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Cikoria- och rödklöverensilage till slaktsvin och dess påverkan på grisars beteende

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Abstract

Even though roughage is a part of the natural diet for pigs, the majority of today's pigs do not have access to it. The time the pigs in modern production system spend on eating is very short, it could be as little as 15 minutes per day. This could lead to digestive or behavioural problems. There is an unused potential for different ley crops and especially legumes, to contribute to the pigs' nutritional supply with both protein and energy and also increase their welfare by stimulate foraging and exploratory behaviour. In this study conventional growing/finishing pigs were given free access to silage of 100% red clover or 100% chicory in excess of 80% of a recommended cereal-based feed ration. The experiment started when the pigs had a live weight of 80 kg and ended at slaughter. The pigs were video recorded with cameras throughout the experiment and their behaviour were analysed two consecutive days at two observation occasions. The pigs' activity, body position and location in the pen were analysed. Social interactions, biting pen fittings and eating silage were observed continuously for five minutes three times per day during the observation occasions. The results showed that pigs in the control treatment were lying down more of the time and spent less time nosing on the pen floor than the pigs in the two silage treatments. This implies that pigs with access to silage were more active than the control pigs. Pigs in the control treatment had significant higher number of biting in pen fittings. The most common social interaction in all three treatments was nosing on other pig. There was significant less bitings/nibblings in the red clover treatment but more head knocks in the chicory treatment compared to the other treatments. The time spent on eating/rooting silage did not differ between the two silage treatments. Access to silage seems to have offered a higher opportunity to perform foraging behaviour and without access to silage the pigs seem to have redirect some of the exploratory behaviour towards pen fittings instead. Social behaviour was also analysed in relation to gender and the two different genotypes the pigs had (Yorkshire x Duroc or Yorkshire x Hampshire). For genotype no significant differences were seen but female pigs had a higher number of social interactions in total and higher frequency of nosings compared to the castrated male pigs. The conclusion of study is that even in this already enriched pig production system (all pigs had straw) the animal welfare can be improved with access to silage, by given a more meaningful occupation than pen manipulation. Both chicory and red clover silage did contribute to the pigs' energy and protein supply, but red clover gave a better daily gain than chicory. Red clover also had a higher potential as roughage to improve the growing/finishing pigs' welfare.

Sammanfattning

Även om grovfoder är en del av grisens naturliga födoval har få av dagens produktionsgrisar tillgång till det. Tiden som grisen idag ägnar åt att äta är väldigt kort, ibland så lite som 15 min per dag. Detta kan leda till matsmältningsproblem och beteendestörningar. Det finns en stor potential att vallgrödor och framförallt baljväxter, kan bidra till grisarnas energi- och proteinförsörjning men även bidra till att öka djurvälfärden genom att stimulera födosöks- och utforskningsbeteende. I den här studien gavs konventionella slaktsvin fri tillgång på ett cikoriaensilage eller ett rödklöverensilage utöver 80% av en rekommenderad spannmålsbaserad fodergiva. Försöket pågick från det att slaktsvinen hade en levandevikt på ca 80 kg fram till slakt. Grisarna filmades under hela försöket och deras beteende analyserades två dagar i följd vid två observationstillfällen. Grisarnas aktivitet, kroppsposition och plats i boxen analyserades. Sociala interaktioner samt bitning av boxinredning och ensilageätning observerades kontinuerligt i fem minuter tre gånger per dag vid observationstillfällena. Resultaten visade att grisarna i kontrollbehandlingen låg ner mer av tiden och ägnade mindre tid åt att nosa på boxgolvet än grisarna i de två ensilagebehandlingarna. Detta innebär att grisarna med tillgång på ensilage var mer aktiva än kontrollgrisarna. Grisar i kontrollbehandlingen hade signifikant högre andel bitningar i boxinredningen. Den vanligaste sociala interaktionen i alla behandlingar var nosa på en annan gris. Det var signifikant mindre bitningar/nafsningar i rödklöverbehandlingen men mer ”hugg” mot en annan gris i cikoriabehandlingen jämfört med de andra behandlingarna. Tiden grisarna ägnade åt att äta/böka ensilage skiljde inte mellan ensilagebehandlingarna. Tillgången på ensilage verkar ha bidragit till att ge en större möjlighet att utföra födosöksbeteende och utan tillgång på ensilage verkar grisarna ha riktat en del av sitt utforskningsbeteende mot inredningen istället. Socialt beteende analyserades även med avseende på kön och efter de två olika raskorsning som grisarna bestod av (Yorkshire x Duroc eller Yorkshire x Hampshire). För raskorsning sågs inga signifikanta skillnader men sogrisar hade högre antal sociala interaktioner totalt samt högre andel nosningar jämfört med hangrisarna. Slutsatsen av studien är att även i redan berikade grisproduktionssystem med strö kan djurvälfärden öka med tillgång på ensilage, genom att ge grisarna en mer meningsfull sysselsättning än bita i boxinredning. Både cikoria- och rödklöverensilage bidrog till grisarna energi- och proteinförsörjning, men rödklövern gav bättre daglig tillväxt än cikorian. Rödklöverensilaget hade också en större potential som grovfoder att förbättra slaktgrisarnas välfärd.

Introduction

Even though roughage is a part of the natural diet for pigs, the majority of today's pigs do not have access to it (ICOPP, 2015). The cereal-based feed rations in modern pig production come in a pellet, meal or mash form and the time the pigs spend eating is very short. It can be as little as 15 minutes of the day the pigs spend eating, and this is to be compared to pigs in semi-natural environment that spend more than half of the daylight period rooting and grazing (Stolba & Wood-Gush, 1989). The short eating time could lead to digestive or behavioural problems (ICOPP, 2015). In organic production free access to roughage is a demand (KRAV, 2015). Roughage is often only seen as an enrichment (Alarik *et al.*, 2012) but is not included in the feed ration calculations. There is a big unused potential for different ley crops to contribute to the pigs' nutritional supply with both protein and energy and also increase their welfare in different aspects (Presto, 2011).

The study has been a part of a larger EU project; *ICOPP –Improved contribution of local feed to support 100% organic feed supply to pigs and poultry,* which is funded by Organic Core II (ICOPP, 2015). The aim of this larger project was to identify economically profitable feeding strategies based on 100% organic feed across Europe for both pigs and poultry. The project has examined different local feed resources and given a better understanding of how those impact growth, health, welfare and the environment. One part of the project aimed to improve the understanding of the possible effects a roughage inclusion in the diet gives on pigs' nutrition, behaviour, health and welfare.

In this study, conventional growing/finishing pigs have been fed a chicory silage or a red clover silage in combination with a commercial feed. The study was carried out as a Master thesis, where the behaviour study was the major part. The aim of the study is to investigate how diets including chicory silage or red clover silage affect pigs' behaviour and production. The main questions I aim to answer are:

- Does access to silage increase the opportunity for pigs to perform more foraging behaviour?
- Does access to silage for pigs decrease the occurrence of aggression and biting pen fittings?
- Are there any differences in pigs' behaviour when feeding chicory silage compared to red clover silage?
- Are there any differences in pigs' behaviour between the two genotypes Yorkshire x Hampshire and Yorkshire x Duroc?
- How will the growth and carcass traits be affected when the pigs are fed chicory and red clover silage?

