Behaviour and hygiene of finishing pigs housed in ‘Moving floor’ pens

– a comparative study

Beteende och hygien hos slaktgrisar inhysta på rörligt golv enligt ’Moving floor concept’

Johanna Viklund

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Swedish University of Agricultural Sciences, SLU
Department of Animal Environment and Health
Agriculture Programme – Animal Science
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Johanna Viklund

Supervisor: **Rebecka Westin, Swedish University of Agricultural Science, Department of Animal Environment and Health**

Assistant supervisor: Jenny Yngvesson, Swedish University of Agricultural Science, Department of Animal Environment and Health

Examiner: Torun Wallgren, Swedish University of Agricultural Science, Department of Animal Environment and Health

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Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Environment and Health

Abstract

Moving floor AB are developing self-cleaning cubicles for pigs and calves. There are however no present published reports on the effects on pigs' behaviour in this system. The aims of this study were to see how workload, pig behaviour, pen and pig hygiene, and resting are influenced by this design and if it will change over time. A focal animal observation study with continuous frequency recording was performed, including both on farm observations and observations from video recordings. Recordings on farm included 120 finishing pigs (TN70 x Danish duroc) divided in six pens each between the Moving floor system (MF) and a control group (C) kept in a traditional stable with long trough pens. For behavioural observations, four focal animals per pen were observed 5 min each during several occasions (108 observations in total). Hygiene in the pens and on the pigs was assessed during five consecutive days and the time farmer put on routine work was measured once in both systems. From the video recordings were three MF pens and two C pen studied. Three focal animals per pen were observed for 10 minutes each during eighteen days in three different time periods (week 2, 4-5 and 7, 432 observations in total). In addition, resting behaviour, both preferred position in the pen and eventual disturbance by first movement of the floor, were observed from the video recordings.

The results show that pigs housed in MF in general behave similar to pigs housed in C i.e. most behaviours occur with the same frequency but were significantly different for some behaviours. MF was standing, manipulating litter, interior and empty feeding trough less than C ($p < 0.05$) during farm observations. During video observation was however MF laying and sitting down more than C in week seven ($p < 0.05$). C pigs were laying more in the beginning of production than in week seven ($p = 0.004$). MF pigs was standing more in week two compared with C for the same week ($p=0.028$). Rooting a pen mate where more frequently performed in MF than in C ($p=0.022$). The frequency of rooting the empty feeding trough was increased for MF from week two to week seven ($p<0.05$) and was performed more in MF than C in last week of observation ($p=0.004$). Manipulation of interior increased in C from the beginning of production to week seven ($p=0.027$) but was not different compared with MF. Frequency of fighting was performed more in MF for week two than the same period for C ($p= 0.025$). Fighting was however increased in C from week two to seven while decreasing in MF.

The differences observed were more likely to depend on the larger space provided in MF that reduce some stress factors, rather than the floor rotation. The larger space during resting seems to give a higher chance of undisturbed sleep from other pen mates in MF.

Hygiene was good in both systems. All pigs in MF pens were considered clean in 99 % of observed occasions compared with 83% in C pens ($p\text{-value} < 0.05$). Pigs housed in MF pens do pick and use a specific dunging area just as in conventional pens which give an overall clean pen. Pigs choose to rest in clean areas of the pen independent of the housing system. The pigs' in MF seems to be more active by the first movement of the floor. However, pigs in C do also move in intervals at this time of night why this needs to be studied further.

This study was performed on a limited number of pigs and further investigation in larger scientific studies is needed to draw more robust conclusions about this new housing system.

Keywords: Moving floor, finishing pigs, behaviour, hygiene, resting

Hur påverkas beteende och hygien på slaktgrisar inhysta i boxar med rörligt golv? – En jämförande studie

Lantbrukaren kommer in från ladugården, trött efter en lång arbetsdag fylld med rengöring av stallar, halmning och behandlingar av djuren. Han sätter på ett naturprogram och ser betande gnuer vandra på savannen. Hundratals friska djur i ständig rörelse. Det måste finnas ett samband. Där föds idén till vad som senare skulle bli *Moving floor AB.* Om inte djuren kan förflytta sig på grund av designen på våra inhysningssystem, så är det just det som måste ändras. Men hur kommer grisarna påverkas av att golvet rör sig? Kommer deras beteende skilja sig från grisar i konventionella boxar och kommer det bli så mycket renare?

En beteendestudie utfördes på Moving floor testgård och utifrån videomaterial inspelat från andra insättningsveckan i slaktgrisstallet fram till slakt. Observationer på gården inkluderade totalt 120 grisar fördelat på sex boxar med rörligt golv och sex kontrollboxar med traditionell långtrågsbox. I en Moving floor box finns ingen spaltyta som signalerar till grisen var den ska gödsla. Storleksmässigt är de rörliga boxarna något större än de konventionella gällande liggyta och längd på fodertråget per gris.

Syftet med studien var att studera, skillnaderna i beteenden mellan grisar hållna på rörligt golv (MF) och grisar i ett konventionellt stall (C). Detta inkluderar till exempel beteenden som födosök, positiva sociala beteenden och aggressiva beteenden. Vidare undersöktes hur deras vila påverkas av att golvet rör sig då man i tidigare studier har sett negativa hälsoaspekter av störd sömn. I litteraturen kan man finna att grisar är renliga och gödslar inte där de äter eller vilar. Därför var ytterligare ett syfte med studien att se var grisarna väljer att gödsla och vila i de båda systemen samt hur gris- och boxhygienen påverkas.

Resultaten visar att grisarna beter sig relativt lika i de två systemen med en del undantag. Direktobservationerna på gården visade att MF stod, manipulerade spånet, inredningen och fodertråget mindre än C. Videoobservationerna visade att MF låg och satt ner mer än C i vecka sju. MF grisar stod upp mer i vecka två jämfört med C samma vecka. Grisar i MF bökade mer på en annan boxmedlem än vad som gjordes i C. Frekvensen av att böka i ett tomt fodertråg ökade i MF från vecka två till vecka sju och gjordes mer i MF under vecka sju än samma vecka i C. Frekvensen av bråk utfördes mer i MF under vecka två än samma period för C men ökade för C från vecka två till sju medan det minskade för MF.

Skillnaderna mellan systemen antas dock bero mer på den större liggytan och det ökade utrymmet vid fodertråget för MF snarare än att det beror på att golvet rör sig. Den större ytan verkar också minska störningen av andra i gruppen under vila.

Grisarna gödslade på spalten i C och vanligen i ett specifikt hörn i MF vilket gav väldigt god hygien. MF grisar ansågs rena vid 99% av alla observationer jämfört med 83% C. Grisar valde att ligga på rena ytor oberoende av system. Golvets första rörelse för dagen verkar ha en inverkan på grisens sovmönster i MF då aktiviteten ökar för dessa. Dock rörde sig även grisarna i C i intervaller vilket gör att vidare studier behövs. Arbetsuppgifterna skiljer sig mycket åt mellan systemen och tiden lantbrukaren har kontakt med djuren verkar bli mindre i MF även om fler observationer skulle behövas.

Den här studien utfördes på ett mycket begränsat antal grisar fördelade på endast sex Moving floor boxar. Vidare studier behövs för att kunna dra några säkra slutsatser om det här nya systemet.

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Abbreviations

C	Control group
cm	centimetre
kg	kilogram
m	meter
MF	Moving Floor
SVA	National Veterinary Institute (Statens Veterinärmedicinska Anstalt)

1. Introduction

According to the Food and Agriculture Organization of the United Nations (FAOSTAT, 2018), the world production of pig meat in was 2017 around 1486 million tons. Pig meat is the type of meat most consumed in Sweden (Lannhard Öberg, 2019), and Swedish pig production is representing 1 % (2,6 million ton) of EU production (FAOSTAT, 2018). The demand for Swedish produced pig meat have increased during the years, while imported meat have decreased (SJV, 2020), This is partly because of consumers' awareness about the advantages and additional values that Swedish animal protection regulations (SFS 2018:1192) brings (SJV, 2020). For instance, compared with the European Council Directive 2008/120/EC and pig production globally, Sweden has extra supplements that make husbandry stricter to provide a higher welfare standard for the animals. These regulations are supposed to give healthier animals and a safe environment where they can express their natural behaviour. This include for example rules about higher space allowance, demand on enrichment, tail docking prohibition and no antibiotics for improvement of growth (SJVFS 2019:20). The consequence of having healthier animals is a lower usage of antibiotics, where Sweden have one of the lowest antibiotic usage in Europe (EMA, 2018). Globally, the amounts and reasons for use of antibiotic varies largely between countries. A major reason is for treatment of sick animals with bacterial infections, but also to treat pen mates of sick animals, for prevention purposes under stressful periods or to improve growth (Aarestrup, 2005). By overusing antibiotics, the risk of bacteria to develop antibiotic resistance increase which eventually make that antibiotics useless for treatment (Aarestrup, 2005, LRF, 2016, Lannhard Öberg, 2019). Worldwide the use of antibiotics in this way are common in pig production and are highly depended on production size and intensity (Lekagul *et al.*, 2019). Instead of giving animal treatments in advance, there are other ways. For instance, to keep a good hygiene in the pen by removing dung every day and wash the facility between batches will minimise sickness and keep animal healthier in the long run (Larsson, 2000).

Moving floor AB is a Swedish family business that started over 20 years ago, developing self-cleaning pens. The idea for a moving floor came up by looking at the natural movement of large flocks of wild gnus grazing at the savannah. These animals were healthy despite their large numbers in close contact with each other. The founder of the company was thinking on his own animals, not being able to

perform this natural behaviour of moving around due to the pen design and production strategy that were standard at the time. He then thought that if the pigs are not able to move around more freely, the pen needs to do this for them and the concept with a moving floor was born. The process has been long but today is the design based on a plastic mat, rotating in predetermined time intervals towards the end of the pen (visible in Figure 1) and the manure is brushed of automatically to a manure belt. The matt dries while rotating back to its place of origin and new sawdust is distributed each time a section of "new" flooring is visible.

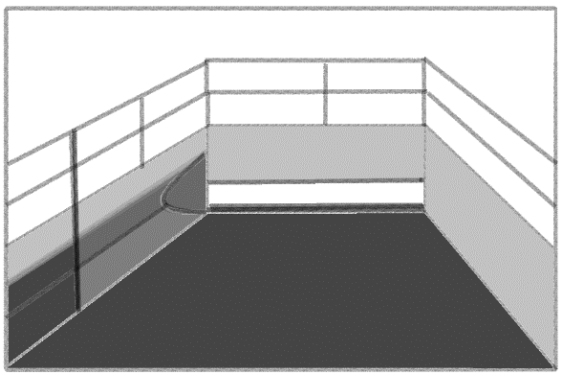

Figure 1. Sketch of the design of a Moving floor pen with the feeding trough to the left. The white part in end of pen is a safety stop.

The company claims that this concept gives a cleaner environment that will lead to healthier animals, lower ammonia levels in the stable and higher profit for the producer due to laboursaving and better growth in healthier animals. They also claim that less antibiotics is expected to be used.

The Moving floor concept is still an innovation project. It has been commercially available for single and group boxes for calves and laying cubicles for cattle for many years and is now used in several countries. In 1997, the concept was tested and approved as a new technique in boxes for growing pigs (10-30 kg) with straw. Approval was done by the Swedish board of agriculture according to the State Agricultural Regulations (SJVFS 2019:13). But the system for pigs is now under further development, especially regarding the durability and robustness of the mat with the goal to get the Moving floor pen commercially available for slaughter pigs.

1.1. Aim and hypothesis

There overall aim of this thesis is to study behaviour, hygiene and resting behaviour of finisher pigs housed in Moving floor pens compared with pigs in conventional partly slatted pens in the same farm.
Specific aims are to:

- examine how finishing pigs, housed in pens with Moving floor concept, behave compared with pigs in conventional pens and how their behaviour changes over time.
- compare both pig and pen hygiene in Moving floor pens with hygiene in conventional pens and to assess were dung will be distributed in the Moving floor pen where there is no slatted floor.
- examine preferences for resting places and potential disturbances during movement of the floor during night.
- give an overview of performed work tasks and general estimation of the working hours associated with the system

The hypothesis generated from the aims are:

- pigs in Moving floor pens will, at the beginning, be more active due to the greater space availability and increased possibility of movement in the larger pen. Activity will however decrease over time and by end of the growth period it will not differ from Control groups in conventional pens.
- pigs in Moving floor pens will pick and use a specific dunging area just as in conventional pens.
- movement of the floor will affect pigs resting behaviour at the beginning of production period when they are newly introduced to this type of pen. But, it will not have a significant effect on resting over time. Choice of resting place will mainly be on clean areas.
- Less caretaker working time is spent per pig in the Moving floor system

2. Literature survey

2.1. Previous studies in Moving floor

There are five previous studies performed on Moving floors self-cleaning pens, all of them on calves. None report a differences in behaviour between calves in Moving floor pens and conventional cubicles regarding posture (Fagerheim and Langseth, 2013, Gustafsson, 2006). Bannbers (2008) study included a run-in period associated with observing calves behaviours. The calves get used to the new environment for three hours and then the floor was rotated four times, 15 minutes appart. The calves showed less reactive behaviour the last rotation compared with the first which make the author draw the conclusion that calves get used to the rotation quite fast. Regarding resting behaviour, calves preferred to lay in the cleanest part of the pen and were not directly affected by the movement itself but some individuals were however forced to get up and move due to get pressed to the front of pen when the floor rotated (Bannbers, 2008). All studies concluded that as long as no disruption occurs, the hygiene level was high (Bannbers, 2008, Huber, 2013, Hårstad, 2017) and most dung were distributed to the end where the manure was removed (Bannbers, 2008, Hårstad, 2017). There is also a hygiene study of the mat itself (no animals included) performed with dung from dairy cattle performed by SVA (Persson Waller, 2016). There results showed much less bacteria on the Moving floor mat that was cleaned according to Moving floors automated cleaning process than the same mat cleaned manually or a conventionally rubber mat. The author however writes that further studies should be done in a running stable to be able to draw fair conclusions. It is however no published studies of that being done.

There is no published study present on the effects on pig behaviour or pig hygiene to this system due to the challenge of finding a robust mat that the pigs did not “eat”. Development is still ongoing, but a small test facility is now in operation, making it possible to study the potential of this new housing system for pigs.

But, it is not just the rotation itself that differs Moving floor to conventional pens, but also the fact that there is no slatted area and therefore no dedicated dunging area which make a study in pig behaviour very interesting and important to perform.

2.2. The pig

The domestication of pigs occurred for around 9 000 years ago from the Eurasian wild boar (*Sus scrofa*) (Giuffra *et al.*, 2000). In nature, pigs are living in small family herds consisting of a few sows with their piglets. Boars often live solitary or in small boar flocks (Jensen, 1993). Sows farrowing normally once per year and get around 5 piglets in each litter (Malmsten *et al.*, 2017). Weaning often occurs around 12 to 17 weeks after farrowing (Broom and Fraser, 2015) where the time of weaning is dependent on for example available food resources or the sow's milk production (Worobec *et al.*, 1999). The rooting and exploration is naturally performed in large areas to collect a high variety of food (Broom and Fraser, 2015).

Today is there around 680 million pigs in the world (Statista, 2020). Commercial pig production differs in many ways from the natural environment for a pig. In Sweden, sows in general farrow 2.2 times per year and gets approximately 12 piglets per litter (WinPig, 2019) who are weaned at ~28 days in Sweden and earliest by the age of 21 days within EU. Weaning by the ae of 21 days is allowed for 10% of the piglets in Sweden under special considerations and if the remaining piglets have an age of 26 days (SJV, 2019). There are both indoor and outdoor production systems. Pigs are group housed but how many pigs that are in one group is regulated depending on pen size. For finishing pigs between 30-110 kg live weight, the total pen size demands per pig in Sweden is ranging between 0.41-1.02 m^2 (SJVFS 2019:20) and between 0.3-0.65 m^2 in EU (Dir 2008/120/EC).

The European Council Directive 2008/120/EC, demand partly solid floor to sows and piglets, but not for finishing pigs. In some countries the standard is to have fully slatted flooring to remain a high level of cleanliness (Kilbride *et al.*, 2009), and this system does not allow for any litter material. According to §13 in the Swedish pig protection regulations (2018:1192) solid flooring on the lying area is necessary, also for slaughter pigs. The solid floor has the advantage by giving a better weight bearing ability and making it more suitable for use of bedding material/ litter (Kilbride *et al.*, 2009). Figure 2 illustrate two common Swedish conventional pen designs. Both pens have solid and partly slatted areas and are

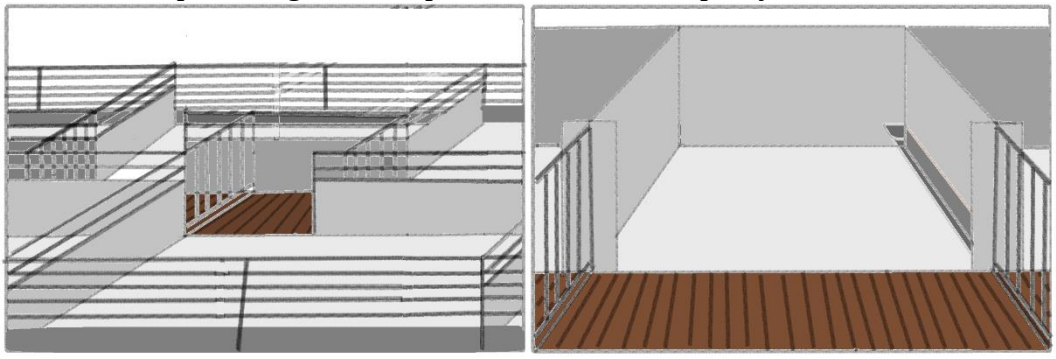

Figure 2. Sketches of two typical Swedish commercial pens with a long trough feeder (left) and with a cross trough feeder (right).

complemented with some type of litter (often straw or sawdust). In the long trough feeder system (left) each pen has its own trough. In the cross-trough-feeder system (right), the trough is shared with the pen next to it.

