencies, but a peak in interaction can be seen during the age of 7 weeks for the chew toy and 12 weeks of age for the yellow ball. However, when analysing this with a Wilcoxon test, no significant difference was found between the treatments for either enrichment ($p > 0.05$).

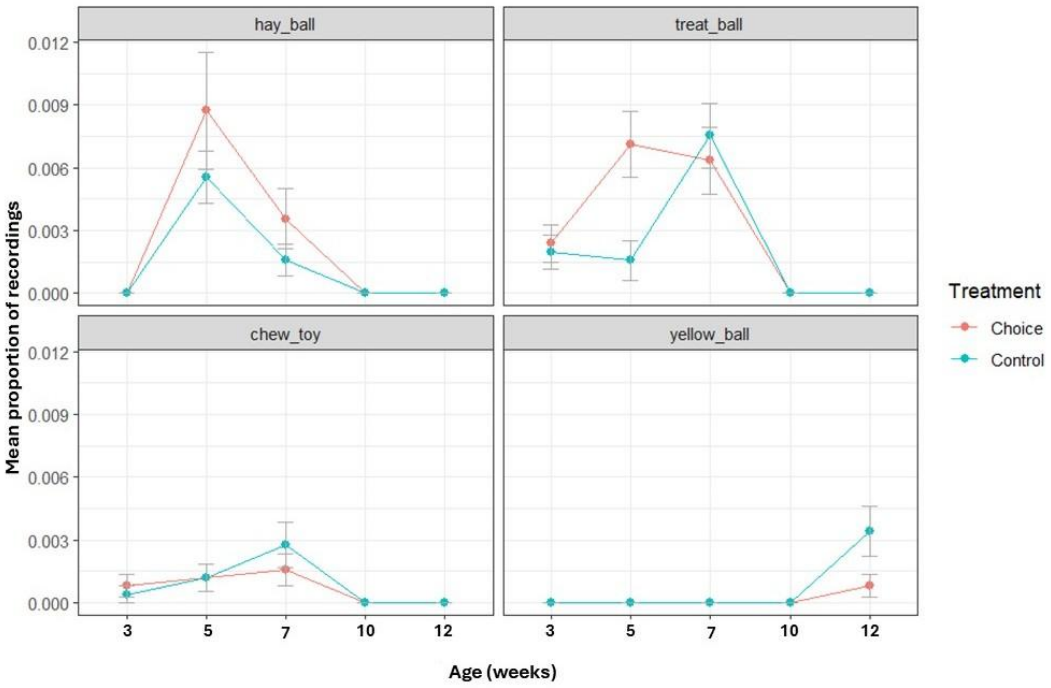

Figure 7. The mean + SE proportion of recordings presented for each enrichment interaction.

Table 7. Results from the binominal general linear mixed model analysis for enrichment interaction with treat ball, investigating the effect of factors.

Category	**Factor**	**χ^2**	**df**	**p-value formatted**
Treat ball	age	4.205	4	0.379
	age:sex	0.301	4	0.990
	sex	0.027	1	0.870
	treatment	0.015	1	0.903
	treatment:age	5.559	4	0.235
	treatment:age:sex	2.534	4	0.639
	treatment:sex	0.502	1	0.478

5. Discussion

The present study found that providing piglets with the freedom of choice results in welfare benefits. It was, for example, found that pigs subjected to the choice treatment were significantly more active compared to the pigs in the control treatment. Moreover, it was also found that pigs in the choice treatment ate significantly more during the age of 5-10 weeks compared to the control. Although no significant results were found concerning enrichment usage, choice treatment tended to interact more with the enrichment than the control treatment.

5.1 Effect on behavioural pattern

Providing pigs with the freedom of choice did influence their behavioural patterns. It was for instance seen that the pigs in the choice treatment were significantly more active compared to the control treatment. Similarly, it was found that control piglets were significantly more inactive than the choice pigs. Providing piglets with diverse feeding opportunities as well as feeders is a way of creating a more complex environment as it provides a variation in their housing conditions. Studies made on rearing piglets in complex environments have found similar results where it was seen that piglets reared in a more enriched environment spent more time active and less time inactive (Beattie et al. 2000). It is thus possible that the freedom of choice has a positive effect on the pig's activity levels.