Literature review

Rooting behaviour

Pigs explore and get to know their environment by rooting, sniffing, biting and chewing on items, both things that are edible and things that are not (Studnitz *et al.*, 2007). This exploratory behaviour is of high importance for pigs and that is why access to rooting material improves the welfare of the domestic pigs. According to the Swedish animal welfare legislation all pigs should have access to straw or an equal litter material with good hygienic quality and in such amount that their exploratory behaviour can be met (SJVFS 2010:15). In an indoor pen for rearing pigs the opportunity to root is strongly limited, but studies have shown that if rooting is prevented, for example by a nose ring, other exploratory behaviour will increase instead (Studnitz *et al.*, 2003). If pigs also were prevented to perform other exploratory behaviour, like chewing and manipulating rooting material, an increase in abnormal behaviour can be seen. Access to rooting material like straw or wood chip is known to reduce abnormal and unwanted behaviour such as manipulation of pen fittings and pen mates in growing pigs (Scott *et al.*, 2006; Jensen & Pedersen, 2010). Jensen & Pedersen (2007) studied six different rooting materials to growing pigs and showed that maize silage, compost and wood chip were preferred over chopped straw. Straw was given the lowest value as rooting material in the study. Their result confirms that pigs want a more complex and mixed rooting material.

Both hunger and curiosity can be the motivation behind rooting behaviour (Studnitz *et al.*, 2007). When growing pigs are fed restrictively during the later parts of the fattening period an increase in rooting behaviour is expected (Beattie & O'Connell, 2002). Hunger can increase the exploratory behaviour but feeding ad libitum does not eradicate the motivation to perform this behaviour. It seems to always involve some level of appetitive foraging behaviour also in ad libitum fed pigs. The curiosity to explore, search for novelty and gather information will continue as long as the pigs have the energy and no other motivation becomes higher than the motivation to explore (Studnitz *et al.*, 2007). A rooting material that is changeable, destructible (maintain the pigs curiosity) and contain edible parts (for appetitive foraging) will be interesting as a rooting material for an extended length of time and in that way satisfy the pigs' exploratory behaviour to a larger extent.

In addition to straw, roughage can be provided, which can then increase the time the pig spends eating and foraging (Olsen *et al.*, 2000). In that way their natural behaviour of exploration and foraging can be better fulfilled. Presto *et al.* (2013) concluded that additional intact silage for pigs already enriched with straw has potential to reduce some damaging social behaviour. Presto *et al.* (2009) saw that aggressive behaviours were lower in groups of pigs fed roughage than for pigs in the control group and the pigs fed roughage were more active. Except from environmental enrichment also space is of importance for fulfilling the exploratory behaviour (Beattie *et al.*, 1996).

Presto *et al*. (2013) studied if the form in which the roughage is fed affects pigs' behaviour. Feeding intact grass/clover silage separated from the commercial diet increased the time pigs spent eating compared to if the silage was chopped and mixed with the commercial feed, silage milled and pelleted together with the commercial feed or a commercial feed alone. The pigs fed intact and chopped silage were more active. A clear (but not significant) tendency was also a decrease in time spending nosing and chewing pen fittings and nosing and biting other pigs. Social interactions can also increase due to manipulation and sorting out parts in silage. The pigs fed intact silage had the lowest number of wounds on their body, which indicate that harmful social behaviour was low in that group. When comparing the group of pigs fed a commercial pelleted diet and the group of pigs fed a pelleted silage diet, the number of wounds was lower in the last group. Even if pelleted silage does not provide the opportunity to a foraging behaviour, it can affect pig behaviour to some extent, probably by the higher fiber content giving the pig a longer feeling of satiation.

Jensen & Pedersen (2010) studied the effect of feeding level and access to rooting material (wood chip) had on pigs' behaviour. Access to wood chip reduced manipulation of pen floor but no significant difference in how much the pigs manipulated the rooting material and the feeding level could be seen. On the other hand a restricted feeding gave rise to more aggression compared to ad libitum feeding. They also studied situations where the feeding space was reduced and when feeding was delayed, but the response to that was not depending on access to wood chip. A reduced feeding space increased aggressive behaviour in the restrictedly fed pigs.

Pigs' ability to digest forage

How well pigs can digest nutrients from forage depends mostly on the proportion of crude fibre (Le Goff *et al.,* 2002). The more crude fiber content, the lower is the digestibility. The digestibility of fibre also increases with the pigs' increase in age and body weight. Adult sows have good capacity to digest dietary fibre in the hindgut. In dry sows as much as 50% of the maintenance energy can be derived from roughage (Sehested *et al.,* 2000). Growing pigs should only be provided a small amount of crude fibre in their diet due to their lower digestive capacity (Wallenbeck *et al*., 2014). Due to the high content of water in roughage compared to commercial cereal feed, the nutrient density is lower and the pigs would therefore also need to consume big amounts to get the same level of nutrients (Crawley, 2015). In piglets, young growing pigs and lactating sows the nutrient concentration needs to be very high. Also the form of the silage has an impact on the silage consumption and nutrient utilization (Wallenbeck *et al.,* 2014).

Studies where growing/finishing pigs are given roughage show varying results, depending on roughage type, the botanical parts, feeding strategy and experimental design (Wallenbeck *et al.,* 2014; Hansen *et al.,* 2006, Presto *et al.,* 2009). Studies indicate that the feeding intake of roughage increases with a restricted feeding ration (Crawley, 2015). With the results from the ICOPP project the recommendation is to increase the silage inclusion to the pigs' diet through phase feeding, with approximate 10% inclusion on DM basis to growing pigs and 12-20% inclusion to finishing pigs (Crawley, 2015). This is corresponding to what they can ingest.

Roughages and silages

Legumes are a group of plants with interest as feed, due to their importance in the crop rotation with their ability to fixate nitrogen and the high crude protein content. Today new varieties have lower content of anti-nutritional substances, which inhibit some of the nutritional uptake (Wallenbeck, 2012). One should bear in mind that silage inclusion leads to increase of nitrogen and phosphorous in the manure (Crawley, 2015). A silage need to be early cut so the crude fibre content is low. Often different grass species is combined with clover or chicory. A grass and clover silage can have a crude protein content of 20-24% of DM and is a very good energy feed for sows. In a study by Hansen *et al.* (2006) the pigs ate more of a grass clover silage than a barley/pea silage on an energy level.

Red clover is a perennial legume which is easily established and useful for both pasture and silage production for pigs (Crawley, 2015). It is the most common legume in Sweden (Swedish Board of Agriculture, 2015a). It is not so persistent (2-3 years) and unfortunate susceptible to some diseases. Red clover is usually considered having high palatability as feed and increases the total feed consumption. Pigs provided red clover forage have shown to have the same good weight gain as those provided lucerne (Crawley, 2015).

Lucerne (*Medicago sativa*) with a deep tap root is drought persistent with a good sustainability and a high production (Swedish Board of Agriculture, 2015b). The crude protein is high, 15-24% (on DM basis) (Crawley, 2015). Lucerne can often be dried and milled and be included in different feed rations (Wallenbeck, 2012). However there is a higher risk of leaf losses when dried to hay compared to silage (Swedish Board of Agriculture, 2015b). A study with grazing growing pigs showed that they received a significant part of their proteins supply from the lucerne pasture (Jacobsen, 2014).

Chicory (*Cichorium intybus*) is a perennial herb (not a legume) with a deep root system, making it drought persistent (Swedish Board of Agriculture, 2015c). It can be a good complement in a forage seed mix, and give a stable and persistent ley (Wallenbeck, 2012). It has a relatively high content of lysine in the leaves, but the crude protein content is lower compared to the legumes (Crawley, 2015; Swedish Board of Agriculture, 2015c). Chicory inclusion to growing pigs has shown to favour lactobacillus in the pigs' intestinal microflora, which can give a prebiotic effect (Ivarsson, 2012). This is because of the high content of dietary fibre (40%).

Rape can also provide an excellent forage feed for pigs as well as kale and swedes (Crawley, 2015). If the rape is wet when grazed it can lead to photosensitization (sun burning) on white skinned pigs.