Even though there are several differences between the wild boar and the domesticated pig, all behaviours are still intact in the modern pig from their ancestry (Gustafsson *et al.*, 1999).

Considering the hierarchy structure for pigs, where less dominant individuals avoid those more dominant (Broom and Fraser, 2015), space allowance and pen design is important for the individuals' wellbeing. The natural behaviours can however sometimes be denied depending on the production type. Two of these behaviours are for example rooting and foraging. Domesticated pigs spend a large time of the day by foraging and exploring (52% and 23% respectively) when living in semi-natural conditions (Stolba and Wood-Gush, 1989). This is not applicable in commercial production where all animals are feed at once, a few time per day (Broom and Fraser, 2015). Neither the variety of feed the pigs get in nature are applicable in commercial production (Broom and Fraser, 2015). Literature show that pigs eating dry feed spend approximately 10% of their time eating in commercial production (Gonyou *et al.*, 1992, Presto *et al.*, 2013, Meunier-Salaün *et al.*, 2014, Tozawa *et al.*, 2016) and even less when given wet feed (Zoric *et al.*, 2015). This is a large difference from the biological state.

2.3. Animal Welfare

The most common definition of welfare is the one stated by Broom (1986), who define welfare as how the animals can cope with their environment. Smulders *et al.* (2006) take it a bit further and describe welfare not just as the wellbeing of the animal, but also the physological responses, behaviour and production quality of an animal.

There are several things that differs when comparing pigs in their natural environment with pigs held in modern production. There are however regulations to control that no animal may suffer. The Swedish animal welfare act (2018:1192) says;

> "Animals shall be kept and cared for in a good environment for animals and in such a way that: 1. their well-being is promoted; 2. they are able to perform behaviours for which they are strongly motivated for and that are important for their well-being (natural behaviour); and 3. behavioural disorders are prevented."

The intensity in todays' livestock production is however associated with several welfare concerns, most common are space allowance, restricted outdoor access,

restricted feeding which is causing hunger and the lack of material to manipulate and root in (Sørensen and Schrader, 2019).

Stolba and Wood-Gush (1984) says that it is obvious that a pig that dies because of insuficiances in the environment have suffered and experienced bad welfare. They mean however that there are signs to look for to be able to evaluate the quality of welfare and one way to do so is by studying some relevant behaviours (Stolba and Wood-Gush, 1984). For example a reduction in activity can be a sign of pain or discomfort in pigs (Kilbride *et al.*, 2009).

The response to a situation in life is however highly individual and is dependent on both genetic parameters and environmental factors (Brown *et al.*, 2009) such as type of production system, space allowance and enrichment (Averós *et al.*, 2010, Tozawa *et al.*, 2016). Another important factor is the floor type and bedding material in the pens which could have a great impact on welfare and health in pigs (Kilbride *et al.*, 2009).

To assess changes in behaviour between two different systems is a well-known way to compare the welfare for the animals in the systems compared (Temple *et al.*, 2011). Which behaviour that is assessed differ in the literature, but to look at normal behaviours performed by pigs is one way (Broom and Fraser, 2015). For example, play behaviour is evolving around week two in piglets in form of a "play fight" and is often an indication of health, while unwanted behaviours (e.g. redirected behaviour to a pen mate or aggression) often are connected with stress or some insufficient factors in the environment (Broom and Fraser, 2015).

2.3.1. Behaviour

Normal behaviour in a species is referred to as how that species would behave in natural conditions and are often involved in biological functions, such as reproduction or survival (Lidfors *et al.*, 2005).

Adaptation and learning will make a variety in actions for all species, but some behaviours are characteristic for a species and may often be observed in an ancestral non captive relatives (Jensen, 2009). A summary of earlier studies on pig behaviour including time budgets is presented in Table 1.

Rooting and foraging

Rooting and exploratory behaviours are elements of foraging behaviour (Broom and Fraser, 2015) and hence, enrichment that is used to fulfil this behavioural need is concluded in many studies to improve animal welfare (Bracke *et al.*, 2006, Day *et al.*, 2002, Tozawa *et al.*, 2016).

Meunier-Salaün *et al.* (2014) studied behavioural activity and health between pigs selected for high and low residual feed intake (RFI). Results show a lower physical activity of those selected for low RFI. There was no major health problem in any of the lines, even though the high RFI line hade higher frequency of leg

problems and tail biting which the authors thought may depend on the higher activity. Tozawa *et al.* (2016) did a comparison in welfare indicators for finishing pigs between two periods of production (early period: ~ week 14-18 and later period: week 20-24) in five different housing systems. Assessed indicators of welfare were behaviour (foraging, exploration, resting, playing, rooting etc), wounds on body and performance (average daily gain and feed conversion ratio) They draw the conclusions that the system with pigs kept in a soil floor paddock gave the highest standard of welfare and that there were similar results between indoor held animals and those who were held in a concrete paddock outside. They also saw that time spent foraging and feeding was decreasing while resting was increasing for pigs in indoor systems between the early and latter growing period.

Social behaviour

Playing is often used as an indication of welfare since it is only expressed when other essential needs are fulfilled (Broom and Fraser, 2015). Newberry *et al.* (1988) were studying different behaviour patterns associated with play in piglets from birth to the age of 14 weeks. Their results showed that play behaviour increased between the age of two to six weeks and later decline with age and that there were no significant differences between the sexes. Tozawa *et al.* (2016) did not observe play behaviour in pigs held in indoor systems at week 16 nor week 21 and Smulders *et al.* (2006) did not observe any play behaviour in finishing pigs at an average age of 26 weeks in a commercial system, which also indicates that playing decrease with age and limited space.

Gonyou *et al.* (1992) studied behaviour and productivity in relation to sex and group size (five or individual). The highest frequencies of eating and standing were observed during the day (8:00-16:00). They also saw that an individually held animal ate at the same time as their neighbours which were the opposite results compared with group-held animals who rather ate alone. This was considered by the authors to be a sign of avoidance that also seemed to increase with age. The authors did also observe a higher frequency of standing in group-held animals, which could depend on this avoidance of other pen mates (Gonyou *et al.* 1992).

Presto *et al.* (2013) investigated how different type of feed affected time budgets and social behaviour in finishing pigs. Observations were done in four different stages between 30-100 kg live weight. In the beginning of the experiment 32 pigs were divided in four groups with different feed; chopped silage mixed with commercial feed, intact silage separately with commercial feed, silage mixed with commercial feed in pelleted form or only commercial feed.

The results showed that the pigs spent on average 76.5% of the time lying down (91.4% of that time inactive). There were higher numbers of social interaction 5-15 minutes before feeding than after. There were also differences in frequency of behaviours performed before feeding (most common were nosing other pigs) and

after feeding (lifting other pig). Their conclusion was that pigs fed silage in addition to straw were more active than pigs fed only with pellets and straw and were considering the silage to provide extra stimulants of foraging behaviour in addition to straw (Presto *et al.*, 2013).

Vocalization

Vocalization have an important role in communication between individuals in many species. The natural habitat of pigs are as earlier mentioned in woodlands, where the sight may be limited and vocalization have an important function to keep contact with rest of the group (Marchant *et al.*, 2001). By listening to the pigs, one can get a hint of the animals state of mind (Kiley, 1972).

There are several sounds in a pigs repertoire; barks, grunt and squeals which with different frequencies, volume and duration gives a variety in communication (Kiley, 1972, Chan *et al.*, 2011). Barking comes with a series of variations that can both alarm for danger but are also used in play and is often followed by freezing (Kiley, 1972, Newberry *et al.*, 1988). It could also appear when pig becomes frustrated or when there is a general disturbance in the group (Kiley, 1972). Grunting is performed with different intervals which may refer to greeting another group member, wellbeing, frustration, or sexual situations (Kiley, 1972). When the frustration enlarges the grunt could be combined with a squeal or a scream, which often are shown in unpleasant situations, for example when being squeezed (Kiley, 1972). The way pigs chose to vocalise seems however to be individual and Marchant *et al.* (2001) mentioned that pigs can take different strategies in vocalization and may choose to be silent to avoid attention.

Abnormal behaviours

Animals that cannot cope with their environment often perform redirected behaviours, either against another pen mate or towards the environment (Broom, 1986, Broom, 1996, Averós *et al.*, 2010). Abnormal behaviours usually affect pigs health and production performance due to injuries or low wellbeing and are used as a welfare indicator (Broom, 1996, Jensen, 2009). Also, normal behaviour that is performed more or less frequently than usually done for the specific species, can also be considered as an abnormal behaviour (Welfare Quality Consortium, 2009). For example, a high level of inactivity is considered to be abnormal (Olczak *et al.*, 2015). To look at the frequency of natural behaviours, and not just stereotypies, is thereby a way to get an insight in how the individuals' coop with their environment.

An early, abrupt weaning can lead to belly nosing, which is a specific type of abnormal behaviour classified as a stereotypy (behaviour performed repetitive and without a distinct function or goal (Mason, 1991)). Belly nosing is suckling and a performance of an excessive up and down snout movement towards another pen mate (Broom and Fraser, 2015). This is often performed quite harsh and can cause inflammation on the receiver. Previous studies show that early weaning (≤28 days

of age) increase the frequency of belly nosing (Worobec *et al.*, 1999). The behaviour seems to increase few days after weaning, peaking around two weeks later and then decrease in frequency, even if it still occurs (Worobec *et al.*, 1999, Bench and Gonyou, 2006). To provide enrichment material for rooting and nosing could reduce the time piglet spending on belly nosing (Bench and Gonyou, 2006).Aggression is a normal behaviour that often occurs in shorter periods of time to settle hierarchy structure (Jensen, 2009). Problems may however arise when animals are held in groups not fitting their ideal herd structure regarding size and density and then there is a higher risk for injuries (Jensen, 2009). Jensen and Wood-Gush (1984) saw that there was less aggressive behaviour in free range systems and well-established groups than in confinement systems. The reason for this seemed to be the ability of avoidance in low-rank individuals.

Tail biting is a common problem in pig production (Welfare Quality® project, 2009). Occurrence of tail, ear and flank biting are dependent on several factors and studies show that those with most effect are environmental, such as nutrition deficiency, hygiene, stocking density and insufficient enrichment (Broom, 1996, Wallgren *et al.*, 2016, Meer *et al.*, 2017).

Table 1. Summary of previous studies time budgets on behaviour performed by pigs (% of behaviour performed during observed time).

Article / **Behaviour**	**Gonyou *et al.* (1992)[1] (n=5)**	**Presto *et al.* (2013)[2] (n=64)**	**Meunier-Salaün *et al.* (2014)[3] (n=192) Day/Night[4]**	**Tozawa *et al.* (2016)[5] (n=20) Early/Latter[6]**	**Rosvold *et al.* (2018) (n=16/n=17) Barren/Straw[7]**
Standing	8.4	*	*	*	22/17
Laying	82	79	80/89	65/71	61/62
Play	*	*	*	0/0	*
Positive social behaviour	*	*	4.6/2.5	3.8/2.0	*
Root floor	*	12	*	*	8.9/7.1
Manipulating interior	*	12	5.3/2.1	6.1/3.3	*
Manipulating litter	*	*	*	2,0/0.5	3.5/5.1
Fight	*	*	0.9/0.3	8.0/3.3	*
Biting	*	3.0	*	(included in fight)	*
Eat/drink[8]	9.6	7.0	7.4/4.7	18/13	*

*=behaviour not included in article

[1]Results from group-held animal

[2]Results from Control group because they were given commercial feed which are more relevant for this study

[3]Percentage of time spending on tasks in finishing pigs at 17 weeks of age during the diurnal/nocturnal period. No definition of assessed behaviour in the article and some behaviours are because of that not included.

[4]Day; between 08:00 and 20:00. Night; between 20:00 and 08:00.

[5]Results from indoor system. Tozawa *et al.* (2016) saw a frequency of 16,8% in prior period and 15.5% in latter period for the behaviour "Disturbed behaviour". That behaviour included several behaviours (for example both rooting pig and belly nosing which are included in this study) but are not distinguishable in the article and are therefore marked *

[6]Early period; between week 14-18. Latter period; between week 20-24

[7]Barren environment were not provided with any nest-building material. Straw-group were provided with a total of three kg per day.

[8]Dry feed

2.3.2. Environment

For production animals to be able to perform natural behaviours, they need to be kept under suitable conditions.

Space allowance

Space allowance and pen structure have a great role in animal welfare. Broom and Fraser (2015) mention the importance of space for movement and exploring, thermoregulation, defecation, resting and avoidance possibilities from other pen mates. Averós *et al.* (2010) showed that there was less negative social behaviour when more space were provided.

The importance of sufficient amount of space also include the space available by the feeding trough. Jensen and Pedersen (2010) saw that restrictive feeding space led to pigs standing more and showing aggressive behaviours more frequently compared to pigs feed ad libitum. In commercial production, all animals are usually feed at the same time which put a demand on the length of the feeding trough and enough of space in automatic feeders for all animals (Broom and Fraser, 2015). This is extra important for low-ranked individual that will have a disadvantage in the competition of space (Brouns and Edwards, 1994) which could lead to some individual not getting their expected amount of feed. That will have a negative effect on growth and productivity as well as welfare and is the reason why there are regulations about minimum trough size per pig (SJVFS 2019:20).

Resting space

Another factor to get comfort and undisturbed rest, is the importance of space. Olczak *et al.* (2015) says that inactive pigs are more profitable since they can keep a higher growth rate. But all animals, especially in young age, need their sleep which is essential for brain development (Jensen, 2009). A barren environment make pigs more prone to rest, which put a demand on e.g. the floor design (slat, chance to undisturbed rest etc.) to higher the comfort of resting to avoid frustration and aggression between penmates (Olczak *et al.*, 2015).

Shi *et al.* (2006) were studying how a cooling system would help pigs with thermoregulation and provide a comfortable resting area. Their results show that when the temperature was above 30.1ºC on the lying area, only around 15% of the pigs would lay there and none if the temperature rises to 33.1ºC. By an air temperature between 15-18ºC, pigs lay closer to each other, stayed away from the manure and got better pen hygiene but were also getting lower growth rates and a tendency of abnormal behaviour increased (Olczak *et al.*, 2015).

According to the Welfare Quality® project (2009), behaviours for comfort around resting can be measured by recording posture, duration of posture and how difficult the posture changes are. However, this is not recommended in farm assessments because the age and weight influences and physical indicators as lesion and bursitis is proposed as a better way to measure comfort (Welfare Quality Consortium, 2009).

Possibility for exploration and rooting

Which housing form the animals are housed in, affects their chances to exploration and rooting and have a large role in expressed behaviours. Tozawa *et al.* (2016) did not see differences in exploration and rooting behaviours between younger pigs in intensive production compared with outdoor production. However, the outdoor produced pigs did show more foraging and exploratory behaviour later in the production and less resting than intensively produced pigs. Nor did the intensively produced pigs express playing or rooting in the same extent as outdoor pigs. This is supported by Averós *et al.* (2010) who showed that there was a greater exploratory activity when more space and rooting material was allowed.

One way to fulfil the need of exploration is by using enrichment, which is demanded in EU directives (Dir 2008/120/EC). The enrichment material needs to be destroyable to give enough motivation and by that keeping the exploratory or feeding search behaviour fulfilled but still not get shredded too quickly (Day *et al.*, 2002). This is often done by using straw but can however be a problem due to slatted floors that could get plugged and lose their function (Day *et al.*, 2002). Bracke *et al.* (2006) showed that hard material (e.g. wood or rubber) are insufficient to stimulate exploratory behaviour because they get quickly soiled and is not available for all pen mates and it increases competition among them. But it is not only the type of enrichment provided that matter, but also how much. Not enough enrichment could lead to that the foraging and exploratory behaviour is redirected to pen mates (Meer *et al.*, 2017). As previous mentioned are pigs more inactive in a barren environment. Taken this in consideration makes undisturbed rest important also for reduce the risk of undesirable behaviours

Averós *et al.* (2010) showed that exploratory behaviour increases when pigs are introduced to new objects that seems to be more interesting than the same old ones. This can explain why permanent objects in the pen (e.g. a chain) is not giving the same motivation to be manipulated by the pig as edible and destructible object (e.g. straw) (Bracke *et al.*, 2006).

Hygiene

Both for the animals and employees is a good pen hygiene important for improving health since high ammonia and dust levels have a negative effect on respiratory organs (Larsson, 2000). Insufficient hygiene increases the risk of disease which affects the wellbeing of the animal and lower productivity (Persson, 2006). Meer *et al.* (2017) showed that insufficient hygiene also increase aggressive behaviour toward pen mates.

