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The Effect of Feeder Space on Pig Behaviour and Performance in Organic Production with a *Pig Sort* Feeding System

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Abstract

Behaviour at feeding and performance of pigs can be influenced by the design of the feeding area. Resources allocated in restricted space cause a disruption in communicative behaviour and even pigs in established hierarchies compete for feed. Therefore, a substantial amount of agonistic behaviour happens at feeders. This study investigates the effect of different numbers of feeding places on pigs' behaviour at feeding and performance at an organic farm. Four behavioural sessions were carried out on growing-finishing pigs in groups of 130, 153, 148 and 128 from April to July 2020. Two numbers of feeding places were tested: 8 for control and 10 for treatment groups. Less agonistic behaviour and better performance were expected in the treatment groups. Seventeen types of behaviour were observed and recorded in a protocol using continuous registration at a group level and scan sampling method in 1-minute intervals. The observational area consisted of a DOMINO *Pig Sort* feeding system that sorts pigs according to weight to different pens as programmed. Pigs were fed *ad libitum* and had unlimited access to pasture. Performance and carcass data were obtained from an online database. The results showed 6.78±2.68 (SD) pigs (range 2-13) and up to 15.70±8.51 (SD) pigs (range 1-34) located in the feeding pens for the control and treatment groups, respectively. More agonistic behaviour with a significant difference in pressing (p=0.000) and pressing + bite (p=0.000) occurred in the treatment groups. Denser feeding pen occupancy and a higher frequency of lying in the treatment groups (p=0.000) resulted in crowding. Vocalization was higher (p=0.028) in the control group. Fewer pigs in the feeding pens with a combination of vocalization used as a communication tool to avoid the conflict can explain the lower occurrence of agonistic behaviour in the control group. The control group was, furthermore, more engaged in positive social interactions, such as nosing (p=0.018), tail/anal sniffing (p=0.000) and pen sniffing (p=0.000). Finally, the total space provided to each pig in the feeding area might have had a greater effect on the expressed behaviour than the number of feeding places. No significant differences were seen in the growth rate and feed efficiency despite the varying frequency of agonistic behaviour. The treatment group consumed more feed (p=0.021) and its carcass quality (lean meat percentage) improved (p=0.025). The treatment group spent more time grazing which might have diminished the effect of higher feed consumption on the growth rate. Moreover, an elevated level of exercise could have enhanced the deposition of lean muscles. Yet, studied literatures offer little support for this assumption, thus, more feeding places afforded the treatment group could have affected the carcass quality. Additionally, a theoretical calculation based on the time needed for a pig to consume the amount of daily feed showed that even 10 feeding places might not be enough to provide sufficient access to all pigs. The limited data (only two batches studied), confounding variables and small sample sizes in performance and carcass data make it difficult to draw any strong conclusions from this study. Considering the complexity of the DOMINO *Pig Sort* feeding system, the change of one attribute neither mitigated the expression of agonistic behaviour at the feeders nor improved overall performance. Additional research over a longer time with larger sample size is needed to confirm the proposed assumptions.

Table of contents

Abbreviations

ADG	average daily gain
ADFI	average daily feed intake
AFR	animal feeding place ratio
cm	centimetre
e.g.	for example (*exempli gratia*)
FE	feed efficiency
g:f	growth:feed
kg	kilogram
kg feed/kg pig	kilogram of feed per kilogram of pig
M	mean
m^2	square meter
min	minutes
SD	standard deviation
SEM	standard error of the mean

1. Introduction

In Sweden, organic production is regulated by the Council Regulation on organic production and labelling of organic products (EU Council Regulation, 834/2007/EC)[1] established by the European Union. Approximately 1.5 million of live swine was kept in Sweden in 2018 (Eurostat, 2020a), thereof 2.4 % under organic conditions (Eurostat, 2020b). Growing pigs in conventional, as well as, in organic productions are housed in groups (EU Council Directive, 2008/120/EC, EU Council Regulation, 834/2007/EC) which is beneficial for their social nature (Jensen, 2002). However, it also imposes daily social constraints for each individual if resources are scarce and located in restricted space (Thomsen et al., 2010, Nielsen et al., 2006).

Social constraints encompass agonistic behaviour that represents any kind of conflict and competition (Mills & Marchant-Forde, 2010). Aggression which is an integral part of agonistic behaviour (Mills & Marchant-Forde, 2010) is known to occur during mixing of unacquainted pigs and most of the research has reflected this period (Turner et al., 2006, Jensen & Yngvesson, 1998, Scheffler et al., 2016). Yet, it has been shown that a substantial amount of agonistic interactions occurs also at feeding in established groups (Ewbank & Meese, 1973, Baxter, 1983, Maselyne et al., 2014). Research pursuing this issue has pointed at crowding as the factor influencing the frequency of agonistic behaviour (Thomsen et al., 2010, Botermans & Svendsen, 2000, O'Connell et al., 2002) and overall welfare of the pigs (Botermans & Svendsen, 2000).

The concept of welfare targets both physical and mental components. Webster's (1995) definition is that "the welfare of an animal is determined by its capacity to avoid suffering and sustain fitness". By the analysis of this definition, physical elements, such as behaviour, physiology, health, productivity, pathology, as well as, emotional mental state are identified (Marchant-Forde, 2009). Another explanation by Broom (1986) - the ability "to cope with its environment" explicitly points to the animal's adaptive response to stress (Marchant-Forde, 2009).

[1] EU Council Regulation, 834/2007/EC will be replaced by EU Council Regulation 848/2018/EC on January 1, 2021.

Pigs must be fed at least once a day and access to feed must be enabled at the same time for all pigs when not fed *ad libitum* or by an automatic system (EU Council Directive, 2008/120/EC). However, according to Nielsen et al. (1996), *ad libitum* feeding is a common practice for growing pigs. Feeding area must be well-defined with a sufficient number of feeding places to prevent crowding and competition (KRAV Standards, 2019).

Pigs have evolved to spend a large part of the day foraging, e.g. rooting and searching for food (Wood-Gush & Vestergaard, 1989) and domestication has affected the need for foraging very little (Gustafsson et al., 1999, Jensen, 2002). Nutritional needs in conventional settings are fulfilled within a short time (de Jonge et al., 2008), and research has shown (Studnitz et al., 2007, Scott et al., 2006, Pedersen et al., 2014) redirected behaviour towards pen mates and pen fixtures with time abundance in the barn and a lack of possibilities to explore foraging sites.

Optimal pigs' performance demonstrated by a steady growth rate, high feed efficiency and good carcass quality is vital for farms to be profitable. One of the crucial criteria to attain a decent performance together with high welfare is a provision of adequate space for each pig at feeders (O'Connell, 2009). Several studies have shown worsening in performance (Rasmussen et al., 2006, Wastell et al., 2018, Botermans & Svendsen, 2000, Georgsson & Svendsen, 2001) and increase in aggressive behaviour (Botermans & Svendsen, 2000, Nielsen et al., 1996, O'Connell et al., 2002) as the number of pigs per one feeding place (AFR) increases. Furthermore, a higher incidence of injuries (Botermans & Svendsen, 2000) and skin lesions (Georgsson & Svendsen, 2001) have been associated with fewer available feeding places. Nonetheless, due to various research settings and other variables (e.g. age, housing, stocking density, space allowance) in the presented studies no final recommendations for the number of feeding places can be drown.

According to the Standards of the Swedish certifying body KRAV, unlike in conventional systems, organic pigs must have access to rootable materials, as well as, the possibility to graze in a free-range area for a minimum of four consecutive months. When pasture is provided, their behavioural need for foraging is satisfied at a greater level compared to conventional production (von Borell & Sorensen, 2004) Yet, a feeder space continues to remain a valuable resource worth fighting to get access to (Thomsen et al., 2010).

There are numerous innovative feeding systems for pig production both focusing on greater performance and elevated welfare. This master thesis was conducted at an organic farm in the south-west of Sweden equipped with a DOMINO *Pig Sort* feeding system that sorts pigs by weight to different feeding pens. This is one of the first farms in Sweden to use this system. Therefore, regarding the newness of the system, there is a need for research aiming to find out a suitable number of feeding places for a specific number of pigs. To my knowledge, no study has been conducted on organic pigs with access to pasture.

2. Background

2.1. Pig Behaviour

Domestic pigs *(Sus scrofa domesticus)* originated from the European wild boar (*Sus scrofa*). Despite centuries spent under human control and selection for production traits, the behaviour of the ancestor has remained well conserved and pigs' fundamental behavioural needs have not been changed (Jensen, 2002). Although they use less costly foraging strategy compared to wild-boar crosses (Gustafsson et al., 1999), they are still endowed with the ability to adapt to the changing environment in the prevailing conditions (Wood-Gush & Vestergaard, 1989, Gustafsson et al., 1999).

2.1.1. Exploration and Foraging

Exploratory and foraging behaviours are tightly interconnected (Jensen, 2002). Exploration of the surroundings is a matter of survival since it provides information about available resources and the novelty of the environment (Studnitz et al., 2007). It is driven either by appetitive behaviour (extrinsic exploration) or curiosity (intrinsic exploration). Hungry pigs perform appetitive behaviour in the form of searching for food until they become satiated (Studnitz et al., 2007). This characterisation overlaps with a definition of foraging behaviour that includes rooting, grazing and browsing (Jensen, 2002). Curiosity, on the other hand, enables adaptation to changes in the environment and preparation for potentially unexpected occurrences (Wood-Gush & Vestergaard, 1989).

Pigs are omnivorous animals and can tailor their diet according to the availability of feedstuff. When natural conditions are favourable, the diet consists mainly of plant-based food items (grass, roots, fruit, berries, seeds) but earthworms, frogs and small rodents may be occasionally consumed as well (Jensen, 2002). Under natural conditions, pigs spend a considerable amount of time foraging within vast range areas due to sparse and scattered allocation of feed resources (Studnitz et al., 2007). However, studies done on a proportion of foraging activity reported varying results.

Pigs with no supplemental feed spent for up to 71 % of their active time foraging (Rodríguez-Estévez et al., 2009) but the activity has been shown to decrease to 24 % in growing-finishing pigs when fed once a day with the Danish indoor recommendations for daily energy intake (Horsted et al., 2012). When restrictively fed with a diet accounting for 25 % of the Danish indoor recommendations for grower-finishers, free-ranging pigs foraged only 19 % of their time per day (Kongsted et al., 2013). The low frequency of foraging observed in Kongsted et al. (2013) might have been caused by unfavourable weather conditions encouraging pigs to stay inside. Stern & Andresen (2003) targeted rooting and reported a frequency per day per group of 8.5 when pigs were offered 80 % compared to 5.8 when fed 100 % of the indoor recommended feed allowance.

Evidence suggests that foraging itself has rewarding properties even without a consummatory component and increases the welfare of pigs regarding control over the environment (Inglis et al., 1997, as cited in de Jonge et al., 2008). The inability to perform foraging behaviour may result in frustration (Wood-Gush and Vestergaard, 1989) and stereotypic behaviour (Bergeron et al., 2006).