In addition to this it is reasonable that inactive posture was the most frequently performed behaviour during this study. This aligns with research that has found that piglets spend the majority of their time resting or sleeping (Puppe et al. 2008), along with that activity periods of pigs are centred around feeding times with resting periods in between (Jensen 2002). Other than this it is also possible that the sampling method influenced that inactive as well as active posture were the most preformed behaviours during this study. The reason for this is that every recording involved recording the pigs' locomotion behaviour – that is, whether they were standing, lying down or walking, for example – as well as recording their non-locomotor behaviours, such as if they were interacting with any enrichments, exploring conspecifics or eating. Regardless of whether the pigs are engaging in non-locomotor behaviour or not, they are always engaging in locomotor behaviour, since they are always either moving about or being still, which is most likely a contributing factor to why active and inactive behaviours were performed the most.

Moreover, significant results were found for agonistic behaviours with mixed results. No clear link can thus be drawn on how a specific treatment affected their agonistic behaviours. However, an increase in agonistic behaviours can be seen in the choice treatment during the age of 10 weeks and a significant difference was found at 12 weeks of age, where the pigs in the choice treatment exhibited significantly higher levels of agonistic behaviours than the pigs in the control treatment. This might be the result of the absence of the familiar enrichment and choice feed. It is possible that the absence of enrichments resulted in redirected exploratory behaviours, which often occurs when pigs are housed in stimulus-poor environments (Dybkjær 1992; Beattie et al. 1995).

In addition to this, fighting and play were rare behaviours to observe and was consequently recorded at low levels. The reason for this is most likely that these are event behaviours that are performed during a short amount of time and might thus have been missed due to the chosen sampling method in this study (Lehner 1992; Donaldson et al. 2002). That no significant difference was seen between treatments was thus most likely due to sampling method.

5.2 Effect on feed intake

Providing pigs with the freedom to freely choose what and how to forage significantly increased their total feed intake during 5-10 weeks of age. From a welfare point of view this is viewed as positive since piglets often eat less during weaning due to stress (Clouard et al. 2012) and thus seeing that the piglets in the choice treatment increased their feed intake compared to control during the age of 5 and 7 weeks is seen as beneficial.

Moreover, stress has been found to negatively affect feed intake in piglets (Bruininx et al. 2002) as well as possibly increase food neophobia (Bolhuis et al. 2009). In addition to this, it has also been found that piglets are more reluctant to eat novel food in unfamiliar environments (Hötzel et al. 2011). As both weaning and moving to a new facility are classified as stressful experiences it is thus reasonable that there is a decrease in feed intake for the control treatment during the age of 5 and 10 weeks, as well as the choice treatment at 10 weeks of age. On the observation at 10 weeks of age all previously provided enrichments and feeds were removed and all pigs were put on a standardized new creep feed, regardless of treatment. Losing the familiar objects as well as the familiar feed was most likely a huge stressor for all pigs, which is probably why they had a reduced feed intake on this day. However, the choice pigs ate significantly more than the control pigs at 10 weeks of age. As research has found that a diverse feeding experience early in life might reduce food neophobia (Middelkoop et al. 2020), it

is possible that the pigs in the choice treatment were not as afraid of the new creep feed and thus ate more.

There is a reduction in feed intake for the choice treatment at 10 weeks of age, but on the observation at 12 weeks of age, a significant difference emerges between the control and choice treatments, with the control treatment eating significantly more than the choice treatment for the first time. The decrease in feed intake could be due to the fact that the feed they are given is no longer as exciting and, above all, is presented differently than it was when they were housed in the farrowing pen; as a result, the pigs in the choice treatment may no longer be as interested in the feed. Alternatively, it may not provide an adequate outlet for their foraging behaviours. In the finishing unit, the feed consists of a monotonous creep feed that is dispensed quickly into a feeding trough (Middelkoop et al. 2019b), which is a major change in how their feed has been presented to them, and likely the reason why the pigs in the choice treatment are decreasing significantly in their feed intake at the age of 12 weeks.