Pigs in Sweden are housed in pens with partly slatted floors while it is common with fully slatted floors in other countries. The purpose with a slatted area is to increase the hygiene in the pen and decrease the workload, but a solid part will on the other hand make it more comfortable for the pigs and enable provision of exploratory material. In nature pigs do not defecate were they eat or sleep, but have instead dedicated dunging areas (Broom and Fraser, 2015). Pigs in confined systems use the solid area as a resting area and dung on the slatted part. There are however not unusual for pigs to turn this system around and begin to dung at the solid part instead which seem to depend on several factors as experience, space allowance, weights of the pigs, floor structure, climate (Larsen *et al.*, 2018) age and reproductive state (Olczak *et al.*, 2015). Larsen *et al.* (2018) means that none of the mentioned factors matters if the stable climate is inadequate. A strategy for thermoregulation in pigs is naturally to wallow in mud (Broom and Fraser, 2015). However, in confined systems, lacking mud, the pigs tend to wallow in their own faeces, which often causing them to dung in the lying area in hot climate (Shi *et al.*, 2006).

There are several ways to prevent poor hygiene in the pen but Larsen *et al.* (2018) draw the conclusion in their study that the most important one is controlling climate (humidity, temperature and draught) in the stable. The problem is often not to provide heat, but to get temperature sufficiently low (Persson, 2006).

The hygiene is also influenced by litter choice and floor structure. There are differences in bacteria presence depending on litter usage (Persson Waller, 2016). In the Swedish study on survival of bacteria in Moving floor pens for calves, the lowest number of bacteria was found when using wood shavings and the highest using chopped straw (Persson Waller, 2016). The smoother surface on the floor design is easier to keep clean but is also more slippery than a floor with structure (Persson Waller, 2016). The friction prevents slips and fall for the animals and are important to avoid injuries (Persson, 2006).

2.3.3. Time spent on management in pig facilities

Mattsson *et al.* (2004) studied the time performing routine work in Swedish pig herds. The results showed that there was no correlation between herd size and the time spent/sow in the sow herds. However, there was a positive correlation between working time spent during farrowing and number of piglets weaned per sow and

year. In specialised slaughter pig herds, the average labour time throughout the whole production period was 10 minutes/pig and the percentage per task is presented in Table 2. In the study by Mattsson *et al.* (2004), cleaning pens and providing straw in pig production, accounted for more than a third of time spent on management. The floors that are partly slatted, in combination with much straw, demand a high amount of time (Mattsson *et al.* 2004).

Table 2. Total labour in Swedish finishing pig production by task, %, from Mattsson et al. (2004) study

Task	**% of total**
Liquid feeding	4
Daily pen cleaning	21
Providing litter	16
Health control medical treatments	7
Sorting, moving and delivery	24
Washing stable units	20
Repairing	5
Other[1]	3

[1] Including writing records, assisting vet, social interactions with staff and salesmen, searching for equip etc.

3. Material and methods

3.1. Animals and housing

The study was performed on a commercial pig farm in Sweden with video recordings from November 2019 to February 2020 and direct observations in February 2020. Both systems were present on the same farm but in different stables/ buildings. The moving floor system was built up in a specific stable, only containing the moving floor pens. A summary of all relevant factors from both systems are presented in Table 3.

3.1.1. Moving floor group (MF)

There were six pens in the Moving floor group (MF) with 10 pigs in each. The pen was 11 m^2 (1.1 m^2/pig) with a feeding trough with a total length of 4.8 m (48 cm/pig). The floor consisted of a plastic mat that was moving in intervals of ~3.3 cm at a time for a total length of 0.4-1 m once every hour between 04:00 and 23:00. When rotating, the manure was brushed off to a manure belt that immediately transported it out from the stable to the manure pit. Once an hour, just after the floor had moved, a litter machine passed over the pens (20 times per day). The litter machine distributed 450 g sawdust/pen in the part of each pen where the renewed flooring was visible (9 kg in total per pen/day). A ball bite drinker was placed in the end of the trough to minimize water waste on the flooring when pigs are drinking that could cause the box to be wet.

Settings for movement of the floor mat were run from a panel in a control room close by. The producer could change how far the floor should move and start the floor manually in addition to the programmed movements. When cleaning the boxes between batches, the floor could be moved 1/3 of its total length at a time to make the whole floor available for cleaning. The farmer estimated this cleaning process to take between four to six hours for manually cleaning six pens with a pressure washer. The litter machine could also be manually started by the producer.

3.1.2. Control group (C)

The Control group (C) was housed in conventional long trough pens (Figure 2) for slaughter pigs. The stable consisted of 42 pens and a total of 410 animals, but only six of the pens with 10 pigs in each were included in this project. The pens were designed with 7.8 m^2 solid- and 2.4 m^2 slatted floor (Table 3 for details) which gave 1.02 m^2 total area per pig. The feeding trough had a length of 3.4 m (34 cm/pig). During the first two weeks of production, pens were provided daily with sawdust and thereafter approximately 1 kg straw per day. The litter was provided each morning after manual cleaning from any manure on the solid flooring. A bite drinker was placed in the slatted area.

Between batches, cleaning was performed first with a robot and then manually with a pressure washer. The farmer estimated the time for cleaning to be 18+6 hours for automatic robot wash and manually cleaning respectively for the 42 pens.

3.1.3. Animals

Animals were purchased from another farm where they were weaned at 5 weeks of age and then delivered when at the age of 11 weeks or weighed around 30 kg (see Table 3 for details). All pigs were crossbreeds, derived from TN70 sows (Landrace x Yorkshire from Topigs Norsvin) crossed with Danish duroc boars.

All animals were fed wet feed with the same recipe. Cereals was produced on the farm (barley, wheat, peas) and concentrate that were purchased from Lantmännen (nutrition index in Appendix 1). The animals were fed four times per day and an automatic light system lit up the stable in C when feed was coming and turned lights off 40 minutes after each feeding. This system was not used in MF stable. Light was manually turned on in both systems when conducting observations at the farm.

Table 3. A summary of information for the Moving floor and the conventional production system studied.

Factor	**Moving floor system**	**Conventional system**
Pen size (m^2)	11 m^2	10.2 m^2
Pen dimensions (m)	5 x 2.2 solid floor	3.4 x 2.3 solid floor
		1.7 x 1.4 slatted floor
m^2/pig (solid floor)	1.1 m^2	0.78 m^2
m^2/pig (total)	1.1 m^2	1.02 m^2
Pens in the stable	6	42
Pens included in project	6	6
Animals/pen	10	10
Input date	2019-11-21	2019-12-04

Input age	11 weeks	11 weeks
Input weight (whole stable in kg)	1840 (30.1 kg/pig)	11120 (26.5 kg/pig)
Feeding trough length (m)	4.8	3.4
Feeding trough length/animal (cm)	48	34
Number of feedings/days	4	4
Time of feedings[1]	04:00	04:00
	08:00	08:00
	13:00	13:00
	18:00	18:00
Food	Cereals produced on farm + concentrate	Cereals produced on farm + concentrate
Drinker	Ball bite drinker	Bite drinker
Litter (kg/pen/day)	9 kg Sawdust	1 kg Straw
Light hours from artificial light (windows excluded)	~8	2.7
Temperature[2], January (Cº)	14.5	17
Humidity[3], January (%)	71	74
Sex distribution in observed pens (gilt/boar %)	50/50	42/57

[1]Time were differing ±1-2 hour between days and weeks. Moving floor had some delay in feeding which varies from day-to-day.

[2]Mean temperature inside stable in January

[3] Mean humidity inside the stable in January

3.2. Recordings on farm

3.2.1. Behavioural observations

A focal animal observation study with continuous frequency recording was performed, according to the same procedure in both systems, during four consecutive days at the farm. Three focal animals were randomly selected in each pen at each observation.

The observer was standing approximately 1 m from the pen in a dark blue overall with a wooden clipboard and observed the frequency of occurring behaviours established in an ethogram (Appendix 2) during five minutes for each focal animal (15 minutes/pen).

The observation structure can be seen in Table 4. MF was observed the first day in two sections. The three first pens were observed 45 minutes before lunch-feeding (as occurred 11:30) and observation for the last three pens started 45 min after

lunch-feeding (12:00). This was repeated for C in day four. On day two C was observed two hours after morning feed (as started by 07:00) and two hours after afternoon feed (as started 15:00). This was repeated on day three for MF.

Table 4. Structure of observation perform on farm

Day	System	Time	Pens observed	Observation length (min)
1	MF	10:45-11:30	3	45
1	MF	12:00-12:45	3	45
2	C	09:00-10:30	6	90
2	C	17:25-18:55	6	90
3	MF	09:00:10:30	6	90
3	MF	17:50-19:20	6	90
4	C	10:00-10:45	3	45
4	C	11:45-12:30	3	45

3.2.2. Hygiene

Hygiene in the pens and on the pigs was assessed in the afternoon, approximately at the same time for five days in a row. MF pens were cleaned once per hour between 4:00-23:00 while manure from C are removed from solid area once per day around 08:00. All 120 pigs included in the study were assessed according to the Welfare Quality® protocol (2009) for pig hygiene. Manure on body was estimated from one free sighted side of the pig and scored according to Table 5.

Table 5. Hygiene on pig scoring according to Welfare Quality Consortium (2009)

Score	**Definition**
0	<20% soiled surface on the free sighted side of the pig
1	20-50% soiled surface on the free sighted side of the pig
2	>50% soiled surface on the free sighted side of the pig

Pen hygiene was assessed according to Wallgren *et al.* (2019) and all MF and C pens were divided in eight and six squares respectively, measuring around 1.4 m^2

(Figure 3). Each square was scored as dirty if more than 50% of the area was soiled with manure or wet.

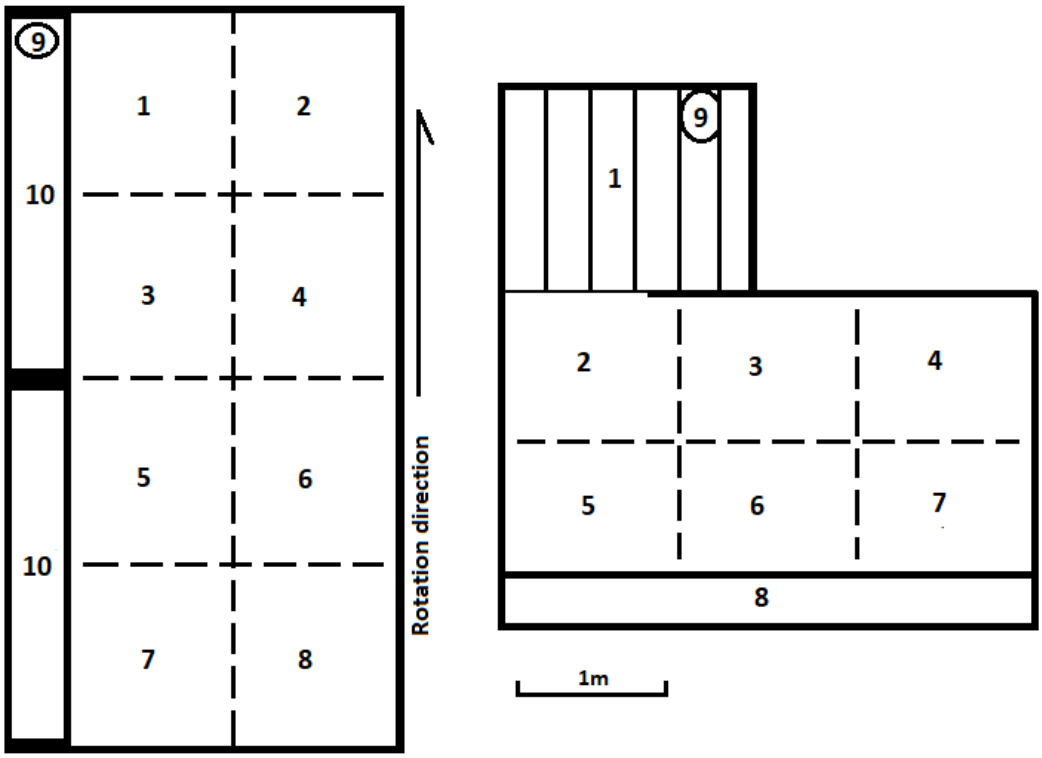

Figure 3. To the left; sketch of a Moving floor pen. Assessed square from 1-8. Number 9=bite drinker. Number 10=feeding trough.

To the right; sketch of Control group pen. Assessed square from 1-7. Number 8=feeding trough. Number 9=bite drinker.

3.2.3. Time performing routine work

The time the farmer put on routine work (checking on the animals, cleaning and giving straw (C only), medical treatment of animals etc.) was measured once in both systems. Time was measured with a stopwatch, starting when the farmer entered the stable and stopping when exiting. Measured time was then divided by the number of pig present in that stable. All tasks performed by the farmer were noted. Routine work was performed in the morning and no further work were done in C. The automatic light system was not used in MF and those pigs were therefore checked an extra time in the afternoon when light was turned off. However, this was not measured.

3.3. Recordings from video material

3.3.1. Behavioural observations

Video cameras were installed in the ceiling above three pens in MF and two pens in C. This difference was because of cameras available. In an earlier batch were also three pens observed in C, one camera per pen and one over the slatted area for all pens. Sight was however not clear above the slatted area and quality got bad. For this batch were instead separate cameras used on the slatted part and in the lying area, which make cameras enough for two pens in C. The recording started two weeks after animals entered the system and were running 24h a day until slaughter.

All video material was first sorted into folders depending on groups and week in the system to make it easier to choose observation day due to different dates of arrival between the groups (C is two weeks younger than MF at the same date).

Observation was performed according to the same ethogram as was used at the farm (Appendix 2) except from vocalization that was not recorded. Three focal animals were chosen that had obvious spots or colouring. If not any individual like that was present in the pen, a randomly visible animal was chosen and closely watched. Each animal was observed for 10 minutes, four times per observation day after feeding (feeding are given approximately 04:00, 08:00, 13:00 and 18:00). Observation days were randomly chosen for similar weeks to enable compatible days between the two systems. This was however not always technical possible due to missing files or poor quality enabling vision, which gave differences in observation days. The structure of observation is displayed in Table 6. Because of the automatic light in C but not in MF, observation started 25 minutes after feeding four times per day which make half of the 30 minutes observation in darkness for group C. The cameras had an infrared function, which enabled some vision even though it was dark. First and last observation was in darkness for MF while the two others was in full light. This made a total of one-hour observation per group and day in light respective darkness.

The behaviours *Rooting floor* and *Manipulation of litter* could not be separated due to the quality of material and was therefore merged into *Manipulating litter/floor* to not get false positive observations. The drinker in MF could not be seen due to the camera angel and the behaviour was therefore removed from the protocol for both systems and not further analysed.

Table 6. Structure of observation perform from video recordings

Week	System	Days of observations/week[1]	Total number of observations[2]	Observation length (total min/week)
2	MF	3	108	1080
2	C	5	96	960
4	MF	1	36	360

5	C	2	48	480
7	MF	2	72	720
7	C	5	72	720

[1]Observation days are differing due to missing files or poor quality enabling vision.

[2]Obsevrations are performed four times per day, 25 minutes after feedings that are given approximately 04:00, 08:00, 13:00 and 18:00 (time were differing ±1-2 hour between days and weeks). Observations are done in three pens from Moving floor and two pens in control, except from control week seven were only recordings from pen one was available.

3.3.2. Resting preferences

In the end of all behaviour observations, frame was paused and the chosen resting space from each pen was assessed. The same square system was used as for assessment of pen hygiene (Figure 3). However, now the square was marked as a chosen resting place if more than 50% of a pigs' body was laying in that square.

3.3.3. Resting behaviour during floor movement

An assessment of resting behaviour in relation to the movement of the floor was performed in MF with C as reference. The floor is doing the first movement around 03:30 and observations of positional changes were assessed between ~03:20-03:50. Behaviours observed are described in Table 7. The observation was assessed three days the second production week in both systems and three days in week seven from MF and one pen in C (due to technical issues with recordings from week seven in the second pen). The number of pigs laying, sitting, or standing up during three consecutive days of observations was counted in 30 seconds intervals and presented in graphs to visualise a pattern.

Table 7. Ethogram used in resting assessment

Behaviour	**Description**
Standing	Body supported by all legs in standing position
Sitting	Hind is on the floor and only two legs are touching the floor in an upright position
Lie	Body touch the floor and is not supported by any legs

3.4. Statistical analysis

Data was edited and sorted in Microsoft Office Excel. Charts were created to get an overview of all data and to see how to proceed with further analysis.

Descriptive results from assessed hygiene scores, pen hygiene and resting area from all pigs were calculated in Excel. The difference in medians for hygiene scores were than tested with a Mann Whitney U test.

The behaviour data from both on-farm observations and recorded videos were transferred to Minitab Statistical Software 18 for statistical analysis but analysed separately due to differences in observation time and performed assessment regarding behaviour and observation time. Descriptive statistical data were calculated for all variables by system and presented as frequency, mean and median.