2.1.2. Contrafreeloading

A phenomenon of contrafreeloading represents a situation when animals that are presented with both freely available food and food that requires them to “work” choose the latter option (Osborne, 1977). Some animals have been found to favour this behaviour in certain circumstances (reviewed in Inglis et al., 1997). Yet, the expression of contrafreeloading depends on various factors such as prior training, level of food deprivation, rearing condition, novelty, effort level to obtain the food, naturalness of the presented task (Inglis et al., 1997) and experimental settings (de Jonge et al., 2008), therefore, the outcomes of the following studies vary. Young & Lawrence (2003) failed to show contrafreeloading in pigs. Perhaps because the experimental conditions in the study by Young & Lawrence (2003) did not resemble a situation encountered in natural conditions (pressing a lever) contrafreeloading was not observed (Inglis et al., 1997). Arguably, Young & Lawrence (2003) stated that the degree of domestication has influenced the level of expression of the phenomena. Inglis et al. (1997) indeed claimed that animals prefer minimizing effort and yet obtain a maximum reward. As shown in Gustafsson et al. (1999), domesticated pigs applied less demanding foraging strategy in contrast with their wild-crosses counterparts. Pigs expressed contrafreeloading when offered with a more natural task, such as seeking for hidden food rewards (chocolate raisins) in straw (de Jonge et al., 2008).

Overall, the preference for contrafreeloading is ultimately explained (adaptive value – Tinbergen, 1963) by various aspects. Firstly, it allows animals to gather information about the environment, as well as, increases the chances for survival (Inglis et al., 1997). Secondly, seeking different food items at scattered locations at changing times reduces the level of the "environmental uncertainty" which helps to mimic a natural foraging situation under artificial conditions (Inglis et al., 1997, de Jonge et al., 2008).

2.1.3. Agonistic Behaviour

Pigs are social animals (Jensen, 2002) and prefer to eat simultaneously (Nielsen et al., 1996). Group housing provides a possibility for simultaneous eating but due to the realities such as limited space, stocking density and feeder design, only a restricted space in a feeding area is allotted to each pig, making such a site potentially defendable (Thomsen et al., 2010). Therefore, social facilitation does not have to induce always positive outcomes due to competition around feeders (Studnitz et al., 2007) and aggression (Baxter, 1983).

The above described represents a theorem of a "social workload". Walker (1995) introduced its definition which is "the effort required, and aggression encountered in negotiating a route through pen mates to a feeder and dislodging pigs which are either feeding or obstructing the feeder". Ewbank & Meese (1973), Baxter (1983) and Maselyne et al. (2014) reported that 90 %, 75 % and 42 % of all agonistic interactions, respectively, happened in the proximity of a feeder. On that account, although growing pigs are fed *ad libitum*, some may still experience hunger because of the inability to get access to feed (Studnitz et al., 2007).

2.2. Learning Abilities

Intensive husbandry systems require animals to interact with technical equipment (Ernst et al., 2005) and pigs successfully cope with this challenge. They are cooperative, perceived as intelligent and able to learn classical and operant conditioning tasks (associative learning) at a fast pace which makes them suitable for various purposes in research (reviewed in Gieling et al., 2011). Habituation, a type of non-associative learning, has been used as an effective tool to accustom pigs to research settings (Chilcott et al., 2001). Habituation occurs when an animal changes the strength of a response to a stimulus due to the repetition (Beaver & Höglund, 2016). It facilitates handling and speeds up readjustment to changes in the environment. For instance, Yorkshire gilts were habituated for a trial to weighing, until they did not find the process aversive anymore (Sadler et al., 2011). Furthermore, after two weeks of acclimatization period, pigs coped well with a computerized feeding system (Young & Lawrence, 1994).

A complex automatic feeding system in a study by Ernst et al. (2005) tested pigs' cognitive adaptation by using specific sounds to summon them for food. Pigs, after the initial training, not only reached 90 – 95 % success rate at operating the system but the following study showed higher IgG concentration, faster wound healing and more seldom exhibition of belly nosing (Ernst et al., 2006). Overall, the feeding system represented a positive challenge, enhanced welfare and decreased boredom without affecting the performance.

Moreover, pigs were found to possess a spatial memory. Laughlin & Mendl (2000) found that domestic pigs successfully avoided previously exploited foraging sites by a shifting strategy. Also, when presented with two food baits of various quantity (3 or 8 sow roll pieces) and profitability (an obstacle or no obstacle on the way), they discriminated between food sites of different values and opted for the larger bait (Held et al., 2005).

2.3. Organic Production

To be labelled as KRAV, Swedish farmers must comply, in addition to the EU legislation, the Standards launched by the organization. KRAV emphasizes values such as animal health and welfare, sustainability, climate protection, social accountability and health (KRAV, 2020). EU Council Regulation, 834/2007/EC and the KRAV Standards require additional prerequisites for pigs compared to general Animal Welfare Act 2018:1192 (Djurskyddslagen, 2018). Namely, farmers must allow pigs to graze outdoors continuously for at least four months during the grazing period. Next, growing pigs must be provided with the opportunity to root, if outdoors on fallow land, forest or woodland, and if indoors in deep litter bedding (straw or other suitable material - EU Council Regulation, 834/2007/EC). Neither the Regulation nor the Standards state a number of feeding places per group.

Several studies have proven that pigs benefit from an enriched environment in many aspects. Studnitz et al. (2007) did an extensive review of the effects of rooting material and concluded that a complex, changeable, destructible material containing edible parts stimulates pigs' curiosity, as well as, foraging behaviour and maintains higher welfare. Moreover, pigs performed less investigatory behaviour towards pen mates if provided with straw (Pedersen et al., 2014, Scott et al., 2006) and exhibited less aggression and abnormal behaviour if housed in deep bedding (Wei et al., 2019). At last, their cognitive functions developed better when given more space, straw, peat and toys (Grimberg-Henrici et al., 2016).

2.4. Feeder Space and Its Effect on Performance and Behaviour

Feed makes up the major expense in the swine industry, precisely up to 70 % of the total cost (Patience et al., 2015). On that account, one of the main attributes for farms to be profitable is expressed as feed efficiency (FE), calculated as a ratio of feed consumed and growth of animals achieved (Patience et al., 2015). Feeders offer various dimensions, designs and features that may influence pigs' average daily gain (ADG), average daily feed intake (ADFI) and lastly farms' net income. Feeders mainly vary in the number of feeding places and whether there is a water source besides feed dispenser (Euken, 2012).

2.4.1. Performance

More pigs per feeder cause either overall lower ADG (Wastell et al., 2018, Rasmussen et al., 2006) or larger within pen variation in ADG in pigs fed both restrictively (Botermans & Svendsen, 2000) and *ad libitum* (Georgsson & Svendsen, 2001). Wastell et al. (2018) recommended the maximum of 10 pigs per feeder place in wet/dry feeders as it resulted in the highest ADG and ADFI compared to 13 and 16 pigs whereas Euken (2012) reported up to 15 pigs. On the contrary, Rasmussen et al. (2006) stated that the AFR (animal/feeding place ratio) of 13:1 had a negative effect both on performance and well-being. Performance remained unchanged despite various AFR in Nielsen et al., 1996. In terms of FE, the results have not been consistent. As the number of pigs per feeder place decreased, FE was worse in Wastell et al., 2018, better in Laitat et al., 2004, and without any difference in Georgsson & Svendsen, 2001. More injuries were reported in the AFR of 16:1 compared to the AFR of 4:1 (Botermans & Svendsen, 2000, Botermans et al., 2000). The impact was biggest for small pigs (> 21 kg) as they were forced to withdraw from feeding in 90 % of eating visits (Botermans et al., 2000). All presented studies did the experiment on pigs in conventional systems.

2.4.2. Behaviour

Overcrowding at feeding area also induced changes in pigs' social behaviour and intervened with well-being. For instance, eating speed increased when a crowding pressure intensified (Rasmussen et al., 2006, Botermans & Svendsen, 2000) indicating elevated social constraints (Botermans & Svendsen, 2000). The AFR of 2.5:1 seemed to be adequate since pigs displayed a feeding pattern similar to individually housed animals (Nielsen et al., 1996) where no competition at feeding occurred. Moreover, the greater AFR reduced aggression at displacements from the feeding site (Rasmussen et al., 2006).

3. Aims and Hypotheses

The main aim of the thesis investigated how an increase from 8 to 10 feeding places in the DOMINO *Pig Sort* feeding system with *ad libitum* feeding influenced the expression of pig behaviour at the feeders. The second aim examined if a provision of more feeding places affected growth rate, feed consumption, feed efficiency and carcass quality.

The hypotheses were that the increase from 8 to 10 feeding places:

- Reduces the frequency of agonistic interactions in the feeding pen.
- Enhances growth rate.
- Improves feed efficiency and carcass quality.

4. Material and Methods

Data were collected at an organic farm in the south-west of Sweden certified by KRAV during four occasions from April to July in 2020.

4.1. Animals

Behavioural observations were performed on organic pigs in the growing-finishing phase at the age of 12 to 20 weeks. Pigs originated from a certified organic breeding herd and were 12 weeks old at entry. Pigs stayed at the farm until a target weight of 125 kg which they reached at approximately 27 weeks of age. The average starting weight was 33.4 kg. Marking with an ear tag was done upon arrival. Pigs were slaughtered at a slaughterhouse in Dalsjöfors.

A layout of the experiment is displayed in Table 1. Behavioural observations took place in the feeding area and only pigs that entered the area were included in total numbers. Both females and surgically castrated males were observed. Sex was not considered. Animal feeding place ratio (AFR) in Table 1 was calculated based on the total number of pigs in the pig unit during the particular days (Table 1) and not on the feeding pen occupancy.

Table 1. Overall layout of the experiment showing the date, compartment, number of feeding places per pen, number of pigs in the compartment, AFR (animal feeding place ratio), age in weeks and group for each observation

Observation	Date	Compartment	Number of feeding spaces	Number of pigs	AFR	Age (weeks)	Group
1st	29-30/4 2020	South	8	130	8.1:1	20	1 - control
2nd	12-13/5 2020	North	10	153	7.7:1	12	2 - treatment
3rd	16-17/6 2020	South	10	148	7.4:1	12	3 - treatment
4th	7-8/7 2020	South	10	128	6.4:1	15	3 - treatment

4.2. Housing and Management

Animals were housed in an uninsulated building with natural ventilation. Access to a concrete outdoor run was given throughout the whole year and pasture was accessible during the grazing period. The pasture was open on the 30th of April 2020 for five or six months, depending on the weather. The control group did not have access to pasture for the first eight weeks whereas treatment groups 2 and 3 grazed on pasture the whole growing-finishing phase. The pig unit was divided into two compartments – the South and North. Each compartment provided deep bedded resting area, drinking area with six separately located drinkers and feeding area with wet/dry feeders (Figure 1) and was designed to accommodate up to 150 pigs. The layout of the South compartment is shown in Figure 2. The North compartment had the same but a mirror image layout.