Moreover, when exploring the development of the behaviours related to eating choice feed and eating creep feed from the automat, the choice treatment seems to prefer the choice feed compared to the creep feed. This might partly have to do with the fact that the choice feed most likely was more palatable than the creep feed (Middelkoop et al. 2019a), but also due to the choice feed providing options in what to feed and thus giving the pigs the possibility to choose themselves what to forage (Hintze & Yee 2023). This possibility to choose can be seen as a way for the choice pigs to develop a sense of agency, as it gives the pigs an opportunity to engage in activities that are rewarding for themselves (Špinka 2019; Hintze & Yee 2023).

When comparing feed intake for the control treatment, it is possible to see that they ate more from the automat than from the special feeders during all ages the special feeders were available. As the creep feed that belongs to the “eating creep feed special” behaviour was presented in the same way as the choice feed was presented, it is thus possible to argue for contrafreeloading. The reason for this is that the piglets had to pull down a lever to get access to the creep feed provided by the automatic feeders, and as the principle behind contrafreeloading is that animals would rather work to gain access to food, even if the same food is available for free in a nearby bowl (Osborne 1977), means that they chose to work instead of eating it for free. From a welfare point of view this is important as it indicates that the pigs have a behavioural need to express appetitive behaviours (Hughes & Duncan 1988).

5.3 Effect on enrichment usage

Although this study did not provide any significant findings regarding if there is a significant treatment effect concerning the use of the different enrichments, there are still aspects that are important to discuss. The result showed that during the observation at the age of 5 weeks, the hay ball was the enrichment item that the pigs interacted with the most, regardless of treatment. The reason for this is most likely that the enrichment was new to this observation day and was installed in the pen just before the observations were set to begin. Novelty has been shown to play an important part in initiating exploration in pigs (Gifford et al. 2007) and has also been found to be intrinsically rewarding (Wood-Gush & Vestergaard 1991). It is therefore possible that the novelty aspect of the hay ball during this observation day resulted in increased explorative behaviours directed towards this enrichment. The drop at the age of 7 weeks in interaction with the hay ball might be due to the fact that the enrichment had not been replaced or altered, which might have reduced the pig's interest. It is thus possible that the pigs had become habituated with the enrichment, which in turn reduces the enrichments usefulness in stimulating the pig's exploration (Apple & Craig 1992).

Apart from this, the treat ball enrichment was of high interest for both the choice treatment and control treatment. Similar reasons, as were provided for the increased interaction with the hay ball, could be provided here as reasons of why they were of high interest. Since the treat balls were replaced every day with another ball, this enrichment is a source of novelty, which is attained by replacing familiar objects with new ones (Gifford et al. 2007). It is therefore possible that this novelty aspect increased the pig's exploration of the enrichment objects. In addition to this the study by Gifford et al. (2007) found that enrichment objects should be altered as often as every two days for pigs to keep being interested in the enrichment. This reinforces the fact that the rotation of this enrichment might have had a big impact on the level of interaction that occurred with it. Moreover, the choice treatments had an overall higher interaction with the treat ball, which may be due to their treat ball being filled with feed. The higher interaction might be due to that the feed could stimulate the pig's motivation for foraging by providing smells and material to chew on (Jensen 2002). Moreover, it has also been shown that food can be a motivational factor for pigs (Stephens et al. 1985), which reinforces that the feed in the treat ball might be a driving factor for the level of interaction that occurred with it.

The chew toy and the yellow ball were overall not widely used during this project. Similarly, to the discussion concerning the hay ball, it is possible that the novelty aspect might have played a part in the level of interaction performed with these objects, but it is also likely to be affected by the fact that these enrichments did

not contain any feed. Apart from this the limited interaction with the chew toy might be due to the way it was distributed in the pen. In a study by Scott et al. (2006) it was found that hanging chew toys were less interesting than straw. The reason for this might be because straw better aligns with pigs' species-specific behaviours, such as foraging (Day et al. 2002). For an enrichment to adequately satisfy pigs foraging and explorative behaviours it is important that the enrichment is odorous, deformable, ingestible, chewable and destructible (van de Weerd et al. 2003). Here the chew toy in this study falls short as it only truly covers the chewable characteristic, which might be another reason why this enrichment was not widely used by the pigs.