All behaviours included in the ethogram (Appendix 2) were assessed in all observed animals. However, several behaviours are not possible, or not likely to be performed while laying down (for example playing, fighting, or slipping). Analysis of these behaviours were therefore performed on active pigs only. Pigs were considered as active if they sit or stand up at least once during observation time. The behaviours *Positive social behaviour*, *Grunting*, *Manipulating litter/floor* and *Belly Nosing* (as giver or receiver) were however also performed when a pig was laying down. These behaviours were therefore analysed with all observed pigs. Likewise, the analysis of posture that also considered all observed animals. Statistical differences in mean frequency of expressed behaviours between the systems and weeks were evaluated with a t-test analysis. Differences were considered as statistically significant if $p<0.05$. The time the farmer performed routine work was divided in separate categories depending on task and the result were divided on total time/pig spent in each system.

4. Results

4.1. Behaviour observations

Specifications from all observations are collected in Appendix 3. The posture behaviours, *Positive social behaviours*, *Grunting*, *Manipulating litter*, *Manipulating litter/floo*r and *Belly nosing* are analysed from all observations while the rest are observed only on active pigs.

4.1.1. On-farm recorded behaviours

Results from behaviour observations are displayed in Figure 5 with specifications in Appendix 3. There was a total of 108 observations performed at the farm (54 in each system, each observed focal animal represented one observation). The distribution of the postures observed can be seen in Figure 4. Pigs in C were more prone to stand up (0.78±0,57 per 5 min (mean ± SD)) than pigs in MF (0.39±0.56, $p = 0.001$).

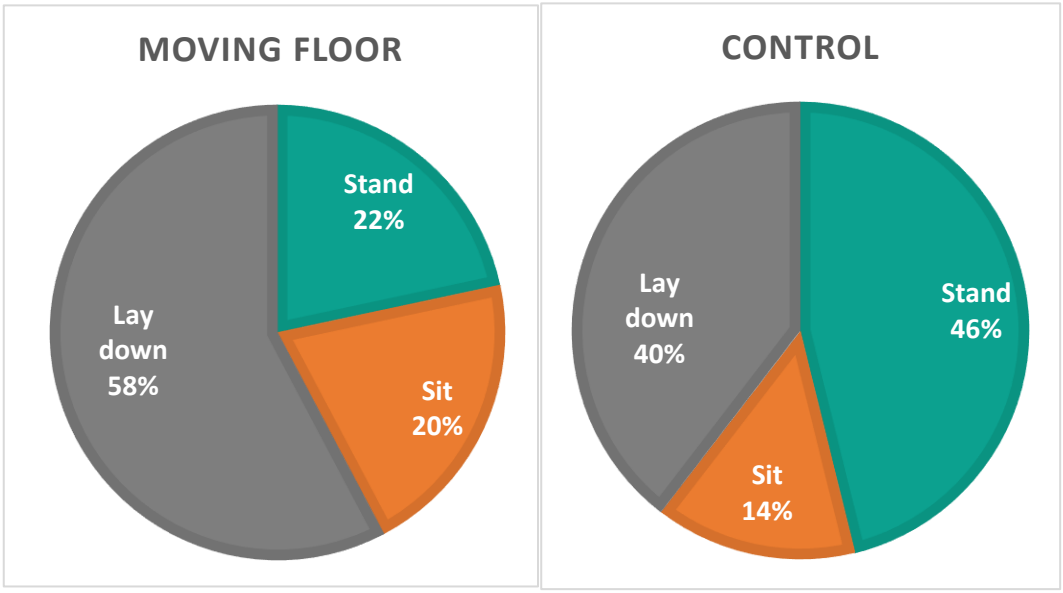

Figure 4. Distribution of posture in observed pigs. To the left; Moving floor pens during on farm observations (n=54). To the right; Control pens during on farm observations (n=54)

MF were manipulating litter less than C (0.78±1.16 and 1.59±1.22 respectively, *p=0.001*) otherwise no differences could be seen in positive social behaviours, grunting or belly nosing between the systems.

There were 25 and 41 observations respectively for MF and C when analysing active pigs and results are shown in Figure 5. MF rooted empty feeding troughs less (0.04±0.20) than C (0.46±0.84, $p = 0.004$) and manipulated the interior less frequently (0.33±0.57 compared with C 1.15±1.33, $p = 0.001$). No significant differences could be seen for vocalizations. Slipping was performed once for C while occurring six times for MF, but the differences was not statistically significant. Behaviour included in *Other* were when focal animal was out of sight when entering the slated area of the pen. There was no observed occasion of playing in neither of the groups.

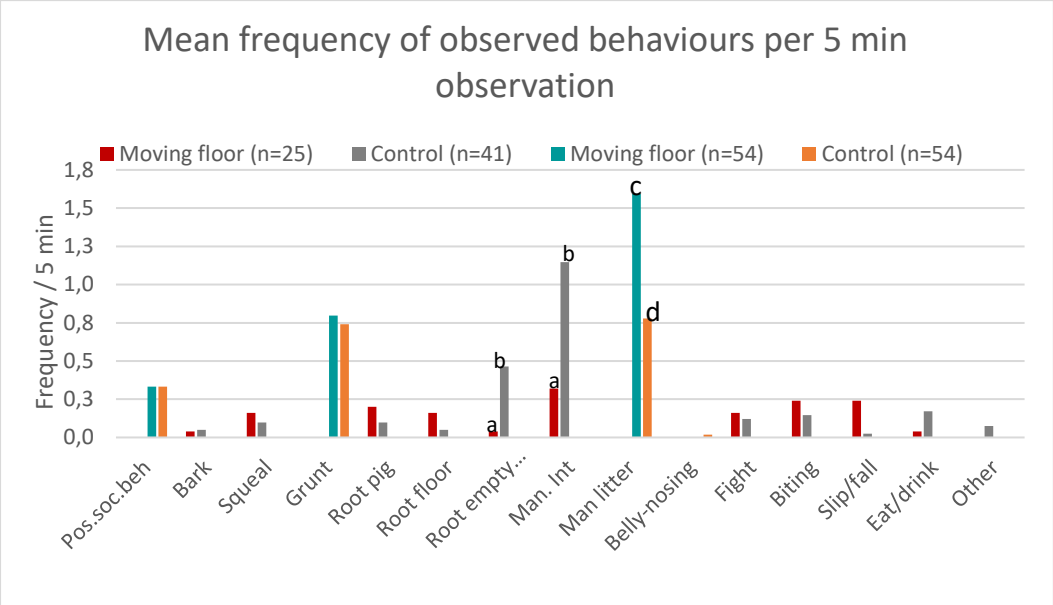

Figure 5. Mean frequency of observed behaviour per 5 min observation. 'Pos.soc.beh', 'Grunt' and 'Man litter' are analysed from all observations (n=54 in both groups). Remaining behaviours are observed in active pigs only (pigs sitting or standing at least once during observation, (Mooving floor; n=25 and Control; n=41). Bars with different letters differs significantly (p<0.05).

4.1.2. Behaviour from recorded video material

There was a total of 432 observations performed from the collected video material (216 in each system, each observation per focal animal represented one observation). Distribution of postures during the different weeks can be seen in Figure 6. C was laying 67% of the observed time compared with MF 59%. MF lay down significantly more (1.07±0.45 per 10 min (mean ± SD) than C in week seven (0.89±0.55, *p=0.033*). C pigs were laying more in the beginning of production (1.22±0.58) than in week seven (0.89±0.55, $p = 0.004$). MF pigs was standing significantly more in week two (0.62±0.72) compared with C for the same week

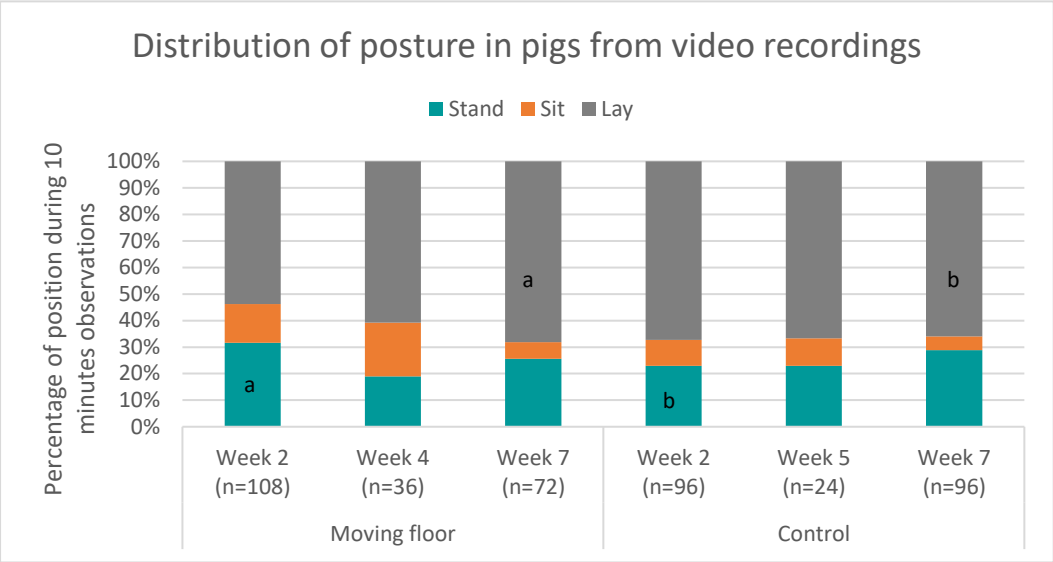

Figure 6. Distribution of posture in observed pigs from video recording divided by weeks. Coloured segment with different letters between systems differs significantly ($p<0.05$).

(0.42±0.59, *p=0.028*). MF was however sitting significantly more (0.25±0.61) than C (0.14±0.41, *p = 0.035*) and tended to sit more in the beginning of the production period (week 2: 0.29±0.69, *p-value = 0.015*; week 4: 0.44±0.74, *p-value = 0.01*) compared to in week seven (0.10±0.34). No significant differences could be seen between MF and C considering manipulation of litter/floor, positive social behaviours or belly nosing.

The results from active pigs' behaviours are displayed in Figure 7. Rooting a pen mate where more frequently performed in MF (0.22±0.46 per 10 min (mean ± SD)) than in C (0.09±0.32, *p=0.022*). The frequency of rooting an empty feeding trough was increased for MF from week two (0.21±0.53) to week seven (1.00±1.29, *p<0.05*) and was performed significantly more in MF than C (0.16±0.37) in the last week of observation (*p=0.004*). Manipulation of interior significantly increased in C from the beginning of production (week 2: 0.15±0.43; week 5: 0.33±0.77) to week seven (0.52±0.71, *p=0.027*) but was not different compared with MF. Frequency of fighting was performed more in MF for week two (0.46±1.00) than the same period for C (0.13±0.34, *p= 0.025*). Fighting was however increased in C from week two to seven (0.52±1.16, *p-value = 0.045*). Biting was observed 23 times in MF compared with four times in C but the difference was not statistically significant (*p-value = 0.08*). There was no slipping or falling observed in C but were however seen 28 times in M. The difference was not possible to evaluate with Students t-test due to the low frequency observed in C. Five occasions of playing were observed in MF and none in C. Behaviours included in *Other* were mainly when focal animal were out of sight when entering the slated area of the pen. Another behaviour observed were four occasions of climbing on interior or the other pen mates (three times in MF and once in C).. This behaviour was however not tested for significance due to the low observation frequency in both systems.

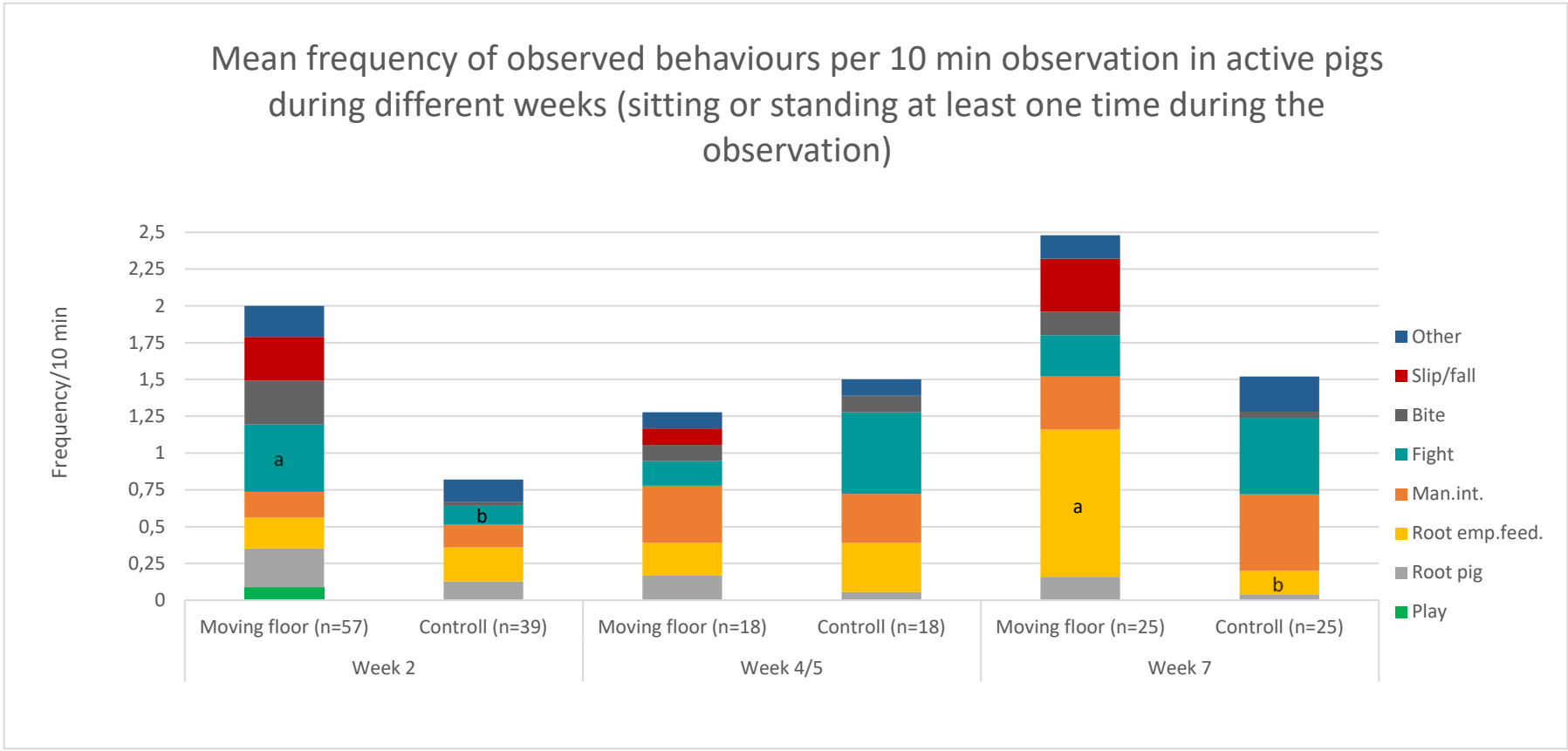

Figure 7. Mean frequency of observed behaviours per 10 min observation in active pigs during different weeks (sitting or standing at least one time during the observation) in both system. Same colour segments with different letters between systems differs significantly ($p<0.05$).

4.2. Hygiene

A summary of the results from manure on body assessment is displayed in Table 8. On the third day of observation MF had technical issues and had not been following the regular cleaning intervals. This led to dung being spread over a larger area than the other observation days. However, there was only one pig in the system that day who was assessed with score 1 and the occasionally lower pen hygiene score seemed not to have a large influence on the pig hygiene. The majority of pigs in both systems were overall clean (Score 0) but more pigs in C scored ≥1. MF had score 0 in 99.3% of the observations contra C who had 83.3%. The differences in number of pigs with score 0 and score 1 between systems were statistically significant (<0.05).

Table 8. Summary of scores for 'Manure on body assessment', from Moving floor (MF, n=60) and Control pigs (C; n=60) during the five observation days.

	Score 0[1]		Score 1[2]		Score 2[3]	
	C	MF	C	MF	C	MF
Day 1	51	60	7	0	1	0
Day 2	53	60	7	0	0	0
Day 3	49	59	11	1	0	0
Day4	51	59	8	1	1	0
Day 5	46	60	14	0	0	0
Median[4]	51[a]	60[b]	8[a]	0[b]	0	0

[1] <20% soiled surface on the free sighted side of the pig

[2] 20-50% soiled surfaces on the free sighted side of the pig

[3] >50% soiled surface on the free sighted side of the pig

[4]Median number of pigs across all days of observation. Numbers with different letters within the same hygiene score differs significantly, p<0.05.

Preferences on dunging areas differed some between the pens in both systems but is following a certain pattern in all pens illustrated in Figure 8 and are presented as the quota of “Times square are considered wet/Total number of observation”.
In MF the right corner, closest to the manure band, was considered wet in all pens (30/30 observations) and the dung was then distributed in most cases along the right side (the side with no feeding trough). Dung was never seen closest to the entrance in the MF pens where new flooring became visible during rotation of the floor. As expected, all pens in C had dung on the slatted area (30/30 observations) and often in the solid area closest to it.