Figure 1. Pictures of the outdoor concrete run (upper-left), pasture with a rooting area (upper-right), resting area (bottom-left) and feeding pens (bottom-right)

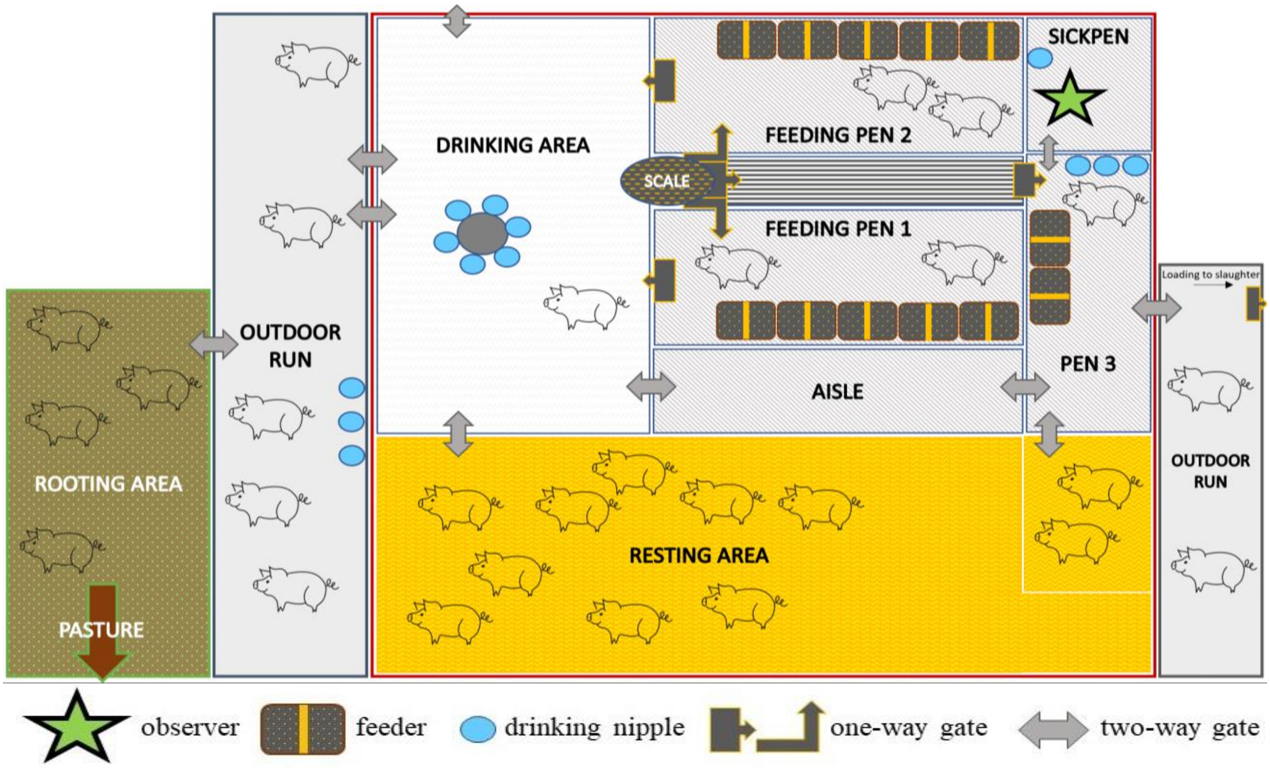


Figure 2. Layout of the South compartment and a position of the observer (green star)

Farm practices

Pigs received *ad libitum* phase feeding diet in a physical form of meal. Phase 1 was fed for the first two weeks, phase 2 until 60 kg and phase 3 until the target weight of 125 kg. The concentrate was enriched by a slaughter mix. Appendix 1 and 2 list the ingredients in the concentrate and the content of the slaughter mix, respectively.

Feeding system

The feeding area consisted of the DOMINO *Pig Sort* feeding system.[2] It is a fully computer-controlled system that sorts out pigs to pen 1, 2, 3 according to weight as programmed. An unlimited number of pigs could have entered the feeding area, no upper limit had been set. The entry to feeding pens was made of a scale which offered several modes to choose from:

- Average weight: sorting out pigs to pen 1 or 2 according to a threshold weight set by the system; (mostly used)
- Weight: sorting out pigs to pen 1 or 2 according to a manually set threshold weight
- 50/50: gates to pens 1, 2 open alternatively regardless of the weight

[2] For more information, please visit: https://www.domino.dk/en/products-for-porkers/sorting-systems-for-pigs

- Random: gates are open allowing to enter a pen of a preference
- Manual: manual system operation; used for machinery cleaning

At arrival, every new batch of pigs had two weeks to get accustomed to the feeding system. After ear-tagging with individual electronic tags, pigs were once manually driven through the scale to register individual arrival weights. The system was set on random mode for the following two days. After this period, a learning phase of 12 days began with 50/50 mode. On day 12, colour marker was placed above the scale to distinguish pigs that entered the feeding pens (colour marked) and those who did not (no mark). Average mode was set on the scale after the learning period. Slow learners (usually 10 % from the whole batch) were taken care of by the personnel that additionally trained them for five days. Pen 3 with less competition was used as a last resort for pigs that did not learn the system.

A simple scheme of the DOMINO *Pig Sort* feeding system provided by a company modified by the author is shown in Figure 3.

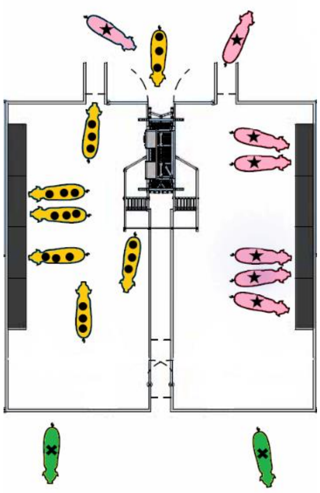


Figure 3. Scheme of the DOMINO Pig Sort feeding system and sorted pigs – lighter (yellow/dots), heavier (pink/star), selected for slaughter or slow learners (green/cross)

Feeders

Pen 1 and 2 each were accommodated with four (control group) or five (treatment groups 2 and 3) double-spaced DOMINO S-22 wet/dry feeders (Figure 4). Pen 3 had two of those feeders. The number of feeders changed due to farm management routines. One feeding place was appropriate for one pig so that up to 8 (control group) and 10 (treatment groups) pigs in one feeding pen could have been eating simultaneously. It was unlikely that one pig occupied more than one feeding place. The feeders had a drinking nipple available for both feeding places which also served as a separation. Feed was dosed *ad libitum* by pushing two pendulums to aside. Pigs could have accessed the feeders at any time and spent unlimited time in the feeding pens.

Figure 4. The DOMINO S-22 ad libitum feeder with water and two pendulums (DOMINO, n.d)

4.3. Recordings

Study design

This project was designed as an intervention study. The control group was represented by group 1 with 8 feeding places per pen whereas the treatment groups consisted of group 2 and 3 with 10 feeding places per pen (Table 1). The first observation was done on the 29th of April 2020 and the last one on the 8th of July 2020 (Table 1).

Recording area

The behavioural observations took place in the feeding area, only in pen 1 and pen 2. Each pen measured 4.6 m in length and 2.3 m in width. Pen 3 accommodated pigs ready for slaughter or slow learners; those pigs were not observed and excluded from the total numbers. The observations were done by one observer who stood outside of the feeding pens to avoid any contact with the animals (Figure 2). The recording took place at pigs' sight, therefore, standing still and avoidance of sudden movements was necessary to keep a disturbance at a minimum.

Ethogram

An ethogram (Table 2) describing seventeen types of pig behaviour was developed, according to Morrison et al. (2003) and Jensen (1980) and modified by the author. Based on the ethogram, a protocol was designed (Appendix 3). One day prior the first observation was dedicated for the protocol testing. Moreover, "forced switch" behaviour was added after the first recording day in the first session (30th of April). The behaviours were recorded with a combination of scan sampling and continuous registration on a group level.

Table 2. Ethogram of pig behaviour

Category	Variable	Definition
Continuous observation		
Switches	Contactless switch	Switching of feeding places without any body contact with other pigs
	Forced switch	Switching of feeding places with body contact of agonistic manner with other pigs
Agonistic behaviour	Vocalization	Grunting, squealing, screaming
	Head to head/body knock	Quick thrust with the head against the head or the body of another pig
	Head to head/body knock + bite	Quick thrust with the head accompanied with bites against the head or the body of another pig
	Parallel and inverse pressing	Pushing with the shoulders against each other from the side or the front
	Parallel and inverse pressing + bite	Pushing with the shoulders against each other from the side or the front with bites
	Tail biting	Chewing or biting another pig's tail
	Fighting	Mutual head to head/body thrusts or pressing with or without bites
	Mounting	Placing front hooves in the back of another pig
Social behaviour	Nose to nose/body	Nosing another pig's nose or any part of its body, apart from the anal region
	Tail/anal sniffing	Sniffing another pig's tail or anus
Exploratory behaviour	Pen sniffing	Sniffing the pen's floor or its fixtures
Immobile behaviour	Standing	Upright position supported by all four legs
	Sitting	Upright position with its back legs bent and fore legs straight
	Lying	Lateral or sternal recumbency
Scan sampling		
Maintenance behaviour	Feeding	Standing with its head in the feeder, assumed to be feeding

Time schedule

Each of the four observational sessions took place from 11 am until 4 pm for two consecutive days. A time schedule was followed to retain the same timing every recording day (Table 3). The day was divided into four rounds of 45 minutes interlaced with two breaks of 30 minutes and a one-hour lunch break. At each round, both pen 1 and pen 2 were observed three times in a row for five minutes with two minutes of a non-observing period in between. Before each recording round, 10 minutes were given to pigs to acclimate to the observer's presence. Time was measured with a stopwatch. Pigs were observed for 120 minutes in total (60 minutes per pen) each day.

Table 3. Time distribution of the observations

11 am - 11.45 am	11.45 am - 12.15 pm	12.15 pm - 1 pm	1 pm - 2 pm	2 pm - 2.45 pm	2.45 pm - 3.15 pm	3.15 pm - 4 pm
pen 1		pen 2		pen 1		pen 2
pen 1		pen 2		pen 1		pen 2
pen 1	break	pen 2	lunch	pen 1	break	pen 2
pen 2		pen 1		pen 2		pen 1
pen 2		pen 1		pen 2		pen 1
pen 2		pen 1		pen 2		pen 1

Scan sampling and continuous registration

Every minute, all pigs in the observed feeding pen and pigs that were feeding (maintenance behaviour) were counted and the numbers were marked in the protocol (scan sampling). Continuous registration on a group level was applied to all pigs in the feeding pen. The number of behaviours performed was marked in a corresponding box. Continuous registration on a group level, as well as, scan sampling started over every minute.

4.4. Additional Data

4.4.1. Performance Data

Performance data were sent directly to the author from a DOMINO company. The data completely covered the batches of pigs in the South and North compartments from the 3rd of March to the 8th of June (control group) and from the 27th of April to the 29th of July (treatment group 2), respectively; as can be seen in Appendix 4. The data comprised of the number of pigs in the compartment, average weight and feed efficiency per day (kg feed/kg pig). Kilogram of feed per kilogram of pig was calculated daily by dividing the amount of feed delivered by the total number of pigs present in each compartment.

4.4.2. Carcass Data and Injuries

Carcass data including a list of injuries from the slaughterhouse website were provided by the farmer. The number of slaughtered pigs, average carcass weight, classification of meat quality and type of injuries were used for the analysis.

4.5. Data Analyses

The data were analysed by using Microsoft Excel 16 and Minitab Statistical Software 19.

4.5.1. Behavioural data

The behavioural observations were unevenly distributed between the control and treatment groups, with two days of observing for the control group and six days of observing for the treatment groups, resulting in 240[3] and 720 observations (120 each day), respectively, for every continuously observed behaviour (Table 2). One minute was considered as one observation. 30 observations from the 8th of July (treatment group 3) were taken away due to zero pigs in the feeding pens[4], resulting in 690 observations used for the analysis.

A frequency per pig per minute for each observation was calculated for sixteen continuously observed behaviours on a group level. Minitab computed descriptive statistics displaying mean, SEM, SD, maximum and minimum values. Two pie charts showing the proportions of frequencies per pig per minute and a bar chart depicting mean of frequencies with SEM as error bars of all behaviours separately were created in Excel. A two-sample Student t-test determined statistical difference of the behaviours between the control group and treatment groups in the bar chart. Alpha value of 0.05 was considered statistically significant ($p < 0.05$).