5.4 Discussion of chosen method

An aspect that needs to be discussed in this study is the complexity of the treatments. In this study the control treatment did not consist of a regular control treatment, which is often referred to as a negative control (Johnson & Besselsen 2002). These types of control treatments are used to ensure than an unknown variable is not affecting the animals in the experiment (Johnson & Besselsen 2002). A negative control treatment in this study would therefore consist of housing the pigs according to Swedish standard, with no access to the added enrichments or feeders. However, if this type of control treatment was used in this study it would not have been possible to determine solely the effect of the provided feed, as the result then also could be due to the extra feeding space or effect of a more enriched environment. Therefore, this type of control treatment was not deemed appropriate for this study.

The control treatment used in this study is regarded as a vehicle control. A vehicle control is meant to determine the effect of a treatment compared to the vehicle delivering it (Johnson & Besselsen 2002). The most common example of this is the use of a saline shot to rule out the effect of saline compared to the treatment dissolved in the saline (Johnson & Besselsen 2002). In the context of this study the saline would be the feeders and enrichments. This type of control treatment was thus deemed necessary to be able to rule out the effect of extra feeding space as well as enriched environment and be sure of that the result was derived from the access of the varied feeds.

An option could be to have three treatments in this study, where one would consist of a negative control, the second the vehicle control used in this study and the third a choice treatment. This would then allow for a comparison of effect size between being given the freedom of choice and the more enriched environment. However, this would either result in increased costs or a reduced treatment size.

Another aspect that needs to be discussed is the sampling method. In this study instantaneous sampling was used to record all behavioural data. However, there are many other methods that are available to use to record behavioural data, such as continuous sampling, which, along with interval sampling, is one of the most common ones to use (Lehner 1992). Continuous sampling is a sampling method considered to provide the most accurate behavioural data out of all sampling methods (Altmann, 1974). The reason for this is that the duration of all behaviours exhibited by the observed individuals is recorded within a specific time period (Lehner 1992). This is viewed as highly beneficial, since the continuous observation of the individuals makes it possible to register more rare behaviours or event behaviours (Lehner 1992).

Instantaneous sampling is an efficient and well-known sampling technique when it comes to recording behavioural states, such as standing or lying, which are ongoing behaviours that extends over a period of time (Lehner 1992). However, the ideal sampling interval for instantaneous sampling can be challenging to determine and depends on the activity level and characteristics of the observed animals (Mancinelli et al. 2023). As a general rule, an animals activity level and variability of behaviours should determine how short the interval should be (Mancinelli et al. 2023). Thus, the more active the observed animals are the shorter the interval should be to reduce the possibility of missing behaviours, while a longer interval could be used for more inactive animals (Mancinelli et al. 2023). Although instantaneous sampling is a suitable sampling method to use when observing behavioural states, it is not as optimal to use when recording behaviours of short duration such as event behaviours (Lehner 1992). The reason for this is that event behaviours, such as play behaviours, are less likely to occur exactly at the moment of sampling; for such behaviours, continuous sampling is therefore preferable (Lehner 1992). This is supported by research conducted by Tacha et al. (1985), in which a comparison of interval and continuous sampling methods for avian studies was performed and found that observations made using continuous sampling resulted in greater behavioural diversity compared to interval sampling. Thus, it can be argued that continuous sampling would likely have resulted in a greater behavioural diversity in this thesis, since it would not have missed any behaviours, unlike instantaneous sampling.

In this study continuous sampling should have been used for the most accurate data collection, since the ethogram consists of both event and state behaviours. However, since the number of pigs used in this study was 60 and it was of interest to observe how behaviours developed over time, it was considered as too labour-intensive with the given resources. According to Altmann (1984), using continuous sampling can be very time consuming if several animals and behaviours are included, which motivated the usage of instantaneous sampling

instead. A short interval time of 15s was chosen to reduce the risk of missing event behaviours. This time interval was chosen as pigs are active animals that tend to spend up to 75% of the daylight period performing active behaviours, such as foraging and investigating (Stolba & Wood-Gush 1989). Despite the short time interval, it cannot be ruled out that certain event behaviours have most likely been missed in this study. In order to reduce the likelihood of missing behaviours, the agonistic behaviours included in the ethogram were provided with a corresponding behaviour for the recipient pig to double the likelihood of registering these behaviours.