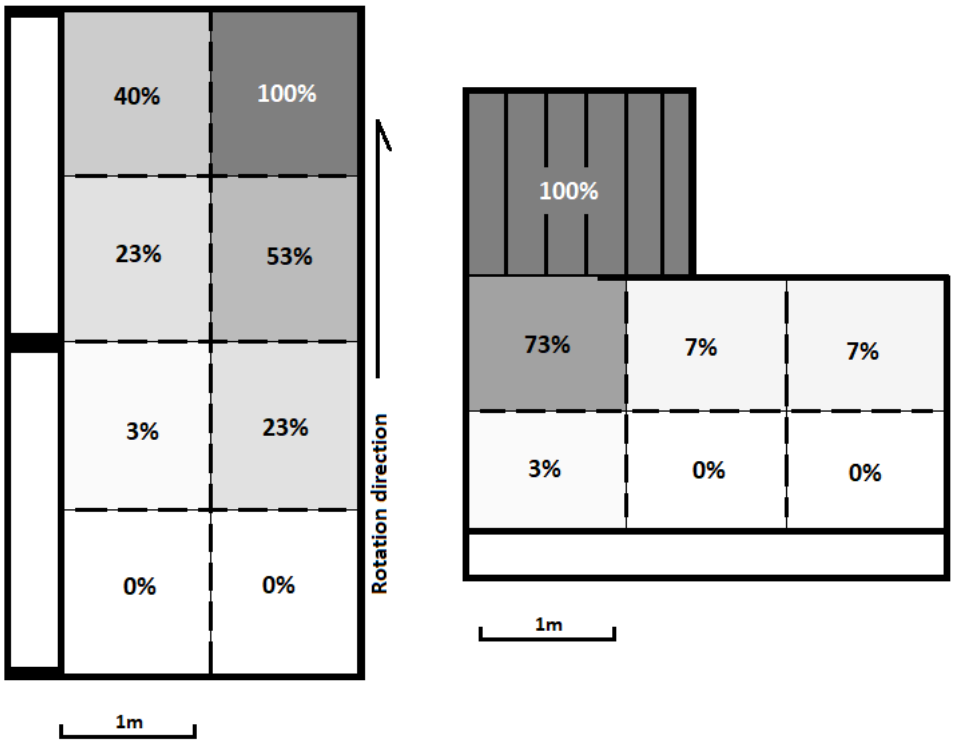

Figure 8. Distribution of dunging areas in 30 observations each from pens in Moving floor system (left) and from Control group (right). Results in each square are presented as the quota of "Times square are considered wet/Total number of observations".

4.3. Resting area

Results from resting preferences can be seen in Figure 9 and are presented as the quota of "Times pigs are laying in that square/Total number of observations". There were small differences between the pens which did not give a strict 100% place for resting. There were also some differences along the day, but no pattern could be distinguished between different times. There was, however, still a preferred resting area that were common between the pens in each system. In MF this could be seen being closest to the entrance, furthest away from the preferred dunging area. The same trend was seen for C where most pigs chose to rest in the corner furthest away from the dunging area and the feeding trough.

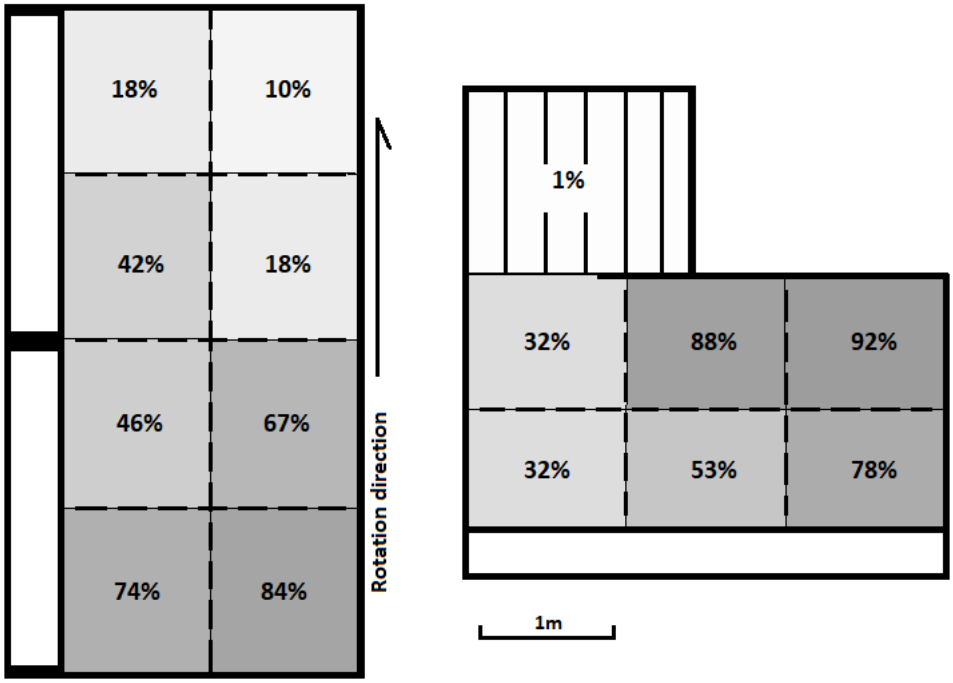

Figure 9. Distribution of chosen resting place in Moving floor system (left, n=72) and from Control group (right, n=72). Results in each square are presented as the quota of "Times pigs are laying in that square/Total number of observations".

4.4. Resting behaviours during floor movements

Graphs for the total amount of animals standing at different time during three days observations are displayed in Figure 10-13. MF pigs are laying in the beginning of the observation and move some time before floor rotation starts. The movement increases for a while and then pigs lay down again. The same pattern was also observed in C. There were also differences in activity from day to day. C were feed at the end of observation in the seventh week. Separate graphs per day for each pen are displayed in Appendix 4.

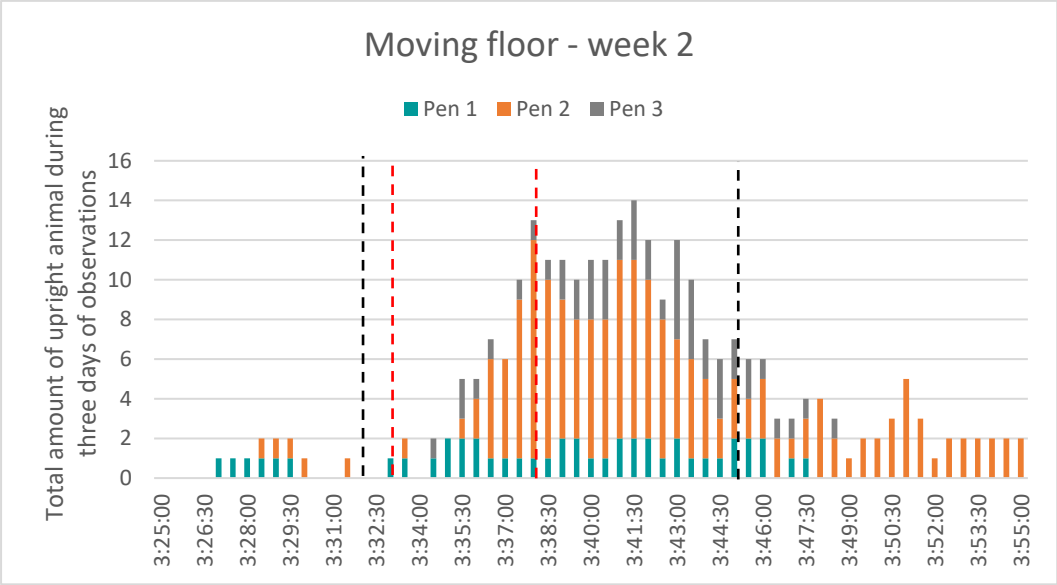

Figure 10. Frequency of animals not laying down during the time observed week 2 in Moving floor pens. Floor movement starts and end by read marker (- - -). Noise from manure belt and floor movement start and end by black marker (- - -)

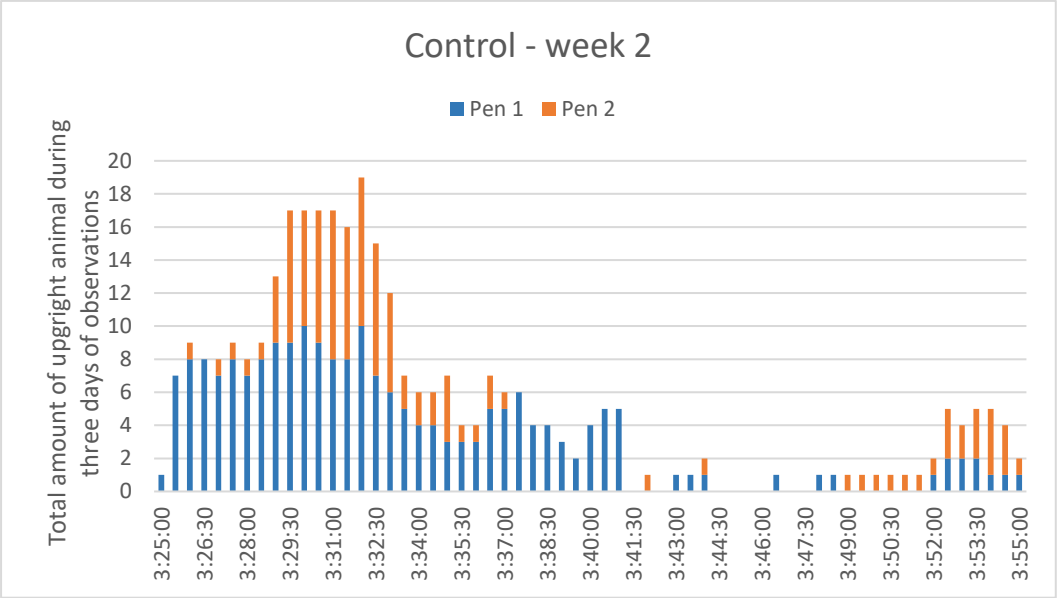

Figure 11. Frequency of animals not laying down during the time observed week 2 in the Control group.

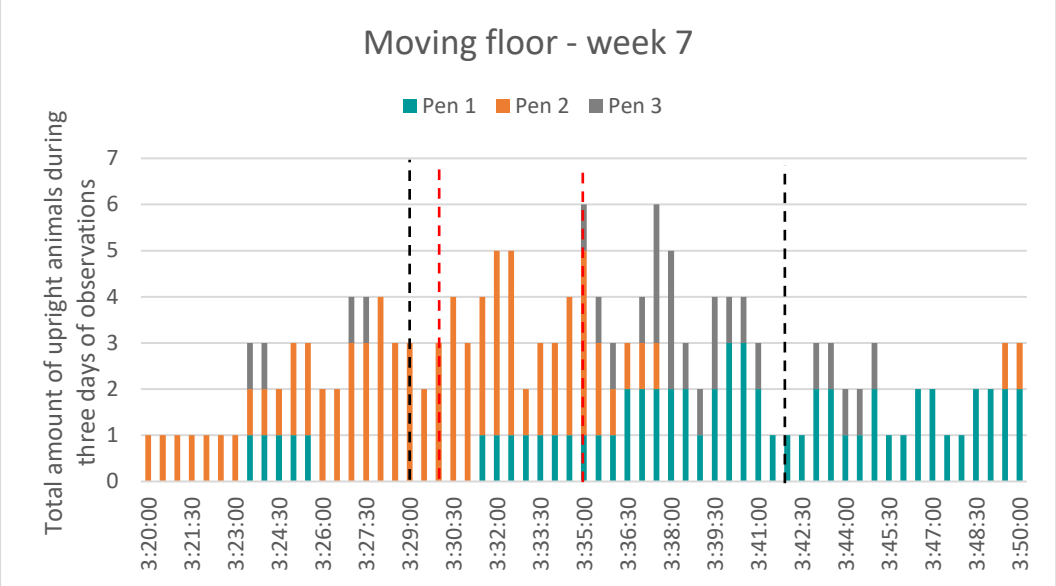

Figure 12. Frequency of animal not laying down during the time observed week 7 in Moving floor. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and end by black marker (- - -)

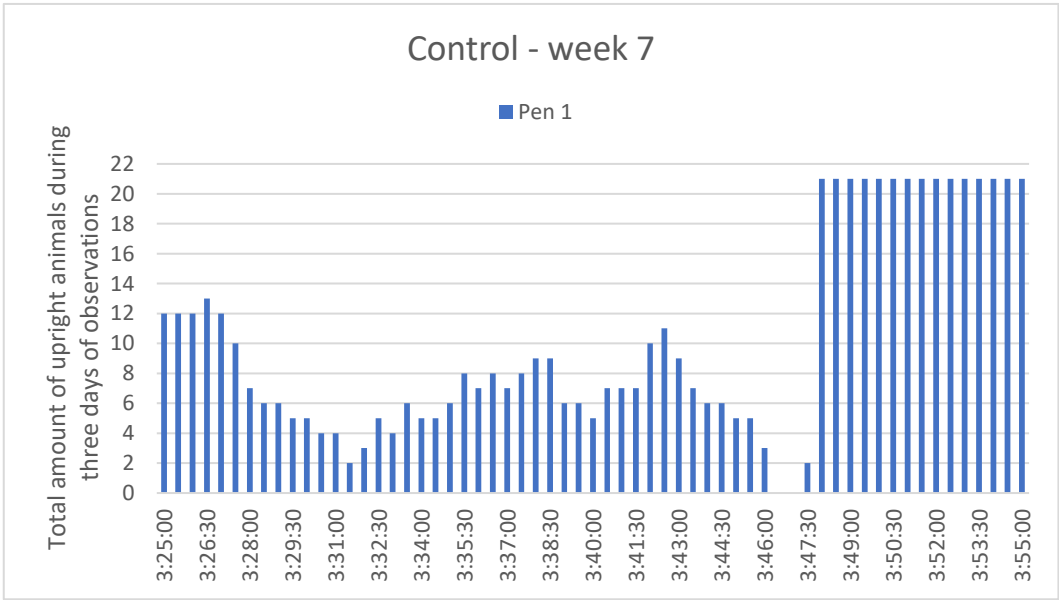

Figure 13. Frequency of animals not laying down during the time observed week 7 in Control pen 1. Feeding started two out of three days and started at red marker (- - -).

4.5. Time performing routine work

The results of time for routine work performed by the farmer are displayed in Table 9. A more detailed table of tasks can be seen in Appendix 5. In C the supervision of all animals was performed at the same time as daily cleaning. In MF no manual cleaning was needed, but animals still got their daily supervision by the farmer. The time performing that task were therefore compared with *Daily pen cleaning* for C. Providing new litter in MF were also done automatically, but the machine needed to be filled each morning and the time performing that task is compared with C's *Providing litter*.

The total time spent in MF was ~7 min (407 sec) which, divided on the 60 pigs present gave 6.78 sec/pig. However, on the day of observation, the farmer run an extra cleaning interval of the floor that was normally not included in day-to-day work. The farmer also wrote a time journal for Moving floor which does not belong to general work in the stable. If excluding the time taken for this (209 sec), the time working in the stable was approximately 3 min (198sec) or 3.3 sec/pig. The total time working in C was ~24 min (1463 sec) which divided on 410 pigs gave 3.57 sec/pig.

Table 9. Total time spent doing morning routines in slaughter pig production by task and system

Moving floor Task	**Time (sec)**	**% of total time**	**Control Task**	**Time (sec)**	**% of total time**
Daily supervision	63	31.8	Daily supervision and pen cleaning	467	31.9
Filling litter machine	135	68.2	Providing litter	667	45.6
Treatments	0	0	Treatments	329	22.5

5. Discussion

The aim with this thesis was to study the behaviour in pigs housed in self-cleaning pens with a rotating floor and how the hygiene was improved in finishing pigs compared with pigs housed in conventional pens with partly slated flooring.
This study included observation both on-farm and from video recordings. There were mainly two reasons for this. First to test the ethogram and specify the behaviours. By seeing the behaviour directly gave a better understanding of how the behaviour are performed and what to look for during the recorded material analysis. Secondly, recorded material did not include vocalization and sound from surroundings which were considered to be interesting factors.
Both methods have of course pros and cons. Direct observation makes it easier to see details in behaviours (e.g what are they manipulate, litter or floor). However, is the observer needed to be really focused not to miss anything and there is always a chance of observer interfere and disturb the animals by being there. This is not a problem when using video recordings. Recorded material have also the ability to paus and regulate speed which could help during analysis. It is also more comfortable for the observer who could make the observation regardless of place or time.

Previous studies have shown that pigs lay down approximately between 60-89% of time (Gonyou *et al.*, 1992, Presto *et al.*, 2013, Meunier-Salaün *et al.*, 2014, Tozawa *et al.*, 2016, Rosvold *et al.*, 2018) which is a bit more than seen in this study. During farm observation were pigs in MF laying down 18% more than pigs in C, while they layed down less than C during observation from video recording. This difference in quota between farm observations and recorded video, could have depended on different number of observed pens. Only two of C pens and three pens from MF were observed instead of the six pens from each system observed at farm. More likely is however that C got disturbed by noticing the observer during on farm assessments depending on the high grade of visibility of the observer in that system. In comparison, the pen wall between observer and pens in MF were mostly a solid wall instead of bars as in C, which make the observer less visible. MF had almost the same percentage of lying down (differed 1%) between assessment on farm and from recordings. MF did however sit more than C in both types of observation, but reasons for this is unclear. C lay significantly less in week seven than in week two.

This may depend on the smaller lying area in C and the decrease in available space per pig due to the growth and they hence disturbed each other more during resting.