Pearson’s correlation and linear regression were established to estimate the correlation between the number of pigs occurring in pen 1 and pen 2 and the frequency of agonistic behaviour between the control group and treatment groups.

4.5.2. Performance Data

Performance data ranged from the 7th of March to the 12th of May for the control group (South compartment) and from the 1st of May to the 6th of July for the

[3] Except for forced switch (n=120). This behaviour was added the second day (30/4/2020) of the first observation.

[4] The pigs were disturbed by a tractor and stayed on pasture.

treatment group 2 (North compartment). To balance the data, days shortly after the arrival due to the system customization, and towards the end when pigs were being sent to the slaughter in unequal batches, were eliminated. Performance data with less than 90 pigs were discarded.

An average daily gain and amount of feed to kilogram of pig (kg of feed/kg pig) were drawn from the datasheets for both groups. Since the DOMINO *Pig Sort* feeding system does not collect data about feed consumption but feed delivery to feeders, the usual equation for feed efficiency gain/feed had to be modified. Therefore, the used equation was ADG/kg of feed to kg of pig. A two-sample Student t-test established any statistical differences for growth rate, kg feed/pig and FE between the control and treatment group 2. Alpha value of 0.05 was considered statistically significant ($p < 0.05$).

Estimated number of feeding places

An adequate number of feeding places necessary to provide sufficient time to consume a daily amount of feed was estimated. Performance data from the North compartment (treatment group 2) from the 12th of June to the 6th of July were used for the estimation. Eating speed of 33.8 ± 4.6 g/min for 90 kg pigs for lever systems was taken from Gonyou & Lou (2000). Pigs in the chosen data range weighed from 80.5 kg to 104.6 kg.

Only feed delivered to 10 feeders (out of 13) located in pens 1 and 2 was considered for the calculation. However, the total amount of feed delivered to all feeders was divided by 12 as one feeder in the sick pen was neglected due to the irregularity of feed delivery. The assumption of equal feed delivery to all 12 feeders was applied. The time needed to consume the daily amount of feed per pig was drawn up from the data and converted to all pigs. This number was then divided by the number of feeding places (8, 10 and 12 - theoretical number).

4.5.3. Carcass Data

Carcass data consisted of a meat quality classification and list of injuries. The data used for the analysis ranged from the 9th of April to the 11th of June (n=107) for the control group and from the 2nd of July to the 20th of August (n=167) for the treatment group 2. Days spent at the farm, average initial weight, average carcass weight and a proportion of the meat quality classification between the groups were computed. A Mann-Whitney U test determined statistical difference ($p < 0.05$) for meat classification. Performance and carcass data from the 3rd group were not used for the analysis because the whole batch of pigs had not yet been slaughtered at the time of the thesis completion.

5. Results

From the 240 and 690 observations for the control and treatment groups, respectively, there were more pigs located and more pigs feeding in the feeding pens in the treatment groups (Table 4). A maximum of 13 pigs was in the pens in the control group whereas there could be up to 34 pigs in the treatment groups. More pigs occupied one feeding place (AFR) in the treatment groups with the highest AFR of 1.6 for all pigs in the 3rd observation and 0.9 for feeding pigs in the 2nd observation. The temperature was the lowest in April and the highest in June.

Table 4. General information about each observation including a group of the pigs, month of the observation, outside temperature, mean, SEM, SD, range, animal feeding place ratio (AFR) for all pigs located and pigs that were feeding in the feeding pens

				All pigs in the feeding pens					Feeding pigs in the feeding pens				
Observation	Group	Month	Outside temperature	Mean	SEM	SD	Range	AFR	Mean	SEM	SD	Range	AFR
1nd	1 - control	April	8 °C	6.78	0.17	2.68	2-13	0.8	4.70	0.13	1.96	1-8	0.6
2nd	2 - treatment	May	9 °C	10.44	0.23	3.52	2-18	1.0	8.54	0.14	2.14	1-10	0.9
3rd	3 - treatment	June	23 °C	15.70	0.55	8.51	4-34	1.6	6.14	0.20	3.11	0-10	0.6
4th	3 - treatment	July	17 °C	12.02	0.43	6.26	1-23	1.2	6.97	0.21	2.97	1-10	0.7

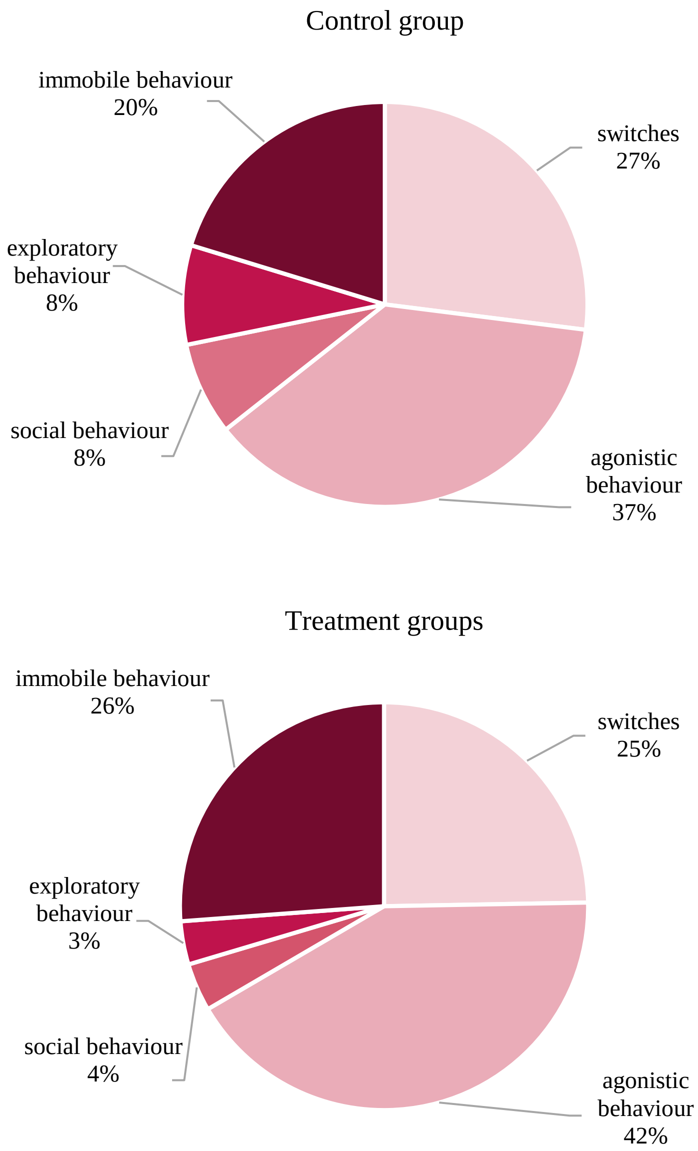
Note:
n=240 observations for the control group
n=690 observations for the treatment groups

5.1. Behavioural Data

The proportion of frequencies of the behaviours between the control and treatment groups can be seen in Figure 5. Mean frequencies together with statistical significances for sixteen types of behaviour are displayed in Figure 6.

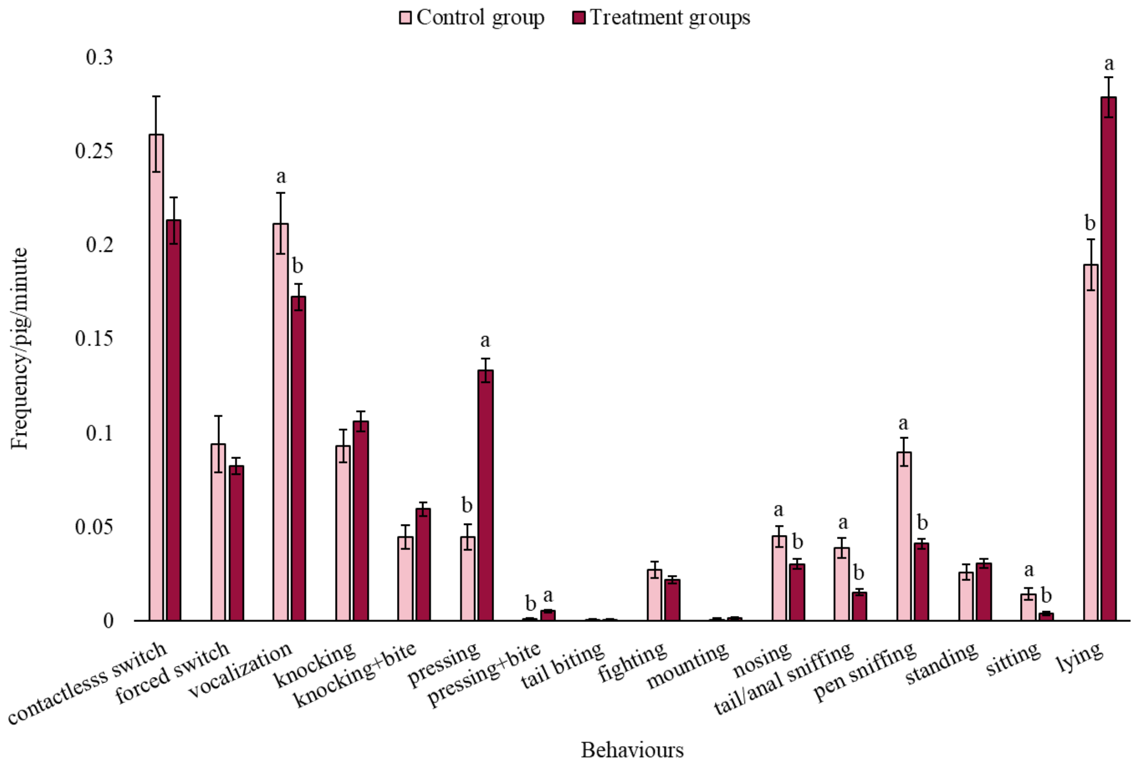
The control group performed both contactless and forced switches more often than the treatment groups (Figure 5). In contrary, in the treatment groups, agonistic behaviour made up 42 % of the behaviours, a bigger proportion compared to 37 % in the control group with the greatest difference in pressing (M±SD=0.13±1.17 for the treatment groups compared to M±SD=0.04±0.11 for the control group, p=0.000). The treatment groups also performed knocking, knocking with bite and pressing with bite more frequently (p=0.000). Vocalization was the most frequent type of agonistic behaviour both in the control and treatment groups but with a higher mean frequency for the former (M±SD=0.21±0.25, 0.17±0.18, respectively; p=0.028). The control group engaged more in social behaviour (8 % Figure 5, p=0.018 for nosing, p=0.000 for tail/anal sniffing), as well as, exploratory behaviour (8 % Figure 5, p=0.000 for pen sniffing) compared to the treatment group with 4 % and 3 %, respectively. By contrast, immobile behaviour prevailed in the latter group with a significant difference in lying (M±SD=0.28±0.28 for the treatment groups compared to M±SD=0.19±0.21 for the control group, p=0.000). Sitting was prevalent in the control group (p=0.000).

The descriptive statistics with mean, SEM, SD, minimum, maximum and p-values for the behaviours are shown in Appendix 5.



Note:
**n=120 for forced switch in the control group*
n=frequency of behaviour/pig/minute

Figure 5. Proportion of frequencies of the behaviours per pig per minute of switches (contactless switch, forced switch), agonistic behaviour (vocalization, knocking, knocking+bite, pressing, pressing+bite, tail biting, fighting, mounting), social behaviour (nosing, tail/anal sniffing), exploratory behaviour (pen sniffing) and immobile behaviour (standing, sitting, lying) between the control group with 8 feeding places (n=240) and treatment groups with 10 feeding places (n=690)*



Note:

**n=120 for forced switch in the control group*
Different letters within each behaviour indicate statistically significant differences between groups (Two-sample Student t-test, P < 0.05).