Effects on carcass and meat quality

A lower live weight and a lower daily gain are expected if part of the diet to finishing pigs is replaced with silage, that have earlier studies shown (Hansen *et al.,* 2006; Wallenbeck *et al.,* 2014; Crawley, 2015). Hansen *et al.,* (2006) fed a restricted organic concentrate diet (70% of the Danish recommendations) to finishing pigs with free access to two different types of silages; barley/pea or grass/clover silage. The daily gain for these pigs was 27% lower than for the pigs with a 100% conventional concentrate diet and 22% lower than pigs with 100% organic concentrate diet. The decrease in daily gain was more pronounced during the winter period compared to the summer period. The difference was also more pronounced in castrated pigs compared to the female pigs. Regarding the carcass quality pigs fed silage had a higher lean meat percentage compared to pigs fed 100% concentrate. They had therefore also a higher yield of loin, leg, leg muscles and tenderloin with a thinner layer of fat on loin and leg when corrected for slaughter weight. Pigs fed 100% concentrate had instead heavier belly parts. The amount of intramuscular fat was lower compared to 100% concentrate fed pigs. That was expected because a higher lean meat percentage is correlated to lower intramuscular fat.

In a study by Wallenbeck *et al.* (2014) growing/finishing pigs were fed a grass/clover silage corresponding to 20% of their metabolizable energy basis in the diet. The weight gain was only 5-15% lower compared to a control diet. The grass/clover silage was given in three different forms; intact silage fed separately, chopped silage mixed with commercial feed, and milled silage pelleted with the commercial feed (where all silage would be totally consumed). The pigs fed the control diet had the highest daily weight gain, and the pigs fed pelleted silage had the second highest daily weight gain. Pigs fed chopped and mixed silage had the lowest killing-out percentage. The lean meat percentage was higher on pigs in the intact silage treatment compared to the pelleted silage treatment and the control treatment.

In non-ruminant animals, like pigs, the portion of unsaturated fatty acids in the meat can quite easily be increased by increasing the unsaturated fatty acids in the pig's diet (Warriss, 2010). An increase in the proportion of polyunsaturated fatty acids in meat is often of interest due to its positive health aspect for humans. But there is a problem with unsaturated fatty acids, they are more sensitive to lipid oxidation and the compound derived from it can cause rancidity and other off-flavours both in cooked and uncooked meat. Meat processing, packing procedure and storage temperature affect the propensity of lipid oxidation and can therefore be adapt to inhibit undesired oxidation. Hansen *et al.* (2006) showed that the pigs fed silage had a higher value of metabolites from lipid oxidation as a result of the higher intake of polyunsaturated fatty acids. When analysing the fatty acid composition in the back fat of the pigs Hansen *et al.* found a lower content of saturated fatty acids (-2%) and a higher content of polyunsaturated fatty acids (2-3%) in pigs fed silage, which the scientists feared could be a problem in the further meat processing.

Towards a more sustainable pig feed production

To achieve a more sustainable animal production, recycling of nutrients is of major importance (Wallenbeck *et al.*, 2014). This is especially important in organic production but also in conventional production. To use locally produced feed stuff for the animals is one way to improve this. Legumes' ability to fixate nitrogen from the air is a well-used and appreciated attribute, and organic crop production relies on legumes for their nitrogen supply to the soil when fertilizers are not permitted. Forage production, which often combines grass cultivation with legumes, has several positive aspects in a crop rotation (Wallenbeck, 2012). A crop rotation with forage is good as preventive weed and pest control and for plant diseases. A forage production has a high potential to provide pig farmers with both protein feed and roughage and hopefully in the future it can be more frequently used also at pig farms. A feeding system including forage could be beneficial economically as well due to it can reduce the overall feeding cost, especially for organic supplementary feeding concentrates (Crawley, 2015). Finally, to provide also conventionally reared pigs some access to forage of some kind can give them behavioural enrichment and overall improve animal welfare (Presto *et al*,. 2013).

Materials and Methods

This study was performed at the Swedish Livestock Research Centre at Funbo Lövsta outside Uppsala, Sweden. The experiment started the 14^{th} of July and ended 15^{th} of August 2014. The pigs were sent to slaughter at the Lövsta slaughterhouse close to the Research Centre. The slaughterhouse is owned by the Swedish University of Agriculture Science and run by the company Lövsta Kött.

The pig herd at the Research Centre is from a Specific Pathogen Free (SPF) production and have a high health status. This means that the herd is free from several microorganisms that cause diseases such as salmonella, scabies, pleuropneumonia, swine enzootic pneumonia (SEP), swine influenza, swine dysentery, ileitis (*Lawsonia intracellularis*) and atrophic rhinitis (Granert, 2013). SPF pigs have a high daily weight gain and will therefore reach slaughter weight at an earlier age (Wallgren *et al.*, 2012).

Animals, housing and feeding

The study included 72 growing/finishing pigs from one production batch (nine birth litters) which were born and reared at the same facility. Half of the pigs were a cross breed between Yorkshire x Hampshire (YxH) from four litters and the other half of Yorkshire x Duroc (YxD) from five litters. At weaning (five weeks of age) the piglets were regrouped to avoid harmful fights at an older age in the farrowing unit. At nine weeks of age and a live weight of approximately 30 kg the pigs were moved to a rearing stable, where they were distributed to 18 pens with four pigs per pen. Each pen consisted of two females and two males, one sex of each cross breed (two YxH and two YxD). The male pigs were immunocastrated with Improvac™ with the first injection at 11 weeks and a second at 15 weeks of age. The pen had concrete floor in the lying and feeding area and a slatted dunging area (1/3 of the pen area). In the slatted area there were gates of metal bars to the pen neighbours. In the lying area the partitions were solid walls. A rack for silage was placed at the solid wall in the lying area. The feed trough was placed along the short side in lying area and had a length of 1.8 m. One water nipple was placed in the slatted area. The lying area was 1.8 m x 2.2 m and the slatted area was 1.8 m x 1.0 m. The pen's total area was then 5.76 m^2, giving an area of 1.44 m^2 per pig. The formation of the pen is shown in Figure 1. All pigs had access to straw and the pens were cleaned daily.

Figure 1. The formation of the pen with silage rack at the right pen wall in the lying area, feed trough in the front of the pen and slatted area in the back of the pen.

All pigs were fed a wet commercial cereal-based feed three times a day (Origo from the feed company Lantmännen). The nutritional value of the dry feed is shown in Table 1. (Lantmännen, 2015). The time for feedings differed from day to day, but occurred in the midmorning, afternoon and evening (generally between 8-10, 14-16, 17-22 o' clock). The feeding system is fully automatic and is monitored by a computer. The feed ration provided 22.3 MJ NE/day.

Table 1. The nutrient composition and energy value in the dry commercial feed (before mixed with water).

	Commercial feed
Dry matter (DM), %	87
NE, MJ/kg	9.3
Crude protein (CP), g/kg	135
Crude fat, g/kg	38
Ash, g/kg	45
Crude fibre, g/kg	56

When the experiment started the growing/finishing pigs had reached a live weight of approximately 80 kg (mean ± std; 81.5 ± 8.03 kg) and an age of four months (16-17 weeks). When the experiment ended and the pigs were send to slaughter, they had a live weight at approximately 110 kg (mean ± std; 108.6 ±10.0 kg) and an age of five months (20-21 weeks). The pigs' carcass weights and meat percentages were collected from the slaughterhouse. One pig of the 72 was taken out from one pen and placed in a sick pen before the experiment started due to tail biting. This pig was not included in the behaviour study, but was included in the production performance data.

Experimental design and treatments

The experiment included three treatment; chicory silage (CH), red clover silage (RC) and control (C). The pigs in the chicory and the red clover treatment were only given 80% of the recommended feed ration of the commercial feed, i.e. 17.9 MJ NE/day and given free access to either a silage of chicory or a silage of red clover. The whole crop (stem, leaf and flower) silage was composed by 100% chicory or 100% red clover. The silages were the first cut, harvested in June the same year. In this study the aim was to evaluate pure chicory and pure red clover, even though silage on farm level always is a combination of both grass and legumes/herbs. The variation in those combinations varies widely, with a pure silage of chicory or red clover the effect of the combinations in silage can be excluded (% in silage). The nutritional composition of the silages were analysed and are presented in Table 2 (Andersson, 2015, pers. comm.).