Social behaviours, vocalization or biting was not significantly different between the systems. Play behaviour was not at all observed during farm observation but at six occasion in MF from video material performed in the second week of production (~13 weeks of age). Play behaviour is a sign of welfare (Broom and Fraser, 2015) and Tozawa *et al.* (2016) also mentioned that play is a sign of animal being in a good mental stage. Newberry *et al.* (1988) showed that play behaviour decreased after six weeks of age. In addition, no signs of play were observed in pigs by the ages 16, 21 and 26 weeks (Smulders *et al.*, 2006; Tozawa *et al.*, 2016). Pigs in this study range between ages 11 to 18 weeks which is on the limit were play behaviour previous have been observed. Because of that is conclusions about mental state hard to draw except that there was a non-significant difference between the systems in this study. A false of error that need to be taken in consideration is the definition of playing that may have been insufficient and some play behaviour could by that have been missed.

Manipulation of litter and rooting floor was hard to separate from the video recordings and was therefore merge into one result. Pigs in both systems were spending much time manipulating the litter provided, but C significantly more than MF pigs in the on-farm observations. A reason for this difference could have been that C had access to straw instead of sawdust, which may be more motivating and interesting to root in (Bracke *et al.*, 2006, Day *et al.*, 2002). The fact that there is a lot of sawdust provided throughout the whole day in MF (9 kg sawdust in total compared with 1 kg straw in C) may also affect the interest of the material. To maintain interest of an object is the novelty, destructibility and eat ability important (Bracke *et al.*, 2006; Averós *et al.*, 2010). Even though straw is not a new object, since it is given each day, it is only provided once which might increase the interest. Further observations with other littering would be a good way to see how different material would affect the behaviour in this new system. The manipulation of litter was however increased from week four to week seven in MF which is the opposite compared with the results from Tozawa *et al.* (2016). Their study showed that foraging decreased in the later period of production, although the pen used in that study was similar to the one used in C, it was an open-air roofed pen. The air and temperature (which is not included in the article) could with other words have interfered with the differences in results.

Manipulating interior was performed significantly more in C than MF when observing at farm. However, much of this behaviour was bar biting, which could possibly be explained again by observer interference by standing by the bars fully visible for the pigs. But, the frequency of manipulating interior increased between week two and seven in C also from video observation but in this case it was the bars

between the pens that was chewed on instead of the ones in front of the feeding trough and observer.

Rooting an empty feeding trough was performed more frequently in MF than for C in recorded material and was increased from second week of production until week seven. During farm observations a higher frequency was instead observed in C. Foraging and exploration are performed a large proportion of the day by pigs (Stolba and Wood-Gush, 1989) and to root at the food source may be considered to have something to do with hunger. However, pigs in both systems get the same amount of feed and there should not be a significant different between the systems regarding hunger. During farm observations were pigs in C approximately two weeks younger than MF that could have interfered with the results considering growth and feed intake. Feeding adjustments are however regulated by the producer in the same ways in both systems. The higher frequency of rooting the empty feeding trough might relate to the space limitations around feeding were some animals are hungrier than others. However, the results should be opposite then because feeding trough is larger per pig in MF. Some uncertainties are related to this data that need to be taken in considerations. Sometimes there was hard to determine if it was feed left in the trough or not when observing from video recordings which could have led false results. The high frequency of rooting the empty feeding trough in C when observing at farm may again have depended on interference of observer by increase curiosity around that area. The absence of hunger is of great matters for welfare and further studies about why the pigs are rooting the feeding trough are needed to draw any conclusions.

Belly nosing occurred one time only at farm observations (in MF) but was seen 20 times in C and 10 in MF on video. In this limited material the difference was not statistically significant. Occurrence of belly nosing is often associated with early weaning. Weaning at day 28 is substantially earlier than in nature and is performed abruptly, however weaning age did not vary between the systems studied. In Worobec *et al.* (1999) belly nosing was seen in piglets weaned at 28 days, even though it was lower than for those weaned at seven or 14 days.

There was a significantly higher occurrence of fighting in MF during week two compared with the same production week in C, but fighting then decreased over time in MF while instead increasing in C. This may have depended on the differences in pen design between systems. According to previous studies, aggressive behaviour increases with space limitations in floor area and at the feeding trough (Averós *et al.*, 2010, Olczak *et al.*, 2015) but also due to frustration. A higher frustration in animals could arise if not being able to get away or always being disturbed (Olczak *et al.*, 2015). Fighting was not expected to increase since it is often depending on the hierarchy that should have been settled already. But the fighting in C may have been caused by space claiming or failed avoidance which in contrast to the larger area/pig in MF will become more frequent. Both the space

available at the feeding trough and in the lying area was larger in MF compared to C.

The hygiene in the farm was overall good and few pigs received a hygiene score ≥1. MF were in general cleaner than C pigs with only two pigs receiving score 1 and none score 2. MF pigs had a distinctive dunging area as was hypothesized. In the report from SVA, Persson Waller (2016) considered the automatically cleaned mat for calves from Moving floor to be cleaner than the other one tested. Further testing in microbial growth should be performed because it only has been done on manure from cattle and especially because this mats structure is different than the one tested previously. Pens in MF were significantly cleaner then pens in C (*p-value<0.05*) during assessment in the afternoon. To take in account is that the pens in MF had been cleaned 4-5 times before, compared with C that been cleaned approximately 4-5 hours before. C was however still considered to be clean (score 0) 83% of the time. Further measures in hygiene between several farms would be interesting to see how different producers' management would affect the results.

At one occasion the cleaning process in MF had not proceeded as usual due to technical failure which lead to an increased number of wet squares. When dealing with technology, this is something to take in consideration and there is notification to the farmer to handle this as soon as possible. The pigs were however still clean even though the automatic cleaning did not take place as planned, which indicates that the pigs still prefer to rest in clean areas. This is also confirmed by the preferred resting area being inverted to the dunging area in both systems. There is however a smaller solid laying area in C which in the end of production results in that the pigs are spread out on the whole solid part and will not have such a distinctive resting place as for MF.

When looking at disturbance when resting at night, there were signs of a higher activity on pigs in MF a time before the floor moved. After a peak, approximately eight minutes after rotation started, activity decrease again (Figure 12). The movement of pigs observed before the rotation of the floor started can depend on the sudden sound arising from activation of the manure belt and the mechanics of the moving floor. Pigs in C were however moving a lot as well and there seems to be activity in intervals in both groups. Feeding occurred at some point between 04:00 and 05:00 am, which make it difficult to know if the movement is because of hunger or disturbance. . Pigs in nature sleep around 33% of their time, mainly by night (Campbell and Tobler, 1984) and should probably have woken up as the sun rises. The activity could depend on hunger and Presto *et al.* (2013) showed that pigs in their study were more socially active 5-15 minutes before feeding than after which could explained this increased movement. It is however activity in C even if no feed were given at the time. Perhaps could there be less disturbance in early morning if changing feeding routines. The producer mentioned that it was hard to get enough time between feedings. One way could be to have fewer feedings but

with larger rations and instead of having the lighting system turned on four times per day, it could be on for continuous eight hours which is more comparable with natural daylight. To ensure an undisturbed rest in MF the first cleaning could be moved to after first feeding when pigs are already up. Pigs were however assessed clean, even when the rotation not been performed (during one observation day), which maybe make it unnecessary to make that early clean and risk disturb the pigs. On the other hand, if pigs become more active 5-15 min before feeding, maybe it is a better strategy to keep the routine like it is now? How this would affect resting behaviours need further investigations. Some standing depended on them being pushed to the end of the pen when floor rotated and was because of that changing position. This could also be seen in Bannbers (2008) study with calves. How often this occurs, and which affect it may have on resting should be further investigated. Other risings could have been depended on interactions from other active pigs but was difficult to distinguish from video recordings

When interpreting the results, the way observation was performed should be taken in consideration. If the pigs are more active before feeding (Presto *et al.*, 2013) it would have been interesting to investigate further how the behaviour would be affected by the system before feeding but this was not performed due to lack of time. Another thing that may have interfered the observation on farm, in addition to the disturbance by observer, was the usage of light. The light was needed to get a clear view during observations but could have influenced pig activity levels when animals are used to get feed in combination with light.

The time spent per pig on performing routine work was almost the same in both systems (3.3 and 3.57 sec per pig for MF and C respectively). To do a robust time comparison between systems repeated measuring during several days, and not just on one occasion, is needed. Work tasks performed in the systems are however different and less time was spent in contact with the animals in MF where litter is provided automatically. The producer mentioned that you may get a better control of the pigs' health when entering the pen for cleaning as in C. For pigs to be used to humans and to be handled in a positive way is important to not cause a stressful situation for the pig when handling is necessary (Brown *et al.*, 2009, Day *et al.*, 2002, Temple *et al.*, 2011). Pigs in neither system appear fearful instead curious and forward. Day *et al.* (2002) mentioned that a fearless attitude towards humans could be a sign of pigs having a positive association towards humans which reduce fear. This may be the case also in this study. Future investigations on human-animal relationship in the MF system should be done. Social aspects, climate effects and ethical aspects are all important to take in consideration to have a sustainable animal production (Scholten *et al*. (2013). The social aspects regarding floor that rotates to achieve a better hygiene in the pen is probably in line with consumers view on a step in the right direction to get higher welfare in the pen for production animals. The high quantity of litter provided each day in the MF pen is also something that

probably appeal the consumer because it “feels good”. This system is still an innovation project under development, and nothing says that a solution for distribution of straw is far away. In this industrial world we are living in, the effectiveness of the system is important to be able to compete on the market and a self-cleaning pen would possibly make a big difference.

Water usage and energy usage are two important climate aspects in a sustainable production. Water is one of the largest resources needed in animal production (Muhlbauer, 2010), for the consumption of the pig but especially for cleaning the pens. But, water of good quality is not obvious in large part of the world. Moving floors concept are not using water in cleaning the floor but instead automatically brush the manure of and will ideally make the end-cleaning between batches more efficient and reduce water usage. Another climate aspect that was not compared in this thesis, was the energy usage. How much, and what source of electricity that are used, is an important climate factor but will also affect the profitability for the system. Previous study by Gustafsson (2006) included a technical evaluation of the system used for calves were the author measured the energy used when cleaning the floor eight times. The results showed that energy consumption was ~500 kWh/year in Moving floors hygiene pen and would cost approximately one working hour (with that year electrical prices and salary standard). The author did not present any kWh from any control stable but considered this to be less electrical consumption than in other systems for calves (Gustafsson, 2006). This type of study should be performed in pig stables as well to see if the same results implies.

However, still there are some ethical aspects to take in consideration. It is important to remember that there are living creatures used in this system and their health and wellbeing need to be prioritized. This study is the first to investigate the effects of keeping finishing pigs in MF pens. It should be followed by others to confirm and clarify the findings in this study and to investigate other aspects of health and wellbeing not included to ensure a high animal welfare status in this new system.

6. Conclusions

Based on the specific aims and hypothesis for this project I conclude:

- in general, pigs housed in pens with Moving floor concept behave similar to pigs housed in conventional pens i.e. most behaviours occur with the same frequency.
  Differences that was observed were more likely to depend on the larger space provided in Moving floor pens which reduce some stress factors, rather than the floor rotation. The larger space during resting seams to give a higher chance of undisturbed sleep from other pen mates in Moving floor pens.
- the activity level do change over time in, and between the systems. Moving floor pigs being more active than control pigs in the beginning of the finishing period.
- pigs housed in Moving floor pens do pick and use a specific dunging area just as in conventional pens which give an overall clean pen. A good pen hygiene level can be reached in both systems.
- pigs in Moving floor pens are very clean with 99% of the pigs scored as clean across all five observation days. Pigs choose to rest in clean areas of the pen independent of the housing system.
- the movement of the floor seem to influence the pigs' activity at first rotation. However, pigs in conventional pens do also move in intervals at this time of night. This needs to be studied further.
- that it is not possible to draw any conclusions regarding eventual differences in time spent for performing routine work based on this small study. Work tasks differ between systems and the time spent in contact with the animals seems to be less in Moving floor.

This study was performed on a limited number of pigs in a facility with only six Moving floor pens. Further investigation in larger scientific studies is needed to draw more robust conclusions about this new housing system.

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Appendix 1

Table 10. Concentrate recipe from Lantmännen. Deltex 3183 and Deltex 2170

Recept	**2020-01-20 1**	**2020-01-20 2**
	Fas 1	**Fas 2**
	0.90 nivå	**0.84 nivå**
Silo 2 2019 60V 38K 8Ä	24.34	25.49
Deltex K2170 pk bk	1.03	0.00
Deltex K3183	2.74	3.24
Vatten	71.88	71.26
Summa	**100.00**	**100.00**
Analysgaranti		
NE väx MJ MJ	2.64	2.71
OE bväx MJ	3.52	3.61
BerCa Gr g	2.35	2.28
Sis Lys g	2.37	2.28
Sis Lys/OE bväx g/MJ	0.68	0.63
Sis Lys/NE väx g/MJ	0.90	0.84
BerCaGmj g	2.28	2.21
SmbPGmj g	0.68	0.67
Råprotein %	4.19	4.11
Torrsubstans %	24.00	24.50
Växttråd %	1.20	1.19
Natrium g	0.54	0.52
Lysin g	2.65	2.55
CyMet g	1.67	1.65
Treonin g	1.81	1.76
Vitamin A Premix IE	1489.73	1439.97
Vit E Premix mg	17.88	17.28

Appendix 2

Table 11. Ethogram modified from Day et al. (2002), Torrey et al. (2013), Tozawa et al. (2016) and Jensen & Pedersen (2018)

Behaviour	Description
Standing	Body supported by all legs in standing position
Sitting	Hind is on the floor and only two legs are touching the floor in an upright position
Laying	Body touch the floor and is not supported by any legs
Play	Playful chasing, jumps and head-knocking with another pen mate
Positive social behaviour	Smells, snug or licking another pig
Barking	An abrupt, harsh sound
Grunt	A guttural sound
Squealing	High pitched scream
Root pig	Snout is lifting another pig and performing an up and down movement
Root floor	Snout is touching the floor and performing an up and down movement (no litter)
Root/lick feeding trough	Snout is touching the trough and performing an up and down movement (no food). Licking the feeding trough
Manipulating interior	Biting, rooting or chewing on any part of the interior excluding given enrichment
Manipulating litter	Biting, rooting, or chewing on litter
Belly nosing	Rubbing the belly of a pen mate with the snout repeatedly with approximately same frequency more than three times on the receivers' belly. Receive belly nosing.
Fighting	Ramming or pushing a pen mate aggressively
Biting	Biting or chewing on another pen mate
Slip/fall	Slip-one or more legs splits away from rest of the legs. Fall-two legs leaving the ground which lead to that pigs' body is touching the ground
Eat/drink	Eating or drinking
Other	Behaviour not mentioned in ethogram that should be specified in comments

Appendix 3

Table 12. Specification from observed behaviours from assessment on farm.