Figure 6. Mean of frequencies of sixteen types of behaviour per pig per minute with error bars (SEM) between the control group with 8 feeding places (n=240) and treatment groups with 10 feeding places (n=690) and their statistical differences*

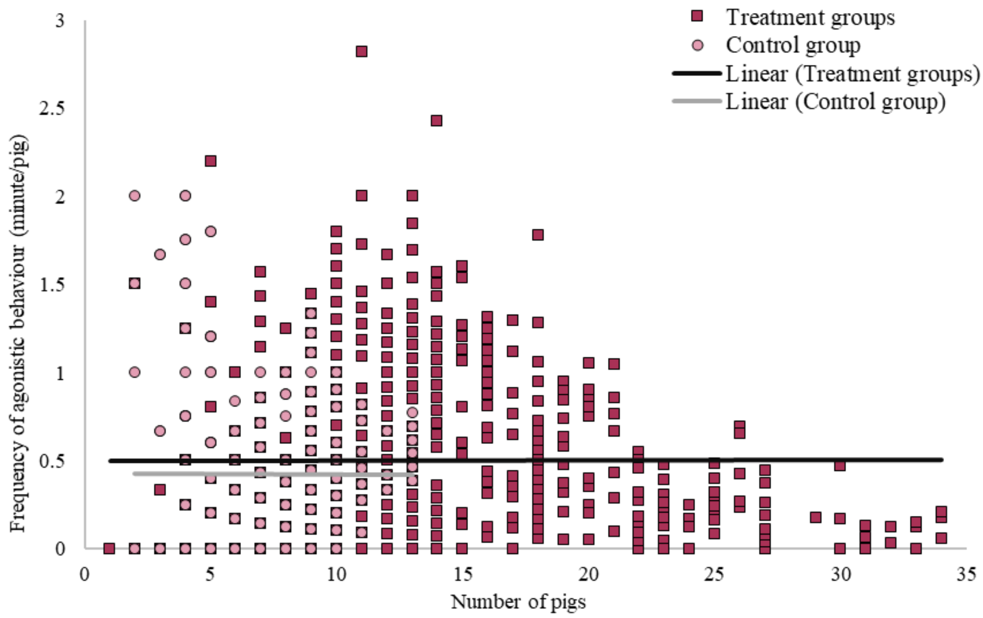


Figure 7. Pearson's correlation and linear regression between the number of pigs in the control (range 2-13) and treatment groups (range 1-34) and the frequency of agonistic behaviour (vocalization, knocking, knocking+bite, pressing, pressing+bite, tail biting, fighting, mounting)

No significant correlation was found between the number of pigs and the frequency of agonistic behaviour for the control or treatment groups (r=-0.004 and +0.002, respectively) (Figure 7).

5.2. Performance Data

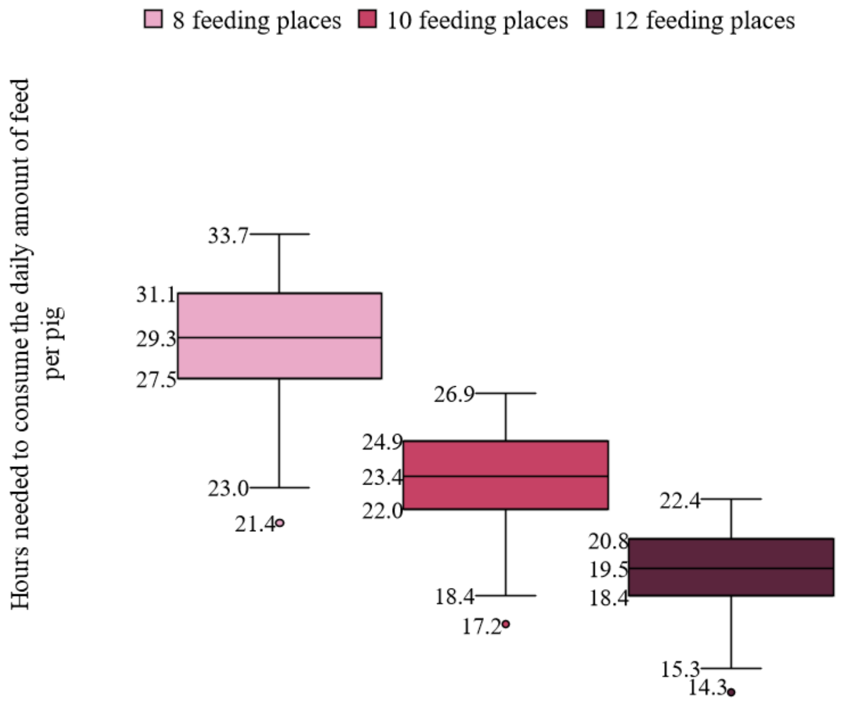
The treatment group 2 had a higher amount of feed delivered per pig (M±SD=3.53±1.01 compared to M±SD=3.18±0.65 for the control group, p=0.021) and their ADG tended to increase. Feed efficiency was not affected by the number of feeding places (Table 5).

Table 5. Descriptive statistics of average daily gain (ADG), kg of feed per kg of pig and feed efficiency (FE; g:f) between the control group with 8 feeding places (n=67 days) and treatment group 2 with 10 feeding place (n=67 days) and their statistical differences

	Control group			Treatment group			p-value
	Mean	SEM	SD	Mean	SEM	SD	
ADG (g)	1021	196	1608	1045	106	868	0.915
Kg feed/pig	3.18	0.08	0.65	3.53	0.12	1.01	0.021
FE	0.33	0.06	0.5	0.33	0.04	0.29	0.965

Note:
**Two-sample Student t-test, P < 0.05*
The chosen date range was from the 7th of March to the 12th of May for the control group (South compartment) and from the 1st of May to the 6th of July for the treatment group 2 (North compartment).

Neither a provision of 8 nor 10 feeding places allowed enough time for pigs that entered the feeding area (M±SD=112±9 number of pigs) to consume the daily amount of feed (M±SD=4.23±0.63 kg) in the chosen date range (12^{th} of June to the 6^{th} of July). Time exceeded 24 hours in 92 % and 28 % cases for the control and treatment group 2, respectively. Theoretically, 12 feeding places would provide the necessary time to eat up the daily amount of feed if the assumptions of no competition around the feeders and consumption of feed for 24 hours were met (Figure 8).



Note:
Used data were taken from the North compartment with 10 feeding places. Pigs' average weight was 93.22 kg and the data ranged from the 12^{th} of June to the 6^{th} of July.

Figure 8. Number of hours needed to consume the daily amount of feed for all pigs (M±SD=112±9 number of pigs) considering the different numbers of feeding places (n=25 days)

5.3. Carcass Data

The number of days spent at the farm was 100 and 115 days for the control and treatment group 2, respectively. The former group had a higher average initial weight (34.4 kg) and also achieved a greater average carcass weight (94.2 kg) compared to the treatment group 2 weighing 31.9 kg at arrival and 91.3 kg at slaughter.

Table 6. Proportion of a meat quality classification between the control group with 8 feeding places (n=107) and treatment group 2 with 10 feeding places (n=167) and their statistical difference

Meat quality classification	Control group	Treatment group	p-value
64-61	13%	13%	
60-57	51%	62%	0.025
56-53	25%	21%	
52-49	10%	4%	

Note:
**Mann Whitney U test, P < 0.05*
Carcass data range from the 9th of April to the 11th of June for the control group and from the 2nd of July to the 20th of August for the treatment group 2.

The treatment group 2 attained a higher meat quality classification than the control group (p=0.025) (Table 6). 13 % of the slaughtered pigs in both groups reached a meat quality classification 61 and higher. However, there were 62 % of pigs in the treatment group 2 compared to 51 % in the control group in the second-highest category (60-57). The treatment group 2 had also a lower percentage of pigs with classification below 56. According to the European scale, the evaluation of pig carcasses is based on the leanness of meat ranging from 45 % - 65 % (Jordbruksverket, 2019).

Parasites in the liver were the most frequent damages found in the control, as well as, the treatment group 2 (48 and 75 cases, respectively). Other liver damage and lung/heart inflammation followed for the control group (5 cases for each) whereas abscess and joint injury for the treatment group 2 (2 cases for each). The other carcass damages occurred only once or were not present (Table 7).

Table 7. Listing of the carcass damages between the control group with 8 feeding places (n=107) and treatment group 2 with 10 feeding places (n=167)

Type of carcass damages	Control group	Treatment group
parasitic liver damage	48	75
other liver damage	5	1
abscess	1	2
joint injury	1	2
lung/heart inflammation	5	1
pneumonia and peritonitis	1	0
lunginflammation (SEP)	1	0
overall infection	1	0
mechanic injury	1	0
others	1	0

6. Discussion

The main aim of the thesis investigated how an increase of feeding places influenced the expression of different types of behaviour at the feeders in pigs at an organic farm. I hypothesized that the group with more feeding places would express less agonistic behaviour. The secondary aim explored if more feeding places affected growth rate, feed consumption, feed efficiency and carcass quality. The corresponding hypothesis to the second aim was that I would see an improvement in the overall performance of pigs housed with more feeding places. The control group was provided with 8 feeding places per pen whereas the treatment groups had access to 10 feeding places per pen.

6.1. Main Findings

The frequency of behaviours varied between the control and treatment groups. The treatment groups performed more agonistic interactions which disproved the main hypothesis. The same group also remained recumbent inside the feeding pens after feeding bouts to a greater extent which resulted in crowding. Despite the lower exhibition of agonistic behaviour in the control group, vocalization was significantly more frequent. Additionally, pigs with fewer places engaged more in social and exploratory behaviours. ADG and FE remained unchanged, but more feed per pig was "consumed[5]" in the treatment group[6]. The treatment group additionally showed a significant improvement in a lean meat percentage.

6.2. Behaviours

Behaviour in the control and treatment groups was influenced by the occupancy of the feeding pens. The animal feeding place ratio was, in theory, higher in the control group than in the treatment groups when calculated for the whole pig unit. However,

[5] Consumed in parentheses because the system collects data about the amount of feed delivered per kilogram of pig, not an actual feed intake (as explained in Material and Methods).

[6] The treatment group in the performance and carcass analyses consisted from one batch of the pigs (treatment group 2).

the AFR based on the feeding pens occupancy was higher for the treatment groups. During the behavioural observations, the pens were less occupied for the control group resulting in fewer pigs per feeding place. The control group's AFR was 0.8 for all pigs and 0.6 for pigs that were feeding whereas the AFR for the treatment groups could have been up to 1.6 for all pigs and 0.9 for pigs assumed to be feeding.

Pigs in both the control and treatment groups were often seen switching between feeding places. It is not surprising as pigs are explorative animals by nature and experiments done in free-ranging conditions have shown a significant time spent looking for food by moving between various foraging areas (Studnitz et al., 2007, Nielsen et al., 2006). Feed sampling helps pigs gain information about available food items to balance their diet (Nielsen et al., 1996). Numerically, the control group switched contactless and forced more often than the treatment groups. Perhaps, fewer pigs in the pen in the control group meant more space and possibilities. Botermans & Svendsen (2000) noted that the possibility of choice played a bigger role in switching than too few feeders per pigs. In their study, pigs fed from four dry feeders often changed places accompanied by agonistic interactions (classified here as "forced switch") despite the low pen occupancy of 26 %. In this study, contactless switches happened more often than forced switches in both groups. In natural conditions, pigs form groups of 2-6 individuals (Graves, 1984, as cited in Jensen, 2002) and foraging takes place in extensive areas (Jensen, 2002) with rare physical contact with others. Thus, a greater occurrence of contactless switches could be logically attributed to a greater space in the pen resulting in no need to unnecessarily interact with other pigs. Moreover, pigs likely evaluated both benefits and costs of forced withdrawals (Rasmussen et al., 2006) and rather opted for no risk of injury than the aggressive acquisition of the feeding site. This all indicates an overall preference for contactless switches when given the opportunity.