Table 2. The nutritional composition of the chicory and the red clover silage.

	Chicory silage	Red clover silage
DM, %	26.3	29.6
Ash, % of DM	11.4	8.8
Crude protein, % of DM	16.2	15.8
Crude fibre, % of DM	23.1	24.4

The control treatment was only given the commercial feed and 100 % of the recommended feed ration. No silage residues were collected and weighed. The distribution of the treatments in the rearing stable is shown in Figure 2.

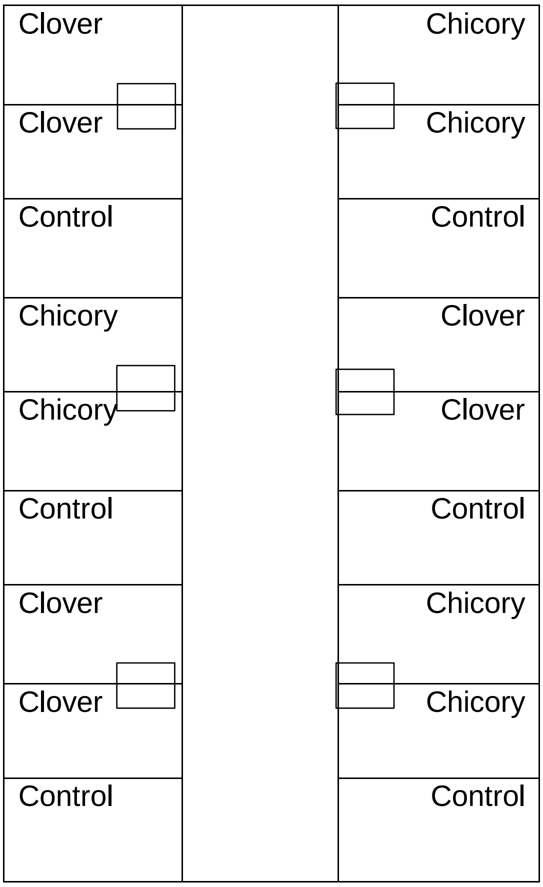

Figure 2. A sketch over the 18 pens in the rearing stable with distributed treatments. Squares represent silage racks.

Behaviour observations

All pens had a camera device installed that recorded the pigs day and night throughout the experiment. The behaviour observations were made from the recorded video material and all observations were made by the same person. The pigs were observed two consecutive days at two occasions during the experiment. First occasion was in beginning of the experiment, 24th and 25th of July (week 2 of the experiment), and the second in the end of the experiment, 7th and 8th of August (week 4 of the experiment). To estimate the pigs' time budget (how the pigs spend their time), an instantaneous scan sampling was done every hour during daytime, 07.00 – 19.00 o'clock. The reason for the choice to do scan sampling only daytime was that the pigs were more active then compared to nighttime, when the majority of the pigs were only sleeping. At each scan sample the activity, body posture and location in the pen were registered. The definitions of the activity behaviours, body postures and the location of the pen are described in an ethogram in Table 3.

Table 3. Ethogram of behaviours of pigs in the video recordings.

Category	Variable	Definition
Scan sampling		
Body posture	Lying on the side	Lying on the side, head on the side
	Lying on the belly	Lying on the belly, with head in a nearly vertical position, front legs not outspread to the side
	Sitting	Front feet on the ground, back legs in lying position
	Standing	Standing or walking on all four feet
Location in pen	Lying area	In the lying area
	Slatted area	At least one leg on the slatted area
Activity	Eating feed	Snout in feed trough
	Eating silage	Snout touching silage rack
	Drinking	Snout touching water nipple
	Nosing/rooting pen floor	Snout touching pen floor (also slatted floor)
	Nosing/biting pen fitting	Snout touching pen fitting
	Nosing/biting other pig	Snout touching other pig (If nosing on other pig in other pen, it will not be register as nosing pen fitting) (If two pigs are fighting it will be register as two nosing events even if one of the snouts is not touching the other one)
	Nothing	Snout in air (If snout happens to touch something while the pig is sleeping it is defined as nothing)
Continuous sampling		
Performing pig	Nosing	Snout touching other pig
	Nibbling/biting	A pig nibbles or bite another pig
	Tail biting	Having another pig's tail in the mouth
	Head knock	Approaching other pig with rapid head movement and open mouth
	Climbing	At least one hoof/leg on the top of another pig
	Riding	A pig is mounting another pig
	Lifting	Snout under the body of another pig and lifting upwards
	Pushing	Pushing another pig with any part of the body in order to displace it, no biting
	Belly massage	A pig massaging another pig's belly or throat
	Biting pen fitting	Biting pen fitting
	Eating/rooting silage	Eating silage and rooting close to the silage rack (a pause for at least 20 seconds is consider as new rooting behaviour)
Receiving pig	No reaction	No change in body position or activity of the receiving pig
	Avoiding	Pig or pig's head turning/moving away from the performing pig
	Return approach	Receiving pig approaching the performing pig with head/snout
	Other pen	Receiving pig is from other pen, no reaction recorded

Social interactions were observed and recorded continuously for 5 minutes three times per day on the same days as the scan sampling. These three occasions occurred 11.15, 13.45 and 17.30 o'clock, to avoid collidation with feeding. The social interaction is divided in a performing pig and a receiving pig, because the severity of a behaviour depends on how it is being received (Presto *et al.*, 2013). A part from social behaviour, eating and rooting silage and biting pen fittings were also registered in the continuous observations. Except from being of big interest in this study, these behaviours could have low frequency and therefore be better to analyse with continuous observations. In the silage treatment pens, pigs were marked with individual numbers on the back. In those pens the identity of the performing and the receiving pig were recorded. The definitions of the social interactions in the continuous sampling are described in the ethogram in Table 3.

Statistical analyses

Statistical analyses were performed in SAS software, version 9.2 (SAS, 1990). Descriptive statistics were calculated with the procedure FREQ and MEANS and the analysis of variance (ANOVA) with the procedure GLM. Only variables that had adequate variation and a normal or approximately normal distribution were analysed with ANOVA, other interesting variables are presented with descriptive statistics. Residuals of the variables in the ANOVA analyses were examined for normal distribution using PROC UNIVARIATE, where the Shapiro-Wilks test for normality and normal probability plot were considered.

Differences in pigs' time budget and social interactions between treatments were analysed with a model including the fixed effects of treatment (CH, RC, C), week (2, 4), time, date nested within week and box nested within treatment. The parameters lying on belly and lying on side in time budget were added together and named "lying down". The interaction between treatment and week and the interaction between treatment and time were also examined in time budget and social interactions. Those interactions were not significant for any of the variables and thus not included in the statistical model.

Differences in social interactions between genotypes and between genders were analysed with a model including the fixed effect of treatment (CH, RC, C), gender (male, female), genotype (YxD, YxH) and box nested within treatment. All social interaction parameters from the performing pig except nosing were added together and named "severe social interactions".

The production performance variables of the study were not analysed in this master thesis, instead the results from the statistical analyses from Andersson *et al.* (2014) are presented as previous results.

Results

Time budget

The pigs spent on average 70.4% of the daytime (7.00-19.00 o'clock) lying down (both on side and on belly). 71.9% of the time the pigs had their snout in the air, i.e. no specific activity, and 11.4% of the time they were nosing/rooting on pen floor. There were significant differences between treatments in time budget, see Figure 3 for body position and location in the pen and Figure 4 for activity.