5.5 Limits of the study

During the course of the project, there have been some setbacks that may have affected the results. For example, errors have occurred during the behavioural observations. Some of the errors that have arisen during observations include, for example, that observers have accidently dropped a pencil in the pen or that the GoPros have stopped working. These errors have all resulted in that one of the observers have had to enter the pen to resolve the issue. This could have impacted the pig's behaviour and thus resulted in inaccurate results. Other than this, the treat balls became a problem as the study progressed. The reason for this was that the older the pigs got, the easier it was for them to soil these balls, which in this case meant that the balls became filled with feces and urine. These hygienic issues resulted in that the feeding schedule was not followed through correctly concerning ball colour. Providing the pigs with the wrong order of the treat balls might have had a small impact on the result concerning interactions with this enrichment, since the novelty aspect of the enrichment was not there on the start of the problem, since the same treat ball was given two days in a row, and a change in colour order might have had an effect. According to research by Deligeorgis et al. (2006), which examined the effect of colour on drinkers on pigs' water intake, it was found that the pigs were not attracted to the green water dispensers, but rather to the red and blue ones. Since the treat balls were red and green, this might therefore have had a small impact on the total interaction with the treat balls.

Another limit of this study is the observers. During this project, new observers with no prior knowledge of ethology have been recruited to conduct behavioural observations. Even though inter-observer reliability has been calculated, there is still a possibility that behaviours have been recorded incorrectly. To minimise differences between observers considerable training of the observers is needed (Rushen et al. 2012). In this project, time was set aside to train the observers so that they would feel confident about how to record the various behaviours. However, this training was most likely not sufficient for them to feel fully

comfortable in their role as observers, and questions have arisen during the observations regarding how certain behaviours should be interpreted. This has likely influenced the results of this study.

An additional limitation is that two pigs from the control treatment were unable to move to the finishing unit, which resulted in two pigs missing on the observations at 10 and 12 weeks of age. This might have influenced the results statistical power on these days (Cohen 1988). However, since the number of excluded pigs were relatively low it is therefore unlikely to have a significant impact on the overall analysis. In addition to this, the pigs have been subjected to procedures, such as blood sampling, health scoring and weighing, during this project, which could have had an impact on their behaviours during behavioural observations. The only procedure that was performed on the pigs the day before behavioural observations were the weighing and health scoring, which were procedures that seemed stressful for the pigs. It is therefore possible that this could have influenced their behaviours the day after when the same observers entered the stable.

Furthermore, another limitation of this study is that the feeders have differed throughout this study in both terms of design and mobility. Having a single type of feeder would have been the best option since introducing new feeders can be a source of novelty, as novelty can be attained by replacing familiar objects to new ones (Gifford et al. 2007). The novelty of an object is an important characteristic that contributes to initiating exploration in pigs (Gifford et al. 2007). It is therefore possible that the change in feeders has increased interaction with the feeders and might thus have influenced the results, causing them to show a higher degree of interaction with feeders then would otherwise have been the case.

5.6 Ethical aspects

When reflecting upon ethical aspects within animal research it is important to involve the 3R's (Sherwin et al. 2003). The 3R's are a principle in animal research aimed at improving animal welfare during animal experiments and was first formulated by Russel & Burch (1959). The principle consists of three R's, which stand for replacement, reduction and refinement (Russel & Burch 1959). With replacement the aim is to replace animals that are supposed to be used in research, if possible, with either less sentient animals or no animals at all (Russel & Burch 1959). The section on reduction proposes that researchers should reduce the number of animals used to the lowest level that is scientifically justifiable, so that no more animals than are necessary are recruited to achieve a sufficiently informative result (Russel & Burch 1959). As for refinement the aim is to reduce the distress, pain and suffering imposed on every individual used to an absolute minimum (Russel & Burch 1959). The 3R's are important to incorporate in

animal research to prevent unnecessary suffering and to prioritize the welfare of laboratory animals. In this study ethical considerations have therefore been made based on the 3R's.