Vocalization was one of the prevalent behaviours among all pigs. It is an important "message conveyor" and a situation when pigs elicit sounds may reflect their welfare state (Manteufell et al., 2004). The pigs could have communicated through vocalizing (Manteufell et al., 2004) to avoid conflicts. On this account, a higher frequency of vocalization in the control group with less agonistic interactions may be elucidated. High pitch sounds (squeals or screams), in that case, served as honest signals conveying useful information that conspecifics could have not obtained another way (so-called signalling theory) (Petak, 2019). According to this theory, a signal must be beneficial for both – the elicitor and receiver (Laidre & Johnstone, 2013). In this study, I had an impression that vocalization rarely occurred alone and often went with other agonistic behaviours. Špinka et al. (n.d.) found a strong correlation between vocalization and aggression in sows at feeding. The suggestion seems plausible since social competition increases vocalization (Schön et al., 2004) and the same was observed during the recordings for this project. However, pigs in the control group which vocalized more also performed less agonistic interactions overall which contradicts the assumption of a linear relationship between vocalization and aggression suggested by Špinka et al. (n.d.). Kiley (1972) as the first linked vocalization to the “level of excitement”. He understood increase in excitement as “an increase in locomotion with the performance of more different activities more often” and added that excitement is often elicited by a frustrating situation. However, Kiley’s theory (1972) is based on high pitch sounds associated with frustration. In this study, types of vocalization were not distinguished which confounded the outcomes since grunting, one of the frequent type of pigs’ vocalization has social rather than agonistic characteristics (Manteuffel et al., 2004). Despite that, a surmise of a greater locomotion in the control group might explain more vocal signals when linked together with the higher frequency of switches, social and exploratory behaviour and the lower frequency of lying behaviour. Nonetheless, a total active state of the pigs was not measured.

Preventing conflicts has an adaptive value (Tinbergen, 1963) since it allows feeding with less disturbance and saves time for other interactions. As mentioned above, the control group engaged more in social nosing, tail/anal sniffing and pen sniffing. Pigs have intrinsic need to use their snouts for communication and mutual recognition (Camerlink et al., 2013); worth mentioning is also a utilization of the snouts for foraging and rooting around half of the day in semi-natural conditions (Stolba & Wood-Gush, 1989). In this study, pigs when indoors satisfied this need by nosing or sniffing body parts of conspecifics and by exploring the pen. However, pen sniffing might have been biased due to a frequent sniffing in the proximity of the observer. It is interesting that the perception of nosing in pig behaviour differs. Oczak et al. (2013) attributed nosing a negative role because they found 46 % of aggressive interactions initiated with nose to nose contact. On the other hand, Camerlink, et al. 2013 showed a relation in only 2.5 % of nosing to injurious oro-nasal behaviour. Access to straw and familiarity of the pigs in Camerlink et al. (2013) and barren environment and an immediate start of the observations after mixing in Oczak et al. (2013) were probable reasons for this disagreement. Based on the similarity of the housing to Camerlink et al. (2013) and findings from the direct observations, social (nosing, tail anal sniffing) and exploratory behaviour (pen sniffing) represented rather a pleasant activity linked to social recognition and foraging than to aggression. More agonistic behaviour occurred in the treatment groups compared to the control group. This finding was unexpected regarding the fact the treatment groups had access to more feeding places but simultaneously there were also more pigs in the feeding pens. Hence, it is worth mentioning that for the analysis the behavioural data were corrected for the number of pigs present in the feeding pens at the time of the observation. The issue with aggression at feeding is that it cannot be fully prevented as the areas with a high population density such as feeding pens experience an interference with the communicatory behaviour (Ewbank & Briant, 1972). It means that even a group of pigs with a stable hierarchy may fight and compete for the establishment of a rank within the group at feeding (Persson et al., 2008). By looking at the issue from consumer demand theory, food for animals has an ultimate value (Dawkins, 1983, as cited in Duncan, 1992) and represents a "necessity". In economic words, animals value the necessity (food) so high that they continue buying it even when income (in this case time) becomes limited and food costs go up (e.g. by imposing an operant conditioning task or obstructive techniques to obtain feed) (Duncan, 1992). Here, it stands for pigs' willingness to fight or defend a feeding site even for an increased price of energy expenditure (Thomsen et al., 2010), shorter feeding time (Nielsen et al., 1996, Rasmussen et al., 2006), competition (Persson et al., 2008, Nielsen et al., 1996, Thomsen et al., 2010, Rasmussen et al., 2006) or greater efforts to obtain the feed (de Jonge et al., 2008).

Additionally, the fact that the treatment groups were by eight and five weeks younger than the control group could have also affected the expression of agonistic behaviour. Scheffler et al. (2016) suggested that aggression is a more stable trait in older pigs but also referred to a difficulty to differentiate between playful and agonistic behaviours in weaned pigs. In this project, not only ago factor might have possibly influenced the behaviour but also a familiarity with this complex feeding system. The observations for the control group were done on older pigs accustomed to the system whereas two observational sessions for the treatment groups took place shortly after their arrival. The novelty of the feeding environment and potential troubles to learn the operation of the system could have served as triggers for agonistic behaviour. Lastly, I speculate that recent regrouping with unacquainted pigs was another contributing factor to an elevated agonistic behaviour in the treatment groups as shown in other studies (Turner et al., 2006, Jensen & Yngvesson, 1998, Scheffler et al., 2016).

By evaluating the behaviours separately, six behaviours included in agonistic behaviour (pressing, pressing + bite, knocking, knocking + bite, tail biting, mounting) happened more frequently in the treatment groups with a significant difference in pressing and pressing + bite. Vocalization (discussed separately) and fighting occurred more in the control group, but the occurrence of fighting was low and only with a slight difference.

One of the most striking explanations for the distribution of agonistic interactions is the occupancy range of the feeding pens. Resources allocated in a restricted area cause accumulation of animals, resulting in crowding and elevated aggression (Thomsen et al., 2010, Botermans & Svendsen, 2000, O'Connell et al., 2002). By considering the dimension of the feeding pen (4.6 x 2.3 m), crowding in the treatment groups was more likely since there were up to 34 pigs at a time whereas the maximum number of pigs in the control group was 13. According to the KRAV Standards (2019), growing pigs (< 85 kg) in organic conditions must have indoor space of > 1.2 m^2 each and > 1.5 m^2 when they reach the finishing phase (< 110 kg). However, these dimensions apply to an overall indoor layout of the barn and do not correspondent to a provided space at frequently visited places like feeding area. Pigs show little territorialism and voluntarily perform intense contact behaviour, but they do need to keep individual distance (Broom & Fraser, 2007). Aggression (Thomsen et al., 2010) or avoidance strategy may be the consequence of space disruption whereas the latter is sometimes preferable (Broom & Fraser, 2007). It is difficult to avoid other pigs in a confined space; thus, aggression can be significantly higher in a lower space allowance (Ewbank & Briant, 1972, Anil et al., 2007). But the groups in Ewbank & Briant (1972), Anil et al. (2007) were provided with much smaller space allowance compared to pigs in my experiment, therefore, the results must be compared with caution. Lastly, the incidence of too many pigs in the feeding pen might have been the reason for the increase in agonistic interactions in the treatment groups as the same was seen in O'Connell et al. (2002).

Pressing was the most frequently performed behaviour among agonistic interactions in the treatment groups. It often occurred during the acquisition of a feeding site, but also on the way to the exit. Considering the high frequency of lying behaviour, pigs in the treatment groups needed to pass through other pigs. The frequency of lying was high in both groups but fewer pigs in the pen on average in the control group created an aisle to exit without excessive contact with other pigs.

Pig behaviour is flexible and influenced by external factors, such as precipitations, wind and temperature (Kongsted et al., 2013). The observance of the treatment groups was scheduled for May, June and July with maximum temperatures of 9, 23 and 17 °C on those particular days (Skovde Historical Weather, n.d.). It was only 8 °C during the recording of the control group in April (Skovde Historical Weather, n.d.). Lying, despite the resting purposes, serves as an important tool to thermoregulate the body. The temperature of the environment (air velocity, humidity and surface temperature) affects the duration, place, time and frequency which pigs spend in lateral or sternal recumbency (Velarde & Geers, 2007). Taking into account pigs' susceptibility to overheating and the fact that eating and the following digestive process generates additional heat (Kwakman et al., 2018), it is expected that they seek cool places for resting at high ambient temperatures. The floor inside of the barn, apart for the deep bedded area, was made of slats which have been found as a favourable flooring to lie down when room temperature rose above 19 °C (Huynh et al., 2005). The temperature inside the barn in June and July most probably reached or even exceeded 19 ° C (inside temperature not measured), so that more pigs remained by the feeders to rest on slats, despite the possibility to go on pasture. Yet, the pigs did not experience heat stress as the temperature during the recordings did not exceed the upper critical point (27 °C; Verstegen et al., 2005). They were also seen huddling which is typical for colder temperatures (Ekkel et al., 2003) but here the likely cause was a limited lying area in the feeding pen.

It is important to acknowledge that more observational days throughout the whole rearing period for both groups are needed to draw conclusions. In general, the DOMINO *Pig Sort* feeding system represents a positive engagement for pigs. Pigs spend more time feeding by having to work for feed in a challenging as well as entertaining way. Altogether, it can mitigate frustration and stereotypies that arise when pigs spend little time or are completely deprived of foraging (Wood-Gush and Vestergaard, 1989, Bergeron et al., 2006). Moreover, the feeding system can be perceived as an environmental enrichment increasing the welfare of pigs regarding the control over the environment and promoting coping abilities.

6.3. Performance

Despite numerous indications from various publications that more aggression causes poorer performance, it was not the case for this study. Growth rate and feed efficiency stayed the same in both groups, but the treatment group consumed more feed and achieved better carcass quality. Since the collected data provided only insight into the issue it cannot be claimed that the variation in performance between the control and treatment groups was caused by changes in behaviour. There were many factors playing a role such as different months of the observations, temperature, age, pasture access and pen occupancies.

Both groups had similar yet high values in ADG. The farm belongs to the top 25 % of the farms in terms of ADG when compared to the Swedish national production database with an average weight gain of 1030 g/day in the best farm (Gård & Djurhälsan, 2020). Persson et al. (2008) found a decrease in ADG by 107 g/day in the group of pigs fed restrictively nine times per day compared to three times per day. ADG was also lower in the AFR of 16:1 compared to 8:1 in Georgsson & Svendsen (2001) (fed restrictively only in the finishing phase). Both studies attributed the decline in growth to an elevated competition at feeding. No changes were spotted in production variables in the groups of 10 pigs accommodated with either one or four feeding spaces with various intensity of aggression (Nielsen et al., 1996). The explication for the unchanged ADG in this experiment could be that the *ad libitum* feeding potentially enabled compensatory feeding sessions to individuals that were forced to stop feeding due to competition. FE remained the same as in Georgsson & Svendsen (2001).