Variable	**System**	**N [1]**	**Sum**	**Mean**	**SD**	**Min**	**Median**	**Max**	**p-value[2]**
Stand	C	54	42	0.78	0.57	0	1	2	**0.001**
	MF	54	21	0.39	0.56	0	0	2	
Sit	C	54	13	0.24	0.55	0	0	2	0.278
	MF	54	20	0.37	0.68	0	0	3	
Laying	C	54	36	0.67	0.61	0	1	2	0.563
	MF	54	56	1.04	0.55	0	1	3	
Play	C	41	0	0	0	0	0	0	*
	MF	24	0	0	0	0	0	0	
Pos.soc.beh	C	54	18	0.33	0.64	0	0	3	*
	MF	54	18	0.33	0.61	0	0	3	
Bark	C	41	2	0.05	0.22	0	0	1	0.895
	MF	24	1	0.04	0.20	0	0	1	
Squeal	C	41	4	0.10	0.30	0	0	1	0.530
	MF	24	4	0.17	0.48	0	0	2	
Grunt	C	54	43	0.79	1.92 7	0	0	12	0.864
	MF	54	40	0.74	1.39	0	0.5	6	
Root pig	C	41	4	0.10	0.37	0	0	2	0.359
	MF	24	5	0.21	0.51	0	0	2	
Root floor	C	41	2	0.05	0.22	0	0	1	0.267
	MF	24	4	0.17	0.48	0	0	2	
Root empty feeding trough	C	41	19	0.46	0.84	0	0	4	**0.004**
	MF	24	1	0.04	0.20	0	0	1	
Man. Int	C	41	47	1.15	1.33	0	1	5	**0.001**
	MF	24	8	0.33	0.57	0	0	2	
Man litter	C	54	86	1.59	1.22	0	1.5	5	**0.001**
	MF	54	42	0.78	1.16	0	0	5	
Belly-nosing	C	54	0	0	0	0	0	0	*
	MF	54	1	0.02	0.14	0	0	1	
Fight	C	41	5	0.12	0.40	0	0	2	0.703
	MF	24	4	0.17	0.48	0	0	2	
Biting	C	41	6	0.15	0.53	0	0	3	0.45

	MF	24	6	0.25	0.53	0	0	2	
Slip/fall	C	41	1	0.02	0.16	0	0	1	0.298
	MF	24	6	0.25	1.03	0	0	5	
Eat/drink	C	41	7	0.17	0.44	0	0	2	0.115
	MF	24	1	0.04	0.20	0	0	1	
Other	C	41	4	0.10	0.37	0	0	2	*
	MF	24	0	0	0	0	0	0	

[1] Observations from all pigs included for posture (stand, sit, lay), 'Positive social behaviour', 'Manipulating litter/floor' and 'Belly nosing'. Rest includes observations from active pigs only (pig standing or sitting at least once during the 5 min observation)

*[2]Differences in mean frequency evaluated with Student's t-test. * indicates that test was not performed due to too low or same mean frequency between groups.*

Table 13. Specification from observed behaviours from video recordings

Variable	System	N[1]	Sum	Mean	SD	Min	Median	Max	p-value[2]
Stand	C	216	88	0.41	0.59	0	0	3	0.081
	MF	216	111	0.51	0.68	0	0	3	
Sit	C	216	31	0.14	0.41	0	0	2	**0.035**
	MF	216	54	0.25	0.61	0	0	4	
Lay	C	216	239	1.11	0.56	0	1	3	*
	MF	216	239	1.11	0.56	0	1	3	
Play	C	82	0	0	0	0	0	0	*
	MF	100	5	0.05	0.30	0	0	2	
Pos.soc.beh	C	216	39	0.18	0.44	0	0	2	0.553
	MF	216	45	0.21	0.53	0	0	3	
Root pig	C	82	7	0.09	0.32	0	0	2	**0.022**
	MF	100	22	0.22	0.46	0	0	2	
Root emp.feed.	C	82	19	0.23	0.55	0	0	3	0.088
	MF	100	41	0.41	0.84	0	0	4	
Man.int.	C	82	25	0.30	0.62	0	0	3	0.594
	MF	100	26	0.26	0.48	0	0	2	
Man lit./floor	C	216	144	0.67	1.07	0	0	6	0.126
	MF	216	184	0.85	1.42	0	0	7	
Belly-Nosing	C	216	20	0.09	0.50	0	0	6	0.252
	MF	216	10	0.05	0.32	0	0	3	
Fight	C	82	28	0.34	0.82	0	0	5	0.881
	MF	100	36	0.36	0.84	0	0	4	
Bite	C	82	4	0.05	0.27	0	0	2	0.080
	MF	100	23	0.23	0.98	0	0	9	
Slip/fall	C	82	0	0	0	0	0	0	*
	MF	100	28	0.28	0.79	0	0	4	
Other	C	82	14	0.17	0.56	0	0	4	0.903
	MF	100	18	0.18	0.44	0	0	2	

[1]Observations from all pigs included for posture (stand, sit, lay), 'Positive social behaviour', 'Manipulating litter/floor' and 'Belly nosing'. Rest includes observations from active pigs only (pig standing or sitting at least once during the 10 min observation)

*[2]Differences in mean frequency evaluated with Student's t-test. * indicates that test was not performed due to too low or same mean frequency between groups.*

Table 14. Specification from behaviours depended on week from video recording

Variable	System	Week	N[1]	Sum	Mean	SD	Min	Med	Max	p-value[2]
Stand	C	2	96	40	0.42	0.59	0	0	3	**0.028**
	MF		108	67	0.62	0.72	0	1	3	
	C	5	48	20	0.42	0.58	0	0	2	*
	MF	4	36	15	0.42	0.55	0	0	2	
	C	7	72	28	0.39	0.59	0	0	2	0.893
	MF		72	29	0.40	0.64	0	0	2	
Sit	C	2	96	17	0.18	0.46	0	0	2	0.175
	MF		108	31	0.29	0.68	0	0	4	
	C	5	48	9	0.19	0.49	0	0	2	0.075
	MF	4	36	16	0.44	0.74	0	0	3	
	C	7	72	5	0.07	0.26	0	0	1	0.582
	MF		72	7	0.10	0.34	0	0	2	
Lay	C	2	96	117	1.22	0.58	0	1	3	0.052
	MF		108	114	1.06	0.61	0	1	3	
	C	5	48	58	1.21	0.46	1	1	3	0.264
	MF	4	36	48	1.33	0.53	1	1	3	
	C	7	72	64	0.89	0.55	0	1	3	**0.033**
	MF		72	77	1.07	0.45	0	1	3	
Play	C	2	39	0	0.00	0.00	0	0	0	*
	MF		57	5	0.09	0.39	0	0	2	
	C	5	18	0	0.00	0.00	0	0	0	*
	MF	4	18	0	0.00	0.00	0	0	0	
	C	7	25	0	0.00	0.00	0	0	0	*
	MF		25	0	0.00	0.00	0	0	0	
Positive Social behaviour	C	2	96	14	0.15	0.35	0	0	1	0.839
	MF		108	17	0.16	0.46	0	0	2	
	C	5	48	9	0.19	0.49	0	0	2	0.255
	MF	4	36	12	0.33	0.63	0	0	2	
	C	7	72	16	0.22	0.51	0	0	2	*
	MF		72	16	0.22	0.56	0	0	3	
Root pig	C	2	39	5	0.13	0.41	0	0	2	0.158
	MF		57	15	0.26	0.52	0	0	2	
	C	5	18	1	0.06	0.24	0	0	1	0.304
	MF	4	18	3	0.17	0.38	0	0	1	
	C	7	25	1	0.04	0.20	0	0	1	0.166
	MF		25	4	0.16	0.37	0	0	1	
Root Empty Feeding trough	C	2	39	9	0.23	0.58	0	0	3	0.862
	MF		57	12	0.21	0.53	0	0	3	
	C	5	18	6	0.33	0.69	0	0	2	0.564
	MF	4	18	4	0.22	0.43	0	0	1	
	C	7	25	4	0.16	0.37	0	0	1	**0.004**

	MF		25	25	1.00	1.29	0	0	4	
Manipulate interior	C	2	39	6	0.15	0.43	0	0	2	0.802
	MF		57	10	0.18	0.38	0	0	1	
	C	5	18	6	0.33	0.77	0	0	3	0.811
	MF	4	18	7	0.39	0.61	0	0	2	
	C	7	25	13	0.52	0.71	0	0	2	0.385
	MF		25	9	0.36	0.57	0	0	2	
Manipulate Litter and floor	C	2	96	65	0.68	1.03	0	0	6	0.256
	MF		108	94	0.87	1.38	0	0	6	
	C	5	48	32	0.67	1.12	0	0	4	0.812
	MF	4	36	26	0.72	1.00	0	0	4	
	C	7	72	47	0.65	1.10	0	0	4	0.313
	MF		72	64	0.89	1.64	0	0	7	
Belly-Nosing	C	2	96	4	0.04	0.25	0	0	2	0.231
	MF		108	1	0.01	0.10	0	0	1	
	C	5	48	4	0.08	0.35	0	0	2	0.783
	MF	4	36	4	0.11	0.52	0	0	3	
	C	7	72	12	0.17	0.77	0	0	6	0.340
	MF		72	5	0.07	0.39	0	0	3	
Fight	C	2	39	5	0.13	0.34	0	0	1	**0.025**
	MF		57	26	0.46	1.00	0	0	4	
	C	5	18	10	0.56	0.92	0	0	3	0.113
	MF	4	18	3	0.17	0.38	0	0	1	
	C	7	25	13	0.52	1.16	0	0	5	0.366
	MF		25	7	0.28	0.61	0	0	2	
Bite	C	2	39	1	0.03	0.16	0	0	1	0.102
	MF		57	17	0.30	1.22	0	0	9	
	C	5	18	2	0.11	0.47	0	0	2	*
	MF	4	18	2	0.11	0.32	0	0	1	
	C	7	25	1	0.04	0.20	0	0	1	0.368
	MF		25	4	0.16	0.62	0	0	3	
Slip/fall	C	2	39	0	0.00	0.00	0	0	0	*
	MF		57	17	0.30	0.84	0	0	4	
	C	5	18	0	0.00	0.00	0	0	0	*
	MF	4	18	2	0.11	0.47	0	0	2	
	C	7	25	0	0.00	0.00	0	0	0	*
	MF		25	9	0.36	0.86	0	0	4	
Other	C	2	39	6	0.15	0.43	0	0	2	0.537
	MF		57	12	0.21	0.45	0	0	2	
	C	5	18	2	0.11	0.32	0	0	1	*
	MF	4	18	2	0.11	0.47	0	0	2	
	C	7	25	6	0.24	0.83	0	0	4	0.663
	MF		25	4	0.16	0.37	0	0	1	

[1]*Observations includes all pigs on posture (stand, sit, lay), 'Positive social behaviour', 'Manipulating litter/floor' and 'Belly nosing'. Rest includes observations fromactive pigs only (standing or sitting at least once during the 10 min observations)*

[2]*Differences in mean frequency evaluated with Student's t-test. * indicates that test was not performed due to too low or same mean frequency between groups.*

Appendix 4

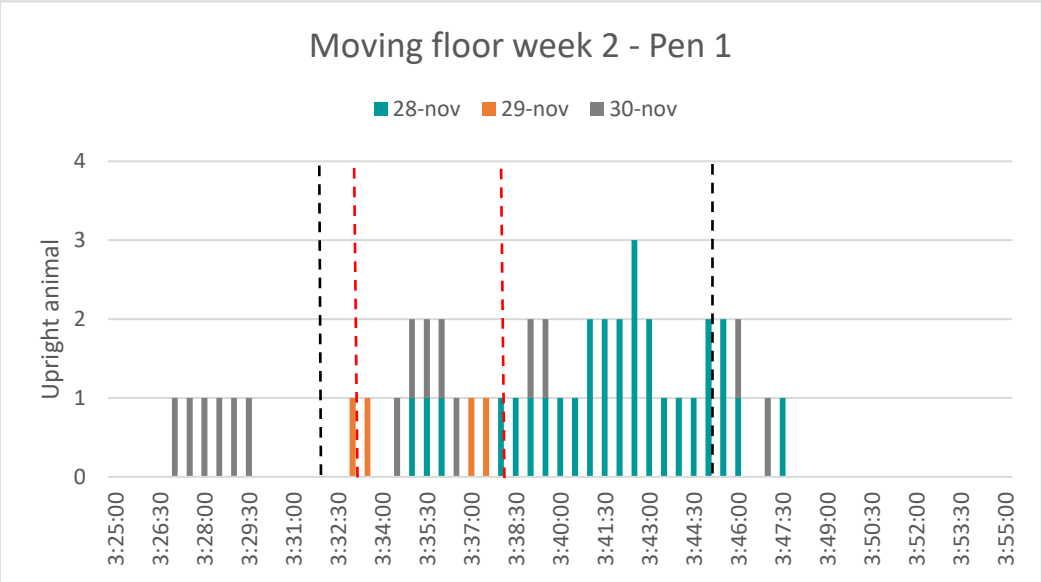

Figure 14. Animals from Moving floor pen 1 standing or sitting up during three observation days in week 2. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

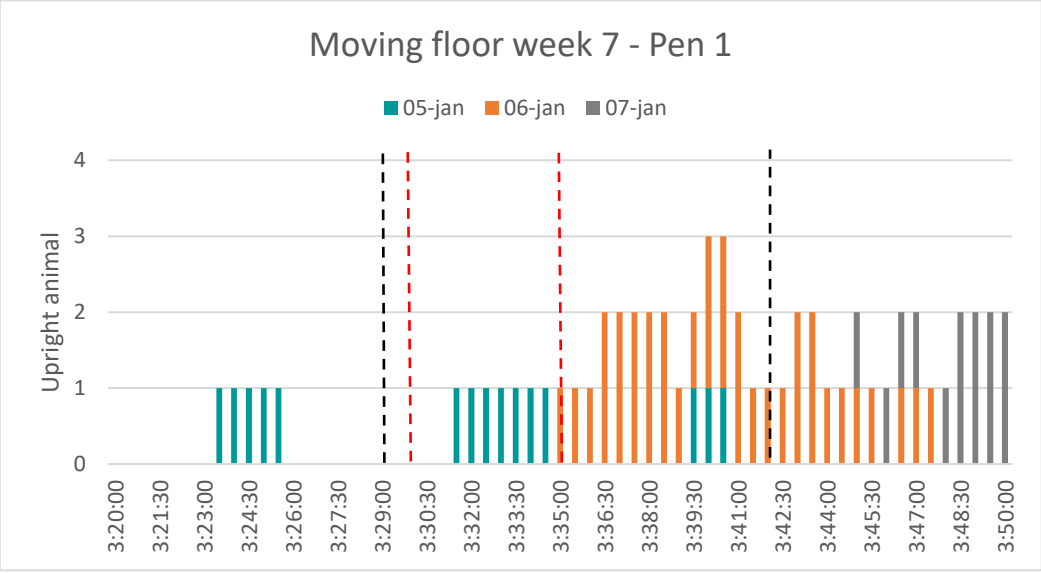

Figure 15. Animals from Moving floor pen 1 standing or sitting up during three observation days in week 7. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

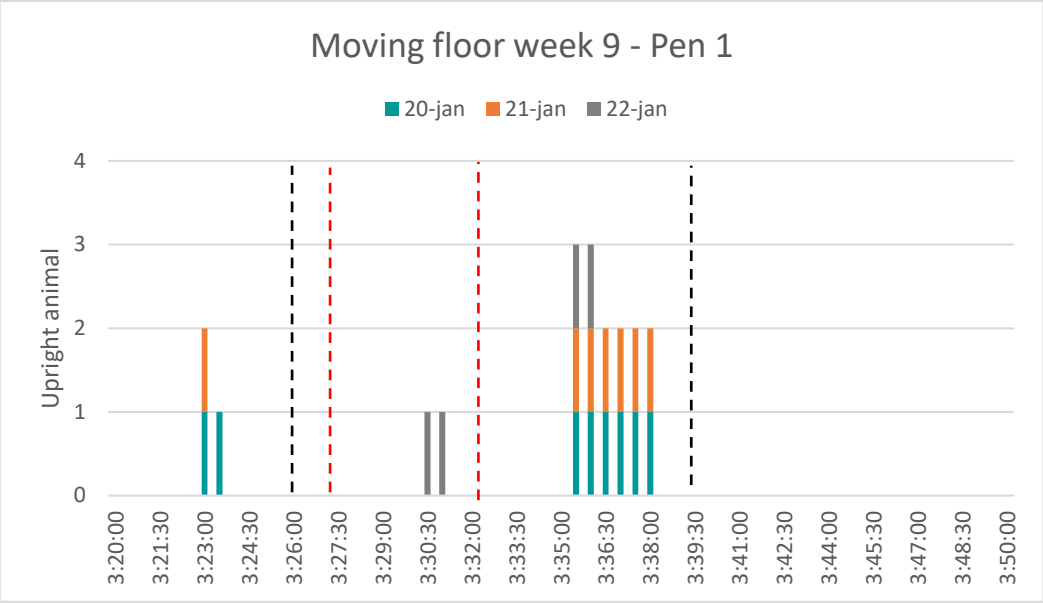

Figure 16. Animals from Moving floor pen 1 standing or sitting up during three observation days in week 9. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

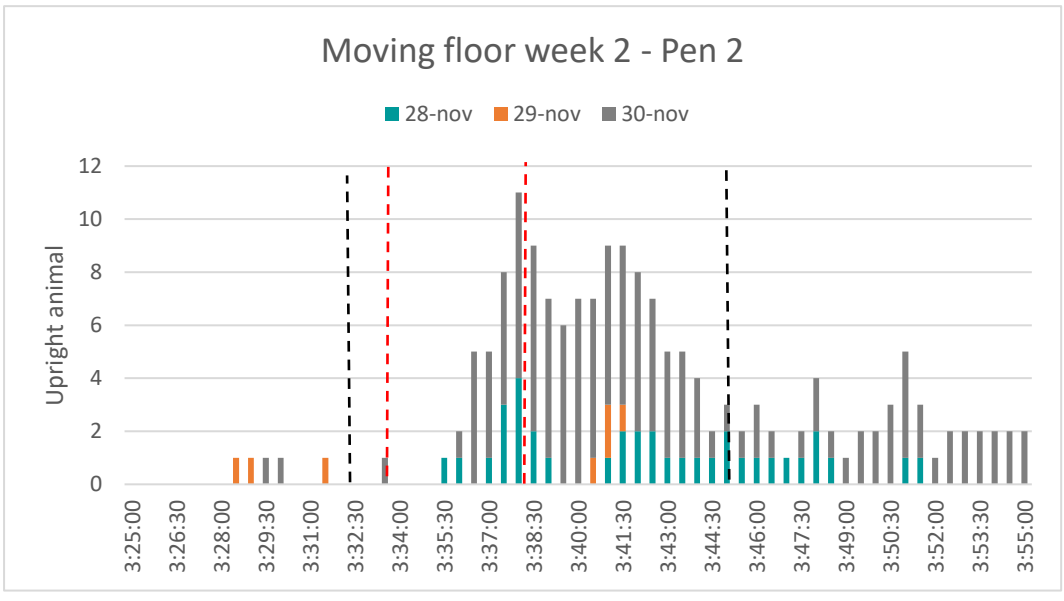

Figure 17. Animals from Moving floor pen 2 standing or sitting up during three observation days in week 2. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