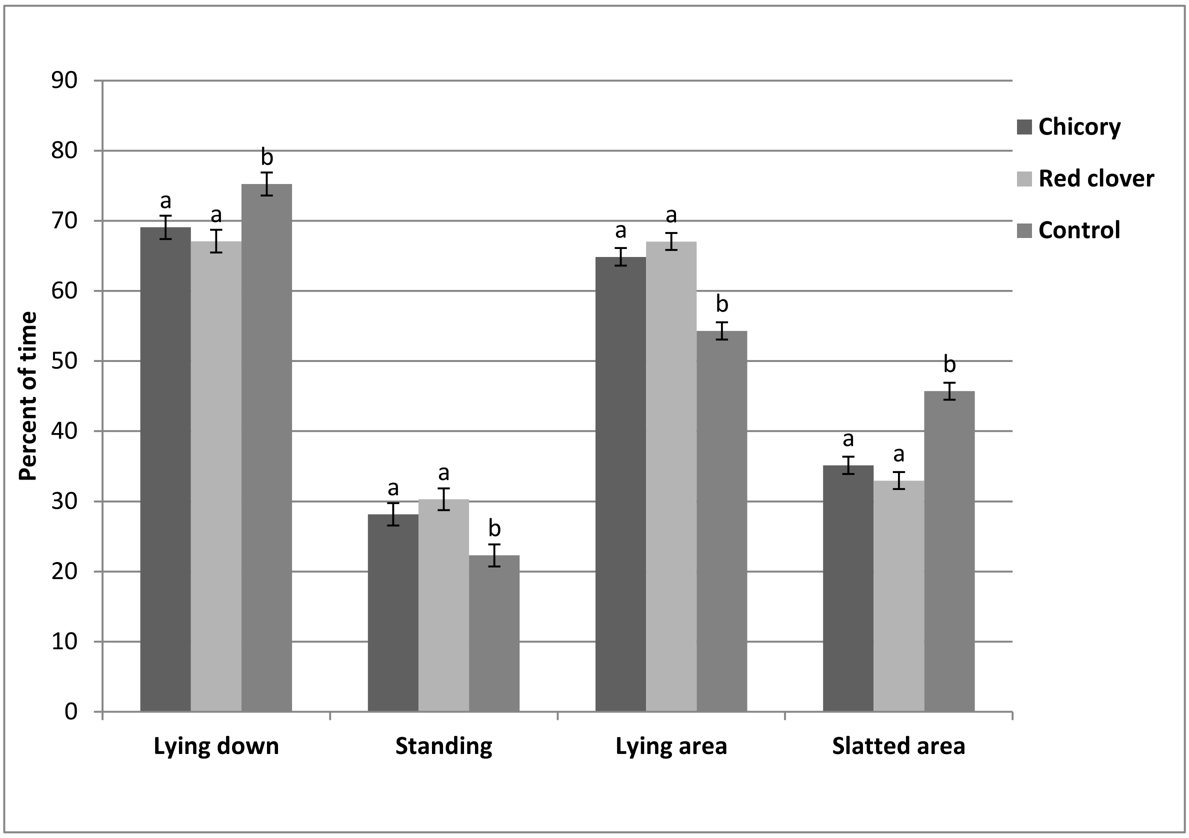

Figure 3. Proportion (%) of time that pigs in treatment CH, RC and C spent on lying down, standing and located in lying area vs. slatted area.(Least squares means ± standard error. Different letters (a, b) indicate pair-wise differences at p< 0.05).

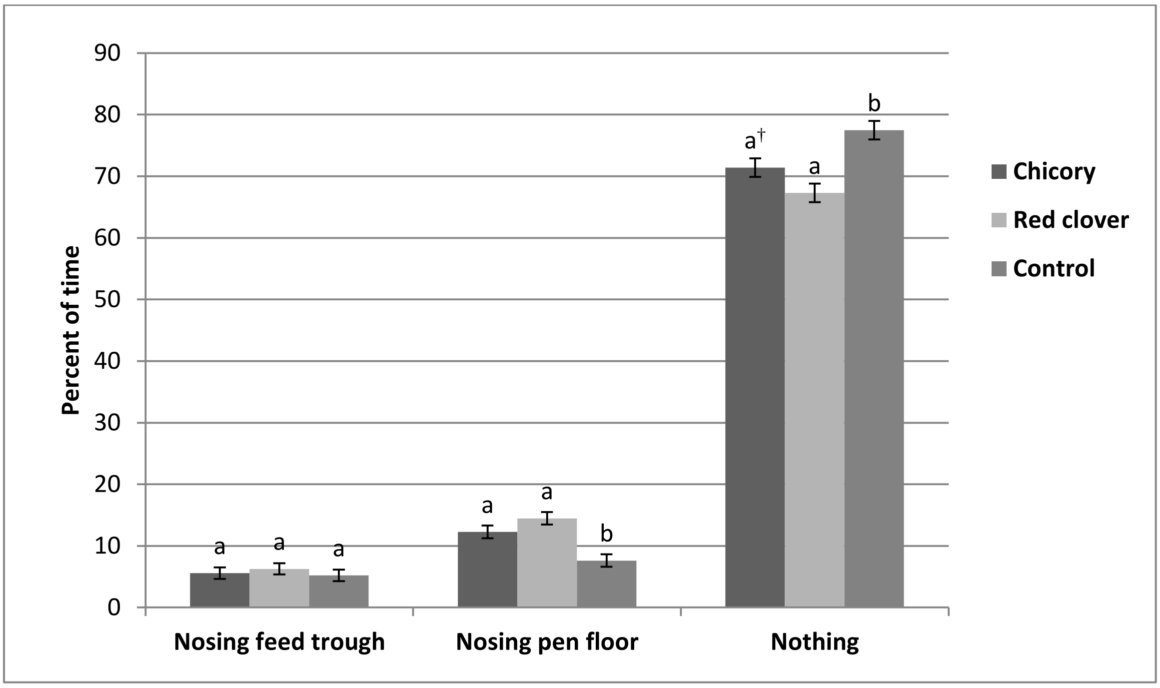

Figure 4. Proportion (%) of time that pigs in treatment CH, RC and C spent on nosing/eating in feed trough, nosing/rooting on pen floor and nothing (snout in air). (Least squares means ± standard error. Different letters (a, b) indicate pair-wise differences at p< 0.05. †: p<0.10).

Pigs in control treatment spent more of their time lying down and less time standing compared to the two silage treatments. They also spent a larger proportion of the time (77.5% vs. 71.4% (CH) and 67.3% (RC)) where they did not do any activity (nothing). This may imply that the control pigs with no access to silage were more inactive than the pigs that were given silage. There were no differences between pigs given chicory silage and pigs given red clover silage in body posture or pen location. Pigs in the control treatment spent less time in the lying area and thus more in the slatted area compared to CH and RC pigs. There was a tendency that CH pigs had a higher proportion of no activity compared to RC pigs (marked with † in Figure 4.). Otherwise there were no differences between the CH and RC treatments. Control pigs spent less time nosing/rooting in the straw on the pen floor than the pigs in the other treatments, which had some silage to manipulate on the pen floor. The time pigs spent nosing in feed trough did not differ between treatments.

There was no difference in how much of the time the pigs were lying down between the first observation occasion and the second (week 2 vs. week 4). There was also no difference in time spent nose/rooting on pen floor between the two observation occasions. In week 4 the pigs increased the time spent on nosing in feed trough ($p<0.001$, LSM ± SEM; 3.312 ± 0.764 (w. 2) vs. 8.066 ± 0.739 (w.4)) and decreased the time spent on no activity ($p<0.05$, LSM ± SEM; 73.850 ± 1.250 (w. 2) vs. 70.264 ± 1.210 (w. 4)). The time spent in the slatted area decreased from week 2 to week 4 ($p<0.001$, LSM ± SEM; 42.944 ±1.015 (w. 2) vs. 32.924 ± 0.982 (w. 4)), which is probably mainly explained by the increase in the pigs' body size.

In Figure 5 the pigs' body posture lying down and the activity nosing/rooting on pen floor are shown in relation to the time of the day. The results indicate an activity increase around the feeding events.

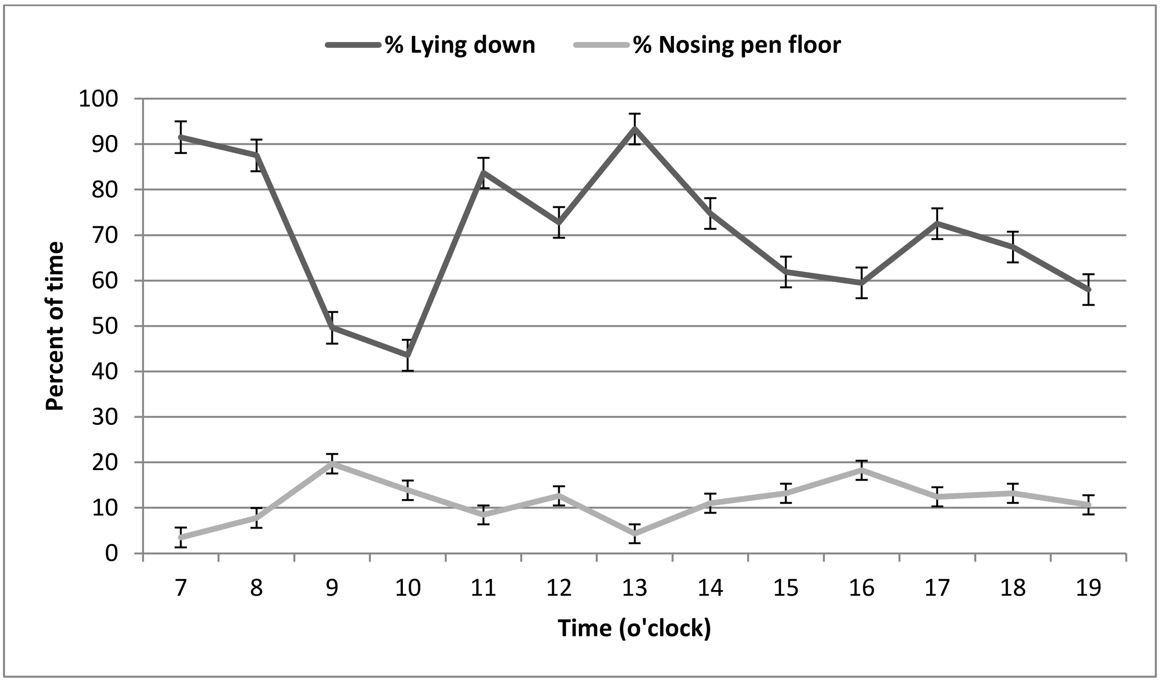

Figure 5. Proportion (%) of time (least squares means ± standard error) that pigs spent lying down and nosing/rooting pen floor during the day.

Behaviour like sitting, eating silage, drinking water, nosing/biting pen fitting and nosing other pig made up a too small proportion of the pigs' time budget (less than 4.4%) to be able to be analysed with ANOVA, i.e. not normally distributed. In Table 4 eating silage, nose/biting pen fitting and nose/biting other pig are presented with mean proportions. The control pigs had the highest proportion of time nosing/biting pen fitting.

Table 4. Mean values (mean ± standard deviation) of proportion (%) of time pigs in CH, RC and C treatment spent on three activities.

	Chicory	Red clover	Control
Eating silage	4.4 ± 10.6%	4.7 ± 11.1%	-
Nose/bite pen fitting	1.2 ± 6.0%	1.5 ± 5.9%	3.8 ± 9.8%
Nose/bite other pig	4.3 ± 10.5%	4.4 ± 11.8%	4.4 ± 11.0%

Social interactions

Total number of social interactions and the behaviours eating silage and biting pen fitting that were observed during the continuous sampling are presented in Table 5. The observations were divided with total number of pigs in each treatment. The total number of social interactions was highest in the control group and the most common interaction in all three treatments was nosing on other pig. The control group had the highest number of biting pen fitting also in this sampling. The total time of the continuous observations was 1 hour in each pen (5 min x 3 times a day x 4 days in total).

Table 5. Total number of social interactions (and two behaviour) per pig on altogether 1 hour of continuous sampling in CH, RC and C treatment.

	Chicory	Red clover	Control
Nosing	9.33	9.70	11.29
Bite/nibbling	0.96	0.35	1.25
Tail biting	0.13	0.09	0.29
Head knock	1.42	0.44	0.29
Climbing	0.38	0.52	0.38
Riding	0	0	0
Lifting	0.08	0.22	0.17
Pushing	1.04	1.35	0.71
Belly massage	0.04	0.17	0.04
Rooting/eating silage	5.33	4.83	-
Biting pen fitting	0.92	0.52	2.58
Total social interactions*	13.38	12.83	14.42

* The number of total social interactions does not include the number of rooting/eating silage or biting pen fitting.

In Figure 6 the response of the receiving pig to a performed behaviour is shown in percentage of all reactions to that behaviour. To nosing the most common response was no reaction. The response to more severe social interactions, like biting, nibbling, head knock and pushing the avoiding response and return approach made out a larger part.

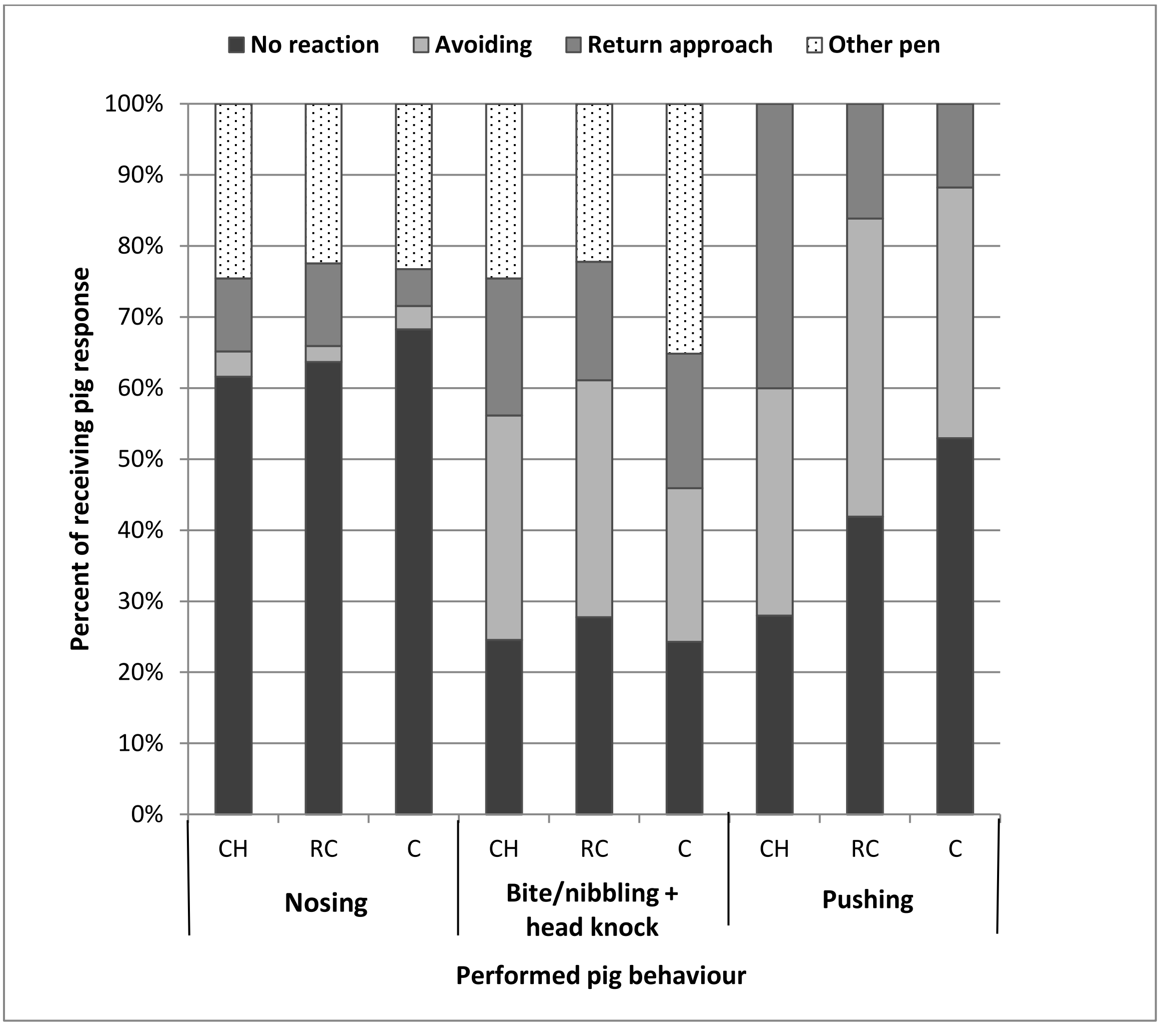

Figure 6. Proportion (%) of the reaction by the receiving pig in the CH, RC and C treatment when received the behaviour nosing, bite/nibbling together with head knock, and pushing.

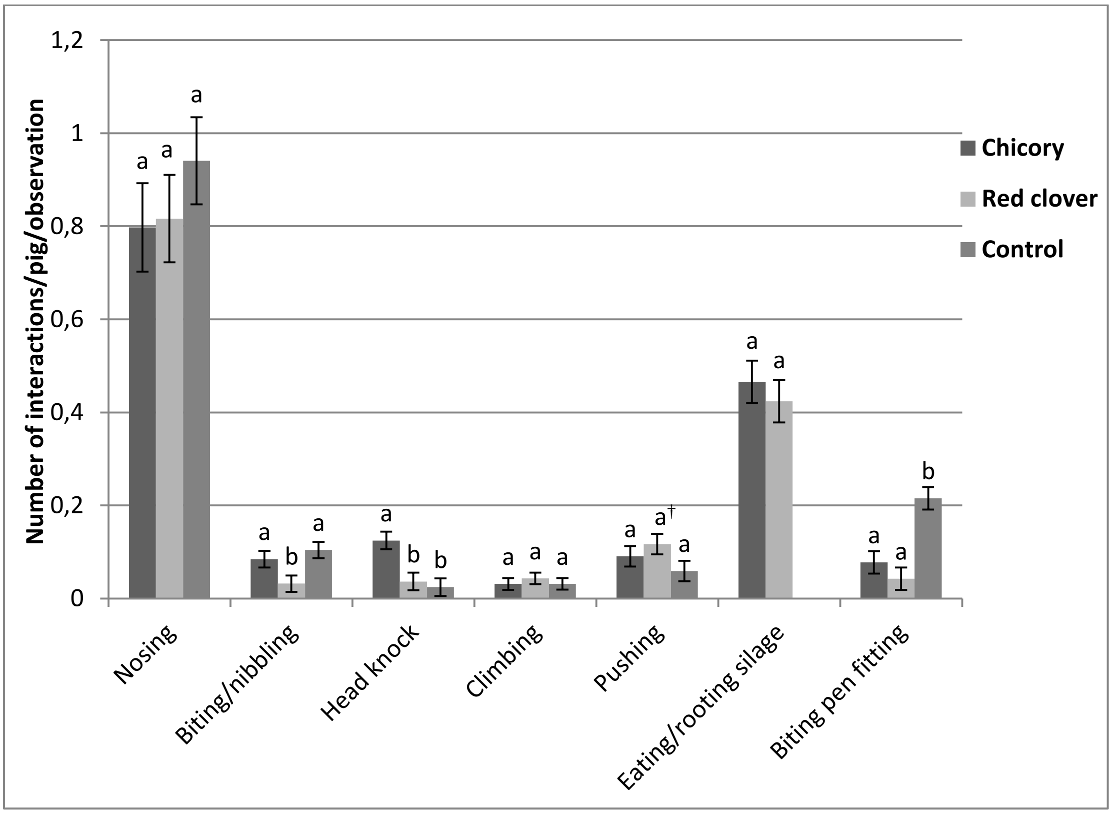

Figure 7. Number of interactions (or behaviour) per pig per continuous observation (a´ 5 min). (Least squares means ± standard error. Different letters (a, b) indicate pair-wise differences at p< 0.05).

In Figure 7 least squares means and standard errors for the social interactions, eating/rooting silage and biting pen fitting are presented. Tail biting, riding (never occurred), lifting and belly massage had a very low frequency and are therefore not normally distributed and not analysed further. There were no significant differences in how much nosing on other pigs, climbing and pushing the pigs did between treatments. There was a tendency (p= 0.064) that RC pigs pushed more often than C pigs. There was less biting and nibbling in RC treatment and more head knocks in CH treatment compared to other treatments. The control pigs clearly bit more in pen fittings than the other pigs (p<0.001), which was also indicated in the time budget results. The number of times the pigs were eating and rooting silage did not differ between the two silage treatments.

In the response of the receiving pig no significant differences could be seen between treatments. Only a tendency (p= 0.058, LSM ± SEM; 0.161 ± 0.030 (CH) vs. 0.080 ± 0.030 (C)) that CH pigs had a bit higher number of return approach than C pigs was seen.

Differences between first observation occasion and the second (week 2 and week 4) are presented in Figure 8. The number of biting and nibblings decreased to week 4, as well as head knocks seems to have done (tendency, p=0.085). Climbing increased, probably mainly due to the pigs' increase in body size and that they more easily walked on each other when moving around in the pen. There was also a tendency (p=0.078) that eating silage decreased in week 4 compared to week 2. The return approach response on a social interaction was decreasing in number to week 4 (p=0.032, LSM ± SEM; 0.160 ± 0.024 (w.2) vs. 0.085 ± 0.024 (w.4)).

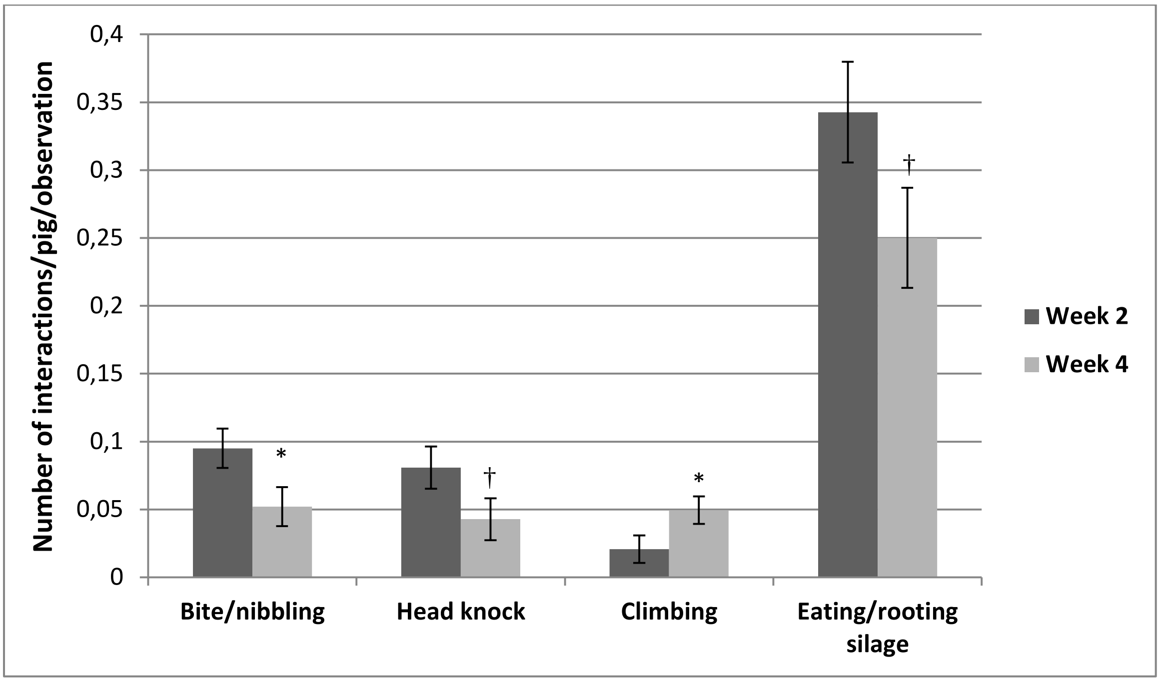

*Figure 8. Number of interactions (or behaviour) per pig per continuous observation (a´ 5 min) in week 2 and week 4. (Least squares means ± standard error. * indicate pair-wise differences at p< 0.05, †: p<0.10).*

Considering the time of the day (11.15, 13.45, 17.30 o'clock) quite many differences could be seen. For example nosing occurred more often in the evening (17.30) than the midmorning (11.15), head knock was most common at lunch time (13.45), more climbing in the evening and less pushing in the midmorning. Biting pen fitting occurred more often in the evening. On the other hand there was no difference in eating silage, that occurred evenly during the day. Considering the total number of interactions all three treatments had the lowest number in the midmorning, this can be explained by 83.7% of the pigs is lying down around this time (11.00 o'clock).

Genotype and gender

The number of social interactions, biting pen fitting and eating/rooting silage in the continuous sampling in the two silage treatments were analysed also from a gender and from a cross breed (YxD or YxH) perspective. The differences that were found in gender are presented in Figure 9. Female pigs had a higher number of nosing interactions as well as total number of social interactions. When the females were the receiving pig the return approach was more frequent than for the male pigs. Only one difference (a tendency, p=0.056) was found between genotypes; the number of severe interactions was higher in Duroc cross breed compare to Hampshire cross breed (LSM ± SEM; 4.479 ± 0.591 (YxD) vs. 2.899 ± 0.529 (YxH)). Severe interaction, a new variable in this analyse, was all social interactions registered according to the ethogram (Table 3, continuous sampling) added together minus nosing (biting/nibbling + tail biting + head knock + climbing + riding + lifting + pushing+ belly massage). In this analyse with only silage treatments, a significant difference could be seen in the behaviour biting pen fitting between the chicory and the red clover treatment. The chicory treatment had higher number of biting of pen fitting in 1 hour continuous observation compared to red clover treatment (LSM ± SEM; 0.913 ± 0.133 vs. 0.352 ± 0.148, p<0.01). There was once again no difference in number of times the pigs ate or rooted in silage between the two silage treatments.

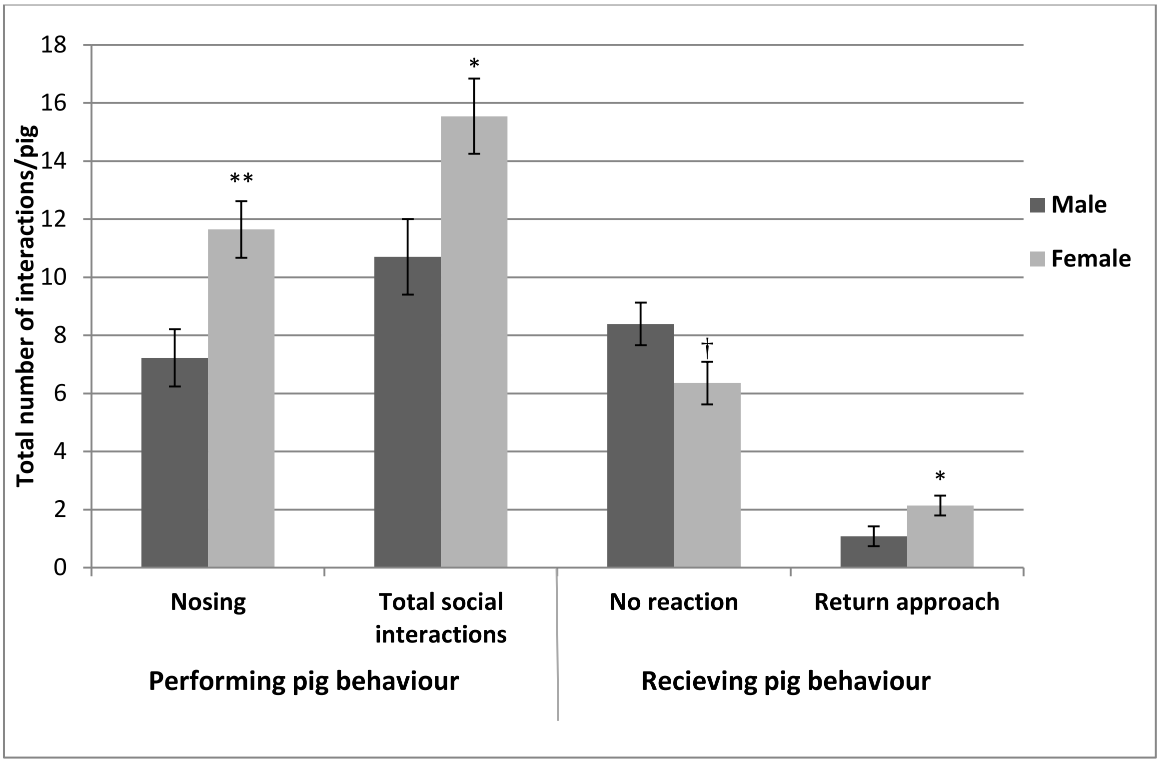

*Figure 9. Total number of interactions per pig on altogether 1 hour of continuous sampling depending on gender. (Least squares means ± standard error. * indicate pair-wise differences at p< 0.05, † indicates p<0.1).*

Previous Results -Production performance

Another part of this study was the production performance of the pigs, but the analyse and the results from that are not part of this master thesis. Andersson *et al.* (2014) have analysed the production performance and presented them in the ICOPP synthesis report. The following results are from that report and are chosen to be included in the master thesis because of the results together with the behaviour results of the study will give a better view of the use of red clover and chicory silage to growing/finishing pigs. Andersson *et al.* saw that the daily gain of the pigs were lower in the silage treatments compared to the control treatment (0.813 kg/day (CH) and 0.860 kg/day (RC) vs. 0.960 kg/day (C) (Andersson, 2015, pers. comm.). The daily gain was 16% lower in the chicory treatment and 10% lower in the red clover treatment. This is to be compared with the commercial feed allowance was 20% lower in the silage treatments. This indicates that the red clover and chicory silages contributed with energy and nutrients to the growing/finishing pigs, where red clover silage seems to have provided nutrient in a better way. As no residues were collected and weighed, the silage consumption is not known. The feed conversion rate (FCR) (kg commercial feed/kg gain) was lowest in the red clover treatment (2.23 kg/kg growth). No differences were found in growth between genotype (YxH or YxD) or gender. Carcass quality was also analysed and presented in the report. Andersson *et al.* saw that carcass weight was lower in the chicory treatment compared to red clover and control treatment ($p=0.027$) and that the killing-out percentage was higher in control group compared to the silage treatments ($p=0.007$). The lean meat percentage did not differ between any of the treatments.

Discussion

This study confirms that today's domestic pigs reared in indoor pens are to a large extent inactive and resting/sleeping during the day (Morrison *et al.*, 2007). The pigs were lying down 70% of the daytime and were rooting/nosing in the litter material on the pen floor only 11% of the daytime. A contributing factor to the high proportion of inactiveness in this study could also have been the hot summer this year. Due to high temperature outside during this experiment period the ventilation system in the rearing stable did not manage to keep the inside temperature as low as desirable. According to the staff the pigs were