The higher feed consumption in the treatment group could be explained by the addition of two more feeding places that provided more time for feeding. An approximated calculation was done to find out the difference in time allowance to eat up the daily amount of feed for 8, 10 and 12 feeding places using earlier data on time needed for feed consumption (REF). Neither 8 nor 10 feeding places provided enough time to consume the amount of daily feed and 24 hours were exceeded by 92 % and 28 %, respectively. In theory, having 12 feeding places would solve the time budget issues. On top of that, more time for feeding possibly affected a lower variance in ADG (SD) in the treatment group indicating more evenly distributed growth. A group of pigs in Wastell et al. (2018) with the AFR of 10:1 had also greater ADFI compared to 13:1 and 16:1, but this study attributed the difference to an increased feed wastage rather than to behavioural causes and longer time allowance to eat the feed.

Nonetheless, the finding of the higher feed consumption contradicts the unchanged ADG between the groups. Perhaps the fact that the treatment group had access to pasture during the whole growing-finishing phase and consequently spent more energy during foraging whereas the control group did not for the first eight weeks could explain no additional gain in the treatment group. In this trial, time spent defending the site could have influenced feed intake per feeding bout but not the total amount of consumed feed for several reasons. First, feed consumption could have been enhanced by the pigs' ability to appraise the situation and increase feeding speed as a consequence to competition (Held et al., 2010, Rasmussen et al., 2006, Botermans & Svendsen, 2000). Second, the pigs were seen to feed at night-time (unpublished data – barn pictures), the same strategy used by submissive and smaller pigs in Botermans et al. (2010).

Carcass quality differed between the groups. Pig carcasses are evaluated based on lean meat percentages ranging from 45 % - 65 % (Jordbruksverket, 2019). The treatment group achieved a significantly better meat quality classification. Persson et al. (2008) saw a drop in lean meat content in the group with more competition by 0.6 %. Although the Persson's findings showed the opposite, a contradiction cannot be claimed based on insufficient data in this study. Likely, other factors have affected the greater lean meat content in the treatment group, e.g. longer time spent grazing outside.

Foraging on pasture can be an important contribution of the energy, protein, as well as, vitamins and minerals (Edwards, 2003). Growing pigs with *ad libitum* access to concentrate may ingest about 0.1 kg DM of a grazed herbage per day (Edwards, 2003). Studies have shown that pigs with a possibility to graze reached a slightly higher although not significant carcass lean meat percentage compared to indoor reared pigs (Botermans et al., 2015, Enfält et al., 1997). Enfält et al. (1997)

attributed the leaner carcass meat percentage to the combination of greater freedom of movement with a generally slower growth rate in organic pigs. But Millet et al. (2004) compared conventional and organic housings and did not see any significant changes in terms of carcass lean meat percentage. After evaluation of these studies, we might ponder that the number of feeding places in the combination with exercise affected the meat quality. However, more research with a bigger sample and over a longer period is needed to confirm this assumption.

Access to pasture is the likely reason why I saw the increase in gastrointestinal parasites in the treatment group. Outdoor access is known to elevate the incidence of nematode parasitic eggs due to pasture soil contamination (Lindgren et al., 2020).

6.4. Economy

An implementation of innovative technologies is comprised of a one-time investment along with a rise in running costs. For farms to be profitable, these must be smaller than the revenue. The DOMINO *Pig Sort* feeding system is a large investment and imposes a bigger demand for labour (pigs' training phase) which anticipates a higher price for the meat. Consumers should be willing to pay more for the meat produced in these systems and attribute the elevated welfare of the animals with the higher price. Farmers expect that the purchase of more feeders generates better carcass quality resulting in a better payment by the slaughterhouses.

6.5. Improvement Suggestions

Crowding

The DOMINO *Pig Sort* feeding system let pigs enter the feeding area in a constant flow, thus, the number of pigs changed almost every minute. Hypothetically, a threshold limit number (maximum number of pigs in the feeding pen) would cease the risk of crowding and decrease agonistic behaviour. Nevertheless, by applying this idea alone, other issues such as potential aggression in front of a gate to the feeding pens would emerge.

First, pigs must go through a scale. The entry gate to a scale opens when it detects a pig in front. In case, there is another pig inside, the pig outside must wait until the pig on the scale is released to one of the feeding pens. If the capacity of the feeding pens exceeded the threshold number, the entry gate would not open and queuing pigs in front of it would give rise to potential conflicts. To avoid clustering, pigs could learn to approach the scale only when they hear a specific signal. Ernst et al. (2005) tested pigs' cognitive learning abilities to operate this kind of system with great success. Various sounds would summon different groups of pigs trained to react only to a sound assigned to them. Pigs using the "call-feeding station" had the same ADG as pigs with conventional feeding system (Ernst et al., 2005).

Lying

Another issue was pigs' lying resting in the feeding pens which led to crowding and difficulty for pigs to stand and eat. Perhaps, reducing the size of the feeding pens might weaken the tendency to rest and solve the problem. By a combination with the threshold number idea, knowing a maximum number of pigs in the pen at a time would make possible to calculate a pen dimension unsuitable for a prolonged stay after eating. An equation for an average lying space in thermoneutral condition could be used: $m^2 = 0.033 \times W^{0.66}$ (Ekkel et al., 2003). The equation would be then accordingly adjusted to provide less space for lying than pigs find comfortable. Next, floor-type has also an impact on pigs' activity level and could be made more abrasive since it has been shown as less attractive for pigs to lie down (Lensink et al., 2013). Besides, fans could be installed to generate draught to which pigs react adversely. An exposure to a high air velocity decreased lying time (Scheepens et al., 1991). The draught also made pigs overall more active and intensified agonistic behaviour, therefore, this recommendation should be treated with caution.

Noise

The last suggestion is about the noise produced by the entry/exit gates. The construction of five hanging metal bars touching the slatted flooring creates a sudden noise when the bars fall on the floor (pigs have to lift the bars and pass under while entering/leaving the pen). The sound levels in pig units range between 60 – 70 dB (Talling et al., 1998) and these gates add unnecessary noise to an already noisy environment. I propose either to cover the ends of the metal bars with a rubber or soften the slats by placing a mat on the floor, eventually both.

6.6. Methodology

This thesis was designed as an intervention study, but its design was unbalanced. The control group was observed for two days giving 240 observations while the treatment groups that consisted of two batches of pigs were recorded for six days adding up to 720 observations. The experiment could not have been done otherwise due to time planning and the farm flow. The unbalanced design with fewer observations for the control group is the biggest limitation of this study, and the conclusions from the results must be interpreted carefully. However, the recordings from the treatment groups represent a solid data set that can be used for a further study targeting this topic.

Even though a direct observation was a suitable method of the recording, a disturbance of pig behaviour whenever the observer entered the barn proved to be a disadvantage. To compensate for the disturbance, the observer waited for 10 minutes before each start of the recording session, however, at times pigs did not seem to be completely habituated to the observer. Perhaps, the observer should have waited for a longer time until all pigs settled down. There was no place to stand and conduct the observations out of the pigs' sight, therefore, biased pig behaviour must be considered. However, it is unlikely that this affected the results as the observer logically affected both the control and treatment groups equally.

Regarding the protocol and recordings, each behaviour was assigned to an individual if distinguishable. This was difficult at times of a dense feeding pen occupancy and some errors at classification might have occurred. E.g. mutual head/body knocking + bites (2 behaviours) or fighting (1 behaviour) were occasionally problematic to tell apart. When facing this issue, a priority was given to record the behaviour in either column over a correct classification.

The behaviours were grouped as it suited best for this study, and it may not agree with other publications. Vocalization was recorded as one of the agonistic behaviours, but it can also be classified separately. Depending on situations, vocalizing has both agonistic and social purposes (Manteufell et al., 2004). In this study, all types of vocalization were recorded, grunting included, which belongs to a social category. Although high-pitch sounds which signal frustration (Kiley, 1972) were prevalent, the issue with grunting might have created misleading indications in the results. Contactless and forced switch had their category of "switches" but a forced switch was an exhibition of agonistic behaviour. Furthermore, switches often happened concurrently with agonistic behaviours and were at times inadvertently missed when the feeding pens were densely occupied.

A parametric two-sample Student t-test was used for the analysis of the behavioural data, despite having a Poisson distribution. Parametric tests are usually used for normally distributed datasets, but the Student t-test does not require a normal distribution in sufficiently large non-normally distributed samples (Lumley et al., 2002). The large amount of recorded observations (n=240 for 8 feeding places, n=720 for 10 feeding places) represents a "sufficiently large" sample size (Lumley et al., 2002). Additionally, the t-test was proven to be a suitable statistical test for its robustness, considering an unbalanced design of this experiment. Another concern might be a mass significance. I used the t-test for a comparison of each behaviour, but the more statistical comparisons are performed, the greater the probability of false conclusion (Lane, 2013). Hence, the fact that only biologically relevant data for the experiment in the large dataset were analysed reduces the risk of the mass significance.

Following the assumption that the number of pigs in the feeding pens affected the expression of agonistic behaviour, a Pearson correlation and linear regression were computed. However, the Pearson correlation coefficient showed zero correlation between the number of pigs and agonistic behaviour. Possibly, the issue was that all eight types of agonistic behaviour were correlated together, and, in some cases, a stronger correlation would have been shown if every single behaviour was correlated with the number of pigs in the feeding pens separately.

6.7. Ethical aspects

Due to the observational character of the study, no ethical permit was needed. No harm was imposed on the studied animals while conducting the study. The observer followed all biosecurity rules and obtained a farmer’s consent about publishing the outcomes from the behavioural observations and the pictures taken at the farm.

7. Conclusions

The main aim was to identify any potential differences in behaviours, with agonistic interactions in focus, expressed at the feeders between the groups provided with 8 or 10 feeding places. Any possible variations in growth rate, feed consumption, feed efficiency and carcass quality were also examined.

Based on the results I conclude that:

- The provision of two extra feeding places did not decrease the expression of agonistic interactions at the feeders since the treatment groups with 10 feeding places performed agonistic behaviour more frequently. However, this finding cannot be solely attributed to the number of feeding places but rather to the denser feeding pen occupancy in the treatment groups. Thus, I cannot conclude that more feeding places caused more agonistic interactions since there were several confounding factors.

- Growth rate remained the same but there was an indication of more even growth in the treatment group. The treatment group also consumed more feed but access to pasture with a consequent higher level of exercise possibly diminished the effect of a faster growth.

- Feed efficiency was not affected by more feeding places. Hence, the treatment group attained a higher lean meat percentage possibly caused by a combination of the longer time spent grazing on pasture with a longer time for feeding. On that account, the improvement in carcass quality can be partly attributed to the increase from 8 to 10 feeding places.

- Theoretical calculation based on the time needed for a pig to consume the daily amount of feed shows that even 10 feeding places might not be enough to provide sufficient access to all 150 pigs.

Considering the complexity of the DOMINO *Pig Sort* feeding system, the change of one attribute neither mitigated the expression of agonistic behaviour at the feeders nor improved overall performance. Additional research over a longer time with a larger sample size is needed to confirm the proposed assumptions.