Concerning the replacement aspect of the 3R's, it is difficult to replace the live pigs used for this study. It was necessary to observe live pigs due to the aim being to see how they behaved when given the freedom of choice. For this project the data was collected using live observations and instantaneous sampling, which are low-invasive methods. In addition, the pigs used in the project were sired for commercial purposes and not solely for the purposes of this project. This makes it possible to argue for that the usage of the live pigs in this project is more ethically justifiable, compared to if the pigs were solely sired for the purpose of this study and housed in a laboratory environment (Sherwin et al. 2003).

Moving over to the reduction aspect of this project, there are also certain challenges involved in discussing this aspect of the 3R's. Before this thesis began the number of pigs that were to be subjected to this study had already been decided, since they were part of a larger research project. Since this project aims to improve the welfare of pigs and the pigs have not been subjected to any invasive procedures, the number of pigs used in the study has not been viewed as an ethical dilemma. However, if the pigs had been subjected to invasive procedures, it would have been highly relevant to discuss the possibility of reducing the number of animals and conducting a statistical power analysis (Cohen, 1988).

In this project the pigs have not been subjected to any invasive or painful methods, which makes it challenging to refine this study more in the context of minimizing the pigs suffering. Regardless of treatment, this project has housed the pigs in environments that are above Swedish standard equipped with more resources in terms of enrichments, meaning that no pigs were housed in harsher conditions than those found on conventional pig farms. Moreover, minimal handling has been performed throughout this project, which is viewed as beneficial for the refinement part of this study. The only handling that has been done with the pigs is painting their numbers on their backs. This segment began as a stressful experience for the pigs as they were exposed to it for the first time at 3 weeks of age, which was at a stage when they were not used to being handled. However, efforts were made to improve this aspect of the project, where it was decided to lift each pig when it was time to paint it, as this made them calmer than when they were kept on the floor. As they grew older, the painting process became much easier, and they were no longer stressed by it. In addition, it was decided to use hair dye instead of regular markers to paint the pigs, in order to reduce the number of times they needed to be painted.

5.7 Sustainability and social aspects

Pork is the second most consumed meat globally (OECD n.d.). Consumers have shown a growing interest not only in the quality and taste of pork, but also in the welfare of pigs (Sandøe & Christersen 2024). As the world's population continues to grow, increased livestock production is needed to meet the demand for animal products, which may result in that issues such as animal welfare are not considered a top priority (Buller et al. 2018; Kim et al. 2024). However, many consumers are keen to ensure that the animal products they eat derive from animals that have lived a good life and that the animals have not been handled poorly (Sandøe & Christersen 2024). Research has also shown that there is a willingness from consumers to pay for welfare-enhanced pork (Denver et al. 2017; Denver et al. 2022). This study thus has positive societal value, as it demonstrates an approach to improving pig welfare.

Achieving a sustainable animal production is not possible without taking animal welfare into consideration and aligns well with Sustainability Development Goals 2 and 12, as they relate to sustainable agriculture. Especially, since ensuring good welfare is an underlying requirement for pigs if they are to be favourable to have in production (Prunier et al. 2010; Kauppinen et al. 2012). Deficiencies in welfare has, for instance, been seen to affect meat quality, daily weight gain and reproductive processes in pigs (Tan et al. 1991; Warriss et al. 1994; Prunier et al. 2010). Poor animal productivity can thus be used as an indicator of poor welfare; however, good productivity should not be viewed as a sole indicator for good welfare, where the farrowing crate is a good example (Kinane et al. 2021). The purpose of designing the farrowing crate was to reduce piglet mortality, which was achieved by restricting the sows' freedom of movement (Robertson et al. 1966). However, although piglet mortality decreased, the sows were subjected to physical and behavioural restrictions, which comprised their natural maternal behaviours and caused physical discomfort (Ceballos et al. 2020).