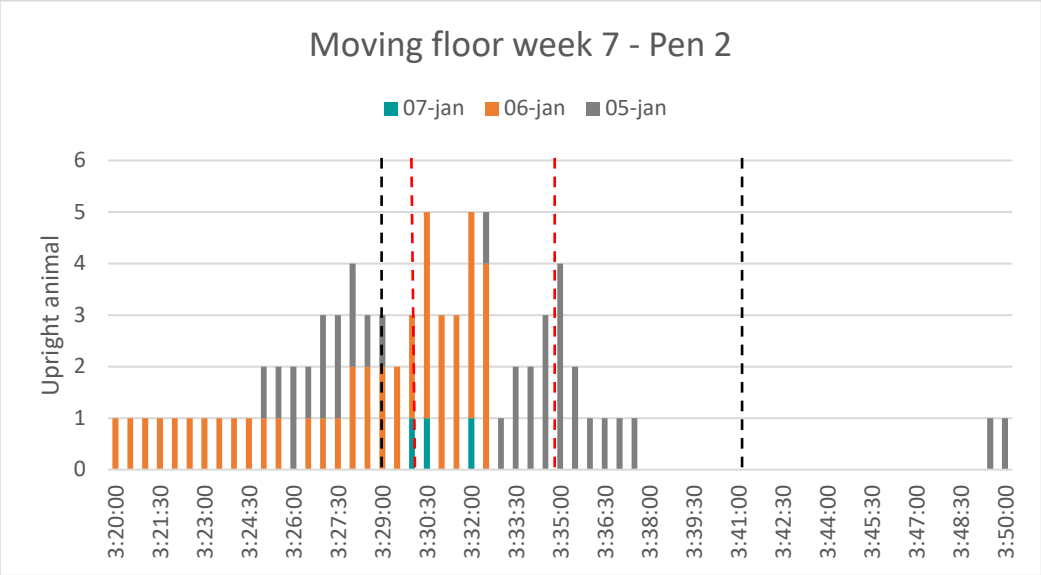

Figure 18. Animals from Moving floor pen 2 standing or sitting up during three observation days in week 7. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

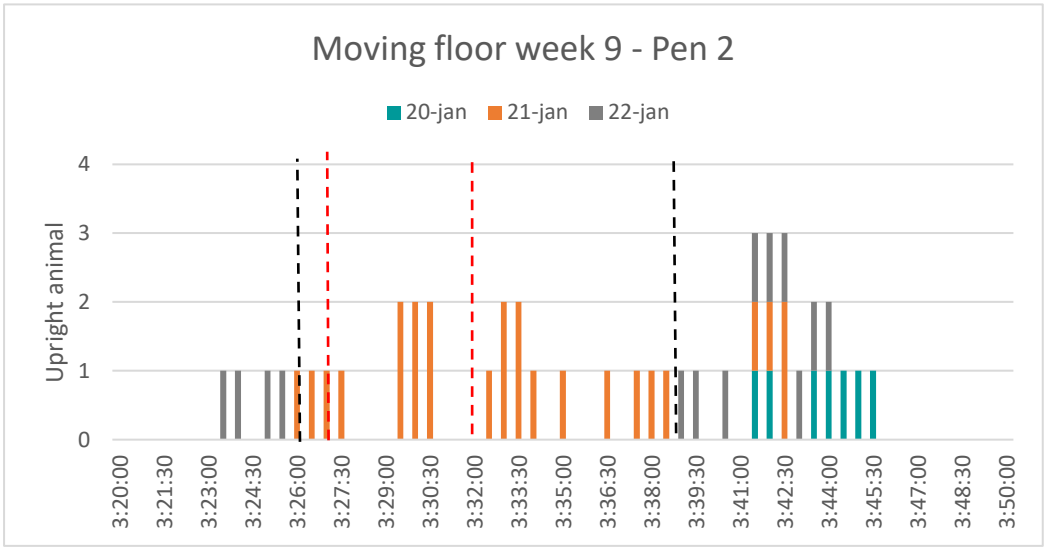

Figure 19. Animals from Moving floor pen 2 standing or sitting up during three observation days in week 9. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

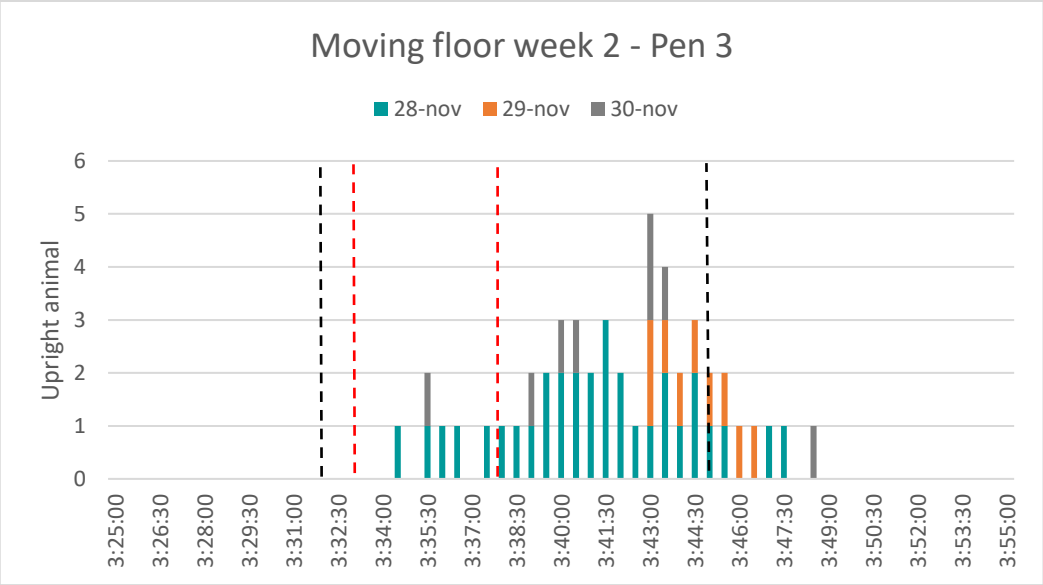

Figure 20. Animals from Moving floor pen 3 standing or sitting up during three observation days in week 2. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

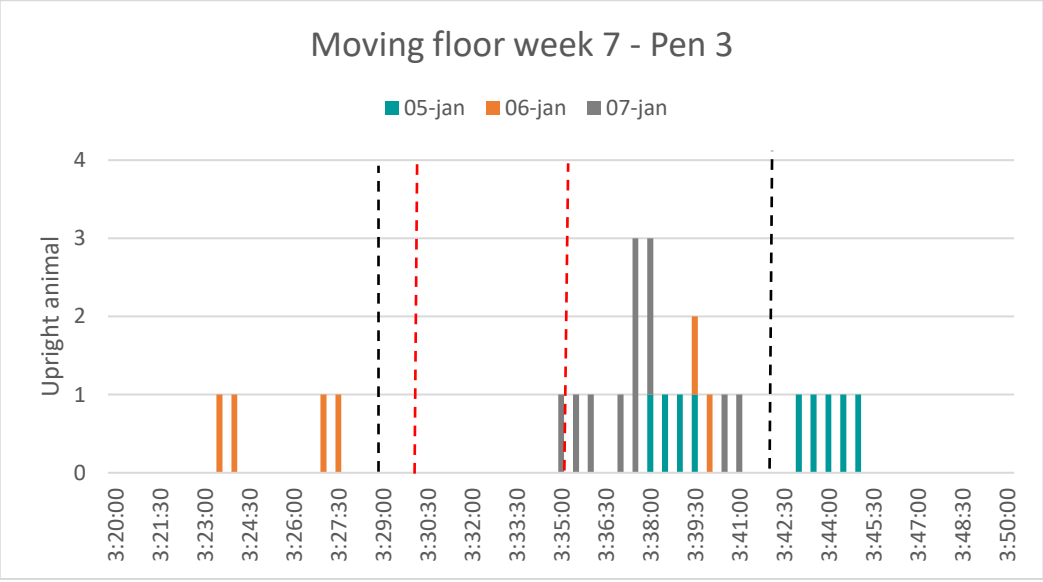

Figure 21. Animals from Moving floor pen 3 standing or sitting up during three observation days in week 7. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

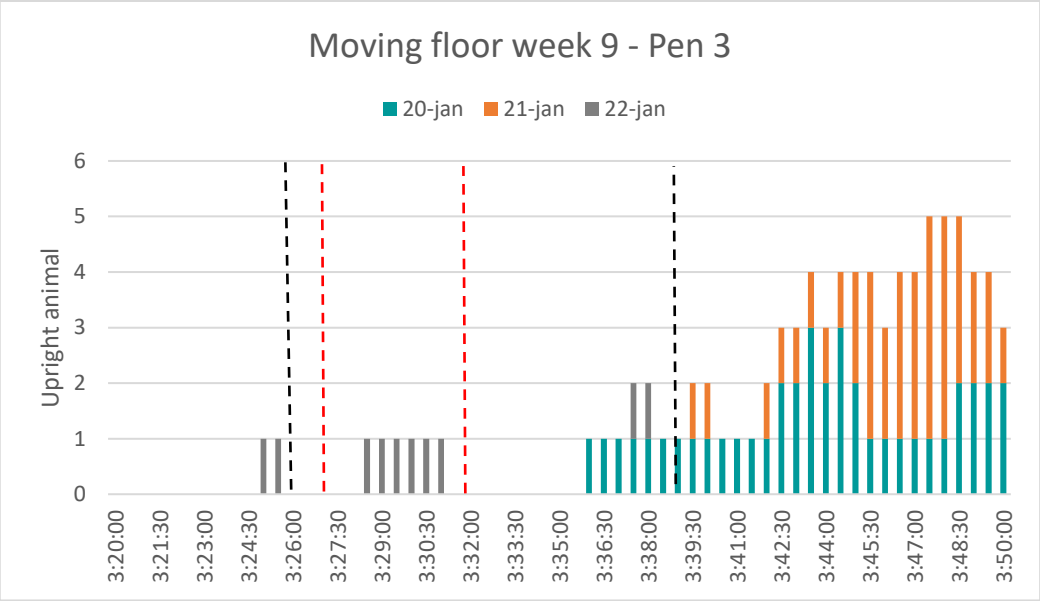

Figure 22. Animals from Moving floor pen 3 standing or sitting up during three observation days in week 9. Floor movement starts and ends by read marker (- - -). Noise from manure belt and floor movement start and ends by black marker (- - -).

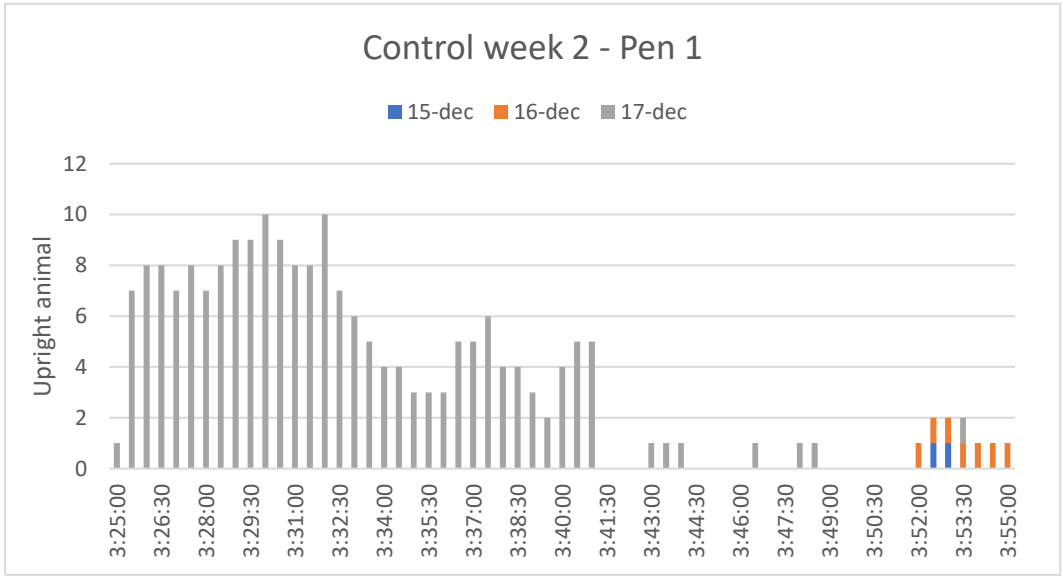

Figure 23. Animals from Control group pen 1 standing or sitting up during time of rotation for Moving floor, three observation days in week 2.

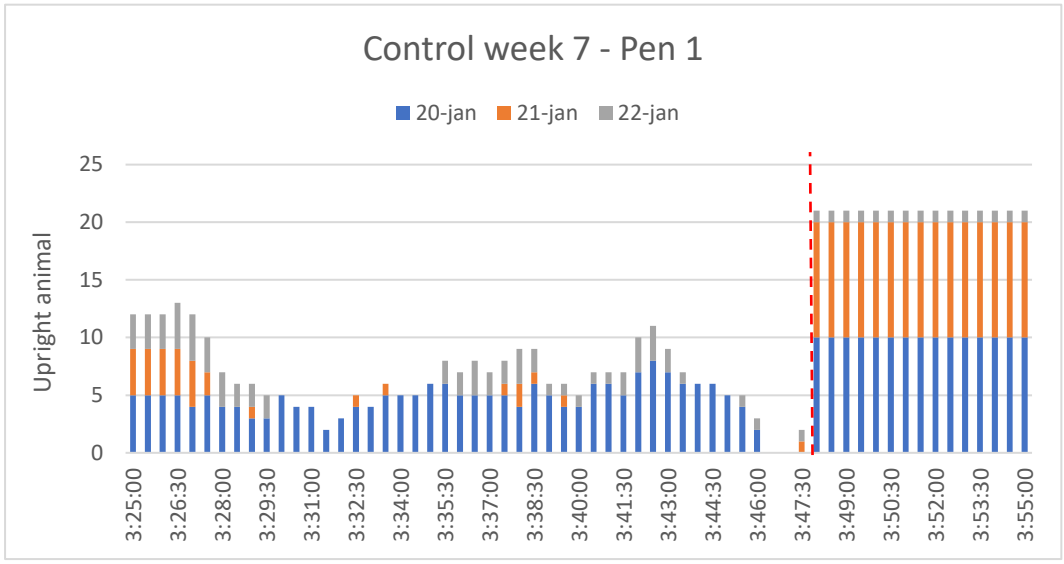

Figure 24. Animals from Control group pen 1 standing or sitting up during time of rotation for Moving floor, three observation days in week 7. Feeding started at red marker (- - -).

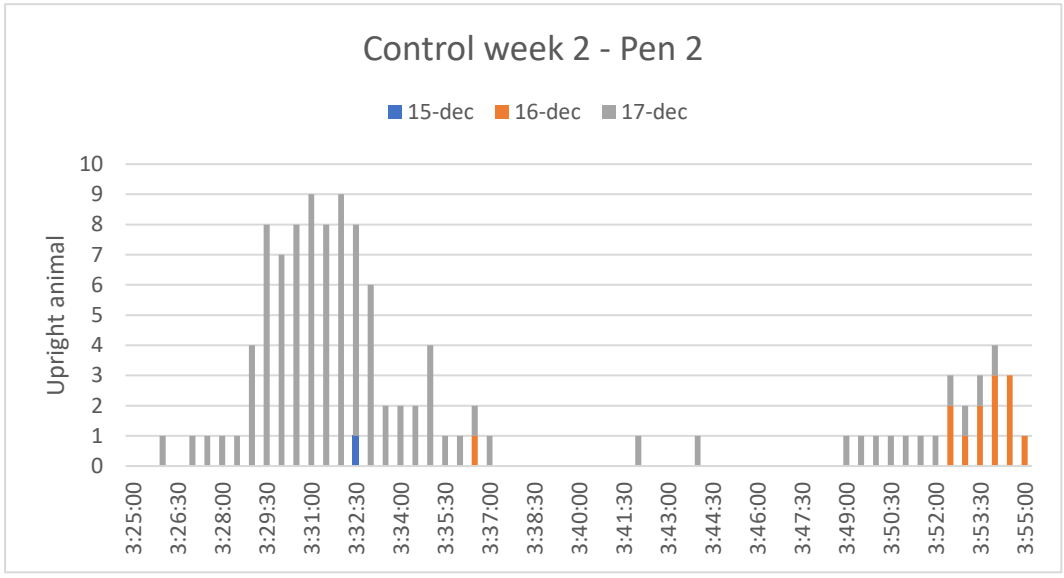

Figure 25. Animals from Control group pen 2 standing or sitting up during time of rotation for Moving floor, three observation days in week 2.

Appendix 5

Time performing routine work in both systems.

MF Time	Task	Comment
08:15:00	Enter stable and checking all pens	
08:16:03	All pens checked. Extra litter is needed and start litter machine.	
08:16:20 – 08:17:38	Filling new sawdust in machine	
08:18:18	Walk out from stable and start an extra cleaning.	Not always done. Just when farmer think it is needed.
08:19:20	Walk in and checking all pens again	Not routine
08:21:04	Writing time journal	
08:21:47	Exit stable	
C Time	**Task**	**Comment**
08:38:00	Fill straw carrier	
08:39:33	Walks out and start manure pit.	
08:40:07	Enter stable and start scraping pens	Health of pigs are checked at the same time
08:46:11	Exit stable and stops manure pit.	
08:47:20	Enter stable and getting straw carrier	
08:47:37	Begin distributing straw (1kg/pen)	
08:50:45	Exit stable and fill straw carrier	
08:52:44	Enter stable and continuing distributing straw.	
08:56:54	Exit stable and getting medicine.	
09:00:51	Enter stable and treat sick animals	
09:02:23	Exit stable	