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Appendix 1

Appendix 1. List of the ingredients in the concentrate - phase 1, phase 2 and phase 3

Ingredients	Phase 1	Phase 2	Phase 3
Wheat	42%	43%	49%
Oats	10%	10%	12%
Fava beans	17%	17%	9%
Corn	14%	15%	16%
Slaughter mix	17%	15%	14%

Appendix 2

Appendix 2. Content of the slaughter mix (Slakt mix - Piggfor Sund Grymtex)

Name	Units	Amount
NE Swine - growing	MJ/kg	8,2
ME estimated	MJ/kg	11
Water	%	8
Rye protein	g/kg	401
Crude fat	g/kg	61
Ash	g/kg	47
Crude protein	g/kg	191
Sodium	g/kg	9,5
Calcium	g/kg	42,2
Lysin	g/kg	27,3
Methionine	g/kg	6,8
Vitamin A	IE/kg	30500
Vitamin D3	IE/kg	3050
Vitamin E	mg/kg	549
Selen	mg/kg	2,4
Nitrogen	g/kg	64,1
Phosphorus	g/kg	10,2
Potassium	g/kg	13,9
Estimated climate value	g CO2 equiv	2114

Appendix 3

Appendix 3. Protocol for the direct observations at the farm

pen	time (min)	no. of pigs	no. of pigs eating	switch of places CONTACTLESS	switch of places FORCED	vocalization squeqing/ grunting	knocking head/body	+bite	pressing inverse/ parallel	+bite	nosing head/body	tail/anal sniffing	tail biting	fighting	pen sniffing	standing	sitting	lying	mounting
	1																		
	2																		
	3																		
	4																		
	5																		
	1																		
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Appendix 4

Appendix 4. Performance data from the South and North compartments

South compartment - 8 feeding places			
Date	Number of pigs	Average weight (kg)	Feed (kg)
03/03/2020	131	34.4	270.4
04/03/2020	130		227.6
05/03/2020	130		175
06/03/2020	130	37.5	199.9
07/03/2020	130	37.9	248.7
08/03/2020	130	39.6	288.7
09/03/2020	120	39.2	289.3
10/03/2020	99	41.3	274.3
11/03/2020	101	40.7	318.4
12/03/2020	107	43.3	316.8
13/03/2020	104	44.4	355.1
14/03/2020	104	46.4	322.8
15/03/2020	104	49.2	345.6
16/03/2020	97	47.3	291
17/03/2020	97	49.7	343.6
18/03/2020	117	50.0	350.8
19/03/2020	117	51.2	335.6
20/03/2020	117	52.9	381.1
21/03/2020	117	53.6	369.6
22/03/2020	117	54.9	349.1
23/03/2020	117	55.0	366.8
24/03/2020	117	56.8	353.1
25/03/2020	117	57.6	384
26/03/2020	117	59.1	412.5
27/03/2020	117	60.8	395.5
28/03/2020	116	62.3	392.7
29/03/2020	116	63.0	352
30/03/2020	116	64.6	412
31/03/2020	116	65.0	422.4
01/04/2020	105	62.8	383.6
02/04/2020	105	66.3	424.9
03/04/2020	105	67.3	396.5
04/04/2020	105	68.9	413.3

05/04/2020	105	70.3	411.6
06/04/2020	105	71.5	411.3
07/04/2020	105	72.8	434
08/04/2020	105	68.0	431.2
09/04/2020	105	72.0	411.3
10/04/2020	101	74.5	446.3
11/04/2020	101	75.8	382.5
12/04/2020	101	77.8	455.3
13/04/2020	101	78.7	439.4
14/04/2020	111	77.4	403.4
15/04/2020	111	82.1	490.6
16/04/2020	111	82.2	447.7
17/04/2020	111	83.0	416.4
18/04/2020	111	85.2	461.6
19/04/2020	111	86.5	462.3
20/04/2020	100	84.3	460.6
21/04/2020	108	84.3	431.8
22/04/2020	100	85.8	478.8
23/04/2020	89	89.2	380.4
24/04/2020	88	91.4	432.2
25/04/2020	87	93.2	449
26/04/2020	87	93.5	428.7
27/04/2020	88	95.4	418.8
28/04/2020	87	96.9	423.8
29/04/2020	100	98.1	481.3
30/04/2020	100	97.9	341.8
01/05/2020	99	99.2	391.6
02/05/2020	99	100.7	372.8
03/05/2020	100	96.1	386.6
04/05/2020	100	97.0	360
05/05/2020	97	98.9	418.6
06/05/2020	88	99.3	584
07/05/2020	86	101.6	438
08/05/2020	85	102.1	423.8
09/05/2020	85	104.2	327.9
10/05/2020	87	104.4	353.9
11/05/2020	96	104.9	338.7
12/05/2020	93	105.9	356.6
13/05/2020	68	104.7	483
14/05/2020	63	104.8	342.8
15/05/2020	62	105.7	297.5
16/05/2020	62	107.1	297.1
17/05/2020	62	107.9	279.9
18/05/2020	62	109.6	356.6
19/05/2020	65	110.8	249.8
20/05/2020	60	113.0	263.6

21/05/2020	60	114.7	262.2
22/05/2020	60	115.0	237
23/05/2020	60	116.9	262.5
24/05/2020	55	117.6	292.4
25/05/2020	61	118.7	306.5
26/05/2020	58	118.9	292.3
27/05/2020	17	115.7	293.9
28/05/2020	12	112.6	234
29/05/2020	15	112.8	62.6
30/05/2020	16	113.6	110.3
31/05/2020	16	115.5	108.1
01/06/2020	16	115.5	125.2
02/06/2020	13	116.8	108.3
03/06/2020	13	115.3	154.9
04/06/2020	8	116.6	94.1
05/06/2020	8	117.9	141.5
06/06/2020	8	118.6	110.8
07/06/2020	8	119.2	94.1
08/06/2020	4	120.8	44.6

North compartment - 10 feeding places

Date	Number	Average weight (kg)	Feed (kg)
27/04/2020	166	31.9	359.5
28/04/2020	166	two extra feeding places	301.7
29/04/2020	166		279.7
30/04/2020	166	34.6	229.1
01/05/2020	164	36.2	245.8
02/05/2020	157	37.7	287.6
03/05/2020	155	38.6	305.9
04/05/2020	152	39.5	297.7
05/05/2020	155	40.4	350.4
06/05/2020	125	41.6	303.3
07/05/2020	124	43.1	343.4
08/05/2020	134	42.4	338.9
09/05/2020	132	43.8	358.6
10/05/2020	132	44.2	308.1
11/05/2020	133	45.0	329.2
12/05/2020	118	45.1	378.9
13/05/2020	113	46.3	346.7
14/05/2020	113	47.8	484
15/05/2020	113	48.8	438.3
16/05/2020	113	49.7	481.7
17/05/2020	113	50.6	469.9
18/05/2020	122	51.8	454.8
19/05/2020	108	52.2	382.6
20/05/2020	122	53.8	483.2

21/05/2020	122	55.4	482.6
22/05/2020	122	56.3	507.7
23/05/2020	122	57.2	197.9
24/05/2020	108	58.7	539
25/05/2020	122	59.2	527.5
26/05/2020	120	61.1	520.6
27/05/2020	121	59.3	580.9
28/05/2020	120	61.0	271.8
29/05/2020	120	62.7	534.6
30/05/2020	120	63.7	549.3
31/05/2020	120	64.8	565.2
01/06/2020	120	66.4	561
02/06/2020	120	68.0	550.1
03/06/2020	120	68.7	572.4
04/06/2020	121	69.8	592.7
05/06/2020	120	70.2	566.2
06/06/2020	120	72.1	519.6
07/06/2020	120	73.1	609.5
08/06/2020	115	74.8	606.1
09/06/2020	115	76.5	535
10/06/2020	115	78.3	596.3
11/06/2020	115	78.8	599.5
12/06/2020	110	80.5	581.5
13/06/2020	120	81.7	536.4
14/06/2020	120	83.2	536
15/06/2020	120	83.7	564.5
16/06/2020	120	85.2	558.6
17/06/2020	117	85.5	570.4
18/06/2020	120	84.0	417.6
19/06/2020	116	88.0	655.3
20/06/2020	116	89.1	551.7
21/06/2020	120	90.0	585.2
22/06/2020	120	90.9	447
23/06/2020	120	91.7	611.4
24/06/2020	109	95.3	618.3
25/06/2020	109	97.3	569.1
26/06/2020	112	97.1	601.4
27/06/2020	116	98.4	581.4
28/06/2020	116	98.4	548.9
29/06/2020	114	99.1	612.8
30/06/2020	106	99.8	633.6
01/07/2020	101	99.7	583.7
02/07/2020	85	100.4	623.7
03/07/2020	101	101.5	471.8
04/07/2020	101	102.3	576.4
05/07/2020	101	103.1	526.5

06/07/2020	101	104.6	490.1
07/07/2020	96	104.4	589.3
08/07/2020	82	106.3	498.5
09/07/2020	71	105.2	548.1
10/07/2020	56	105.8	434.7
11/07/2020	55	106.5	510
12/07/2020	31	106.0	372.3
13/07/2020	30	105.0	293.7
14/07/2020	26	105.8	307.7
15/07/2020	31	107.5	329.7
16/07/2020	30	108.6	271.9
17/07/2020	31	110.0	256
18/07/2020	31	111.0	304.5
19/07/2020	31	112.0	380.8
20/07/2020	21	113.1	324.1
21/07/2020	20	113.5	274.6
22/07/2020	8	113.0	80.2
23/07/2020	-3	113.4	225.3
24/07/2020	8	115.4	214.3
25/07/2020	8	116.6	211.3
26/07/2020	8	118.5	232.2
27/07/2020	8	117.9	392.3
28/07/2020	-16	117.2	337.6
29/07/2020	-20	116.3	152.2

Appendix 5

Appendix 5. Descriptive statistics of mean frequencies of sixteen types of behaviour per pig located in the feeding area per minute between the control group with 8 feeding places and treatment groups with 10 feeding places and their statistical differences

Behaviour	Control group						Treatment groups						p-value
	n	Mean	SEM	SD	Min	Max	n	Mean	SEM	SD	Min	Max	
Contactlesss switch	240	0.26	0.02	0.31	0	2.5	690	0.21	0.01	0.33	0	3	0.054
Forced switch	120	0.09	0.02	0.16	0	0.75	690	0.08	0.00	0.12	0	0.78	0.462
Vocalization	240	0.21	0.02	0.25	0	1.5	690	0.17	0.01	0.18	0	1	0.028
Knocking	240	0.09	0.01	0.13	0	0.75	690	0.11	0.01	0.14	0	1	0.197
Knocking+bite	240	0.04	0.01	0.10	0	0.67	690	0.06	0.00	0.10	0	0.58	0.410
Pressing	240	0.04	0.01	0.11	0	0.75	690	0.13	0.01	0.17	0	0.8	0.000
Pressing+bite	240	0.00	0.00	0.01	0	0.09	690	0.01	0.00	0.02	0	0.25	0.000
Tail biting	240	0.00	0.00	0.01	0	0.11	690	0.00	0.00	0.01	0	0.15	0.615
Fighting	240	0.03	0.00	0.07	0	0.33	690	0.02	0.00	0.06	0	0.5	0.281
Mounting	240	0.00	0.00	0.01	0	0.11	690	0.00	0.00	0.01	0	0.10	0.285
Nosing	240	0.05	0.01	0.09	0	0.5	690	0.03	0.00	0.07	0	1	0.018
Tail/anal sniffing	240	0.04	0.01	0.08	0	0.56	690	0.02	0.00	0.04	0	0.31	0.000
Pen sniffing	240	0.09	0.01	0.12	0	0.54	690	0.04	0.00	0.07	0	0.5	0.000
Standing	240	0.03	0.00	0.06	0	0.33	690	0.03	0.00	0.06	0	0.43	0.311
Sitting	240	0.01	0.00	0.05	0	0.25	690	0.00	0.00	0.03	0	0.5	0.000
Lying	240	0.19	0.01	0.21	0	0.71	690	0.28	0.01	0.28	0	1	0.000