Current pig production is focused on efficiency and being highly productive (Pedersen 2024). The drive to improve production efficiency has led to a desire for larger litters in order to increase the number of slaughtered pigs per sow and thereby maximise the farm's financial revenue (Rutherford et al. 2013). Increase of litter size is viewed as an implication to piglets' welfare as this increases the risk of them not being able to consume sufficient amounts of milk or colostrum (Decaluwé et al. 2014). Along with the problem of not being able to consume sufficient amounts of milk the majority of piglets do not learn how to eat solid feed before weaning (Bruininx et al. 2002). This study shows that providing piglets with the possibility to freely choose what to forage results in them eating

more solid feed pre-weaning as well as post-weaning and thus contributes to knowledge of practises that results in more sustainable pig farming.

5.8 Practical applications and future research

This study has a significant practical value. The reason for this is that it provides an insight into how to increase feed intake in piglets during and after weaning. This is a major animal welfare concern that needs a solution, due to both improving animal welfare but also the farms economy. Other than this, this study gives an insight to how providing piglets with a more natural foraging experience affects them in a commercial setting. Providing piglets with the freedom of choice is a scarcely researched area within animal science and new studies is thus necessary for continued and future research.

Future studies should investigate other feeder possibilities, such as providing more sturdy feeders or providing the piglets with a trough. As studies have found that providing a larger feeding space results in piglets spending more time feeding as well as that feeder design and accessibility significantly affects piglets' consumption (Appleby et al. 1992; Middelkoop et al. 2019a). Moreover, future studies should explore the possibility of providing feed choices in the finishing unit as well, or ways to provide the feed in a more stimulating way, as the pigs in the choice treatment in this study had a significant decrease in feed intake during this period.

6. Conclusion

Providing piglets with the freedom of choice had a positive effect on their feed intake during and after weaning. Moreover, this access was found to increase their activity and reduce their inactivity. No significant findings were found concerning enrichment usage, but altering the enrichments seems to result in increased interaction. Therefore, providing freedom of choice of feed may offer an additional welfare benefits to enrichment alone, but more studies using larger sample sizes are needed to confirm this.

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Popular science summary

Today's pig production is highly intensive due to an increased global demand for pork. This increase in demand has resulted in larger industrialised production units where a higher number of pigs are needed. For the production to be economically beneficial the pigs are housed in pens with limited space for every individual that has no or a scarce amount of enrichment, such as straw, to keep them occupied. These housing conditions are one of the major reasons why there has been an increased animal welfare concern from consumers as well as scientists.

Another major animal welfare issue in the current pig production is the early weaning of piglets. The reason for this is that under semi-natural conditions, the weaning process would be gradual where the sow would gradually decrease the nursing of her piglets from her second week of lactation and have them fully weaned from milk at 17 weeks of age. However, in pig production this process occurs abruptly when the piglets are 28 days of age, which subjects the piglets to a great deal of stress. This is partly due to them being separated from the sow, but also due to an abrupt diet change from milk to solid feed. Since piglets are not familiar with eating solid feed, it is thus common that a decrease in feed intake occurs after weaning as well as them being subjected to post-weaning diarrhoea.

Providing piglets with a diverse feeding experience before weaning has been found to increase their feed intake post-weaning. It has also been found that providing animals with the opportunity to choose between resources, such as different kinds of feeds or enrichments, makes them engage in activities that are rewarding for themselves, and therefore promotes positive welfare. The aim of this study was thus to investigate how providing piglets with the freedom of choice, in terms of feed options, affects their welfare, behavioural development, feed intake and enrichment usage.

To investigate this a behavioural study was performed that involved observing piglets that belonged to either a control or choice treatment. The choice treatment comprised of the piglets being offered different feed options in different types of feeders, while the control treatment was offered a standardized creep feed in the same type of feeders. Both treatments were thus housed in enriched environments, but choice differed from control by also having the opportunity to freely choose between different feed options. Behavioural observations were performed on five days over a period from before weaning till after they had been moved to the finishing unit.

Providing piglets with the freedom of choice significantly increased their feed intake during the weaning period, which is viewed as highly positive from a welfare point of view as it is common that piglets eat less during weaning due to stress. Moreover, a significant increase in activity levels was seen for the pigs in the choice treatment, and, although not significant, they also tended to interact more with the enrichments compared to the control treatment. Providing freedom of choice in the current pig production may thus be a promising approach to increase pig welfare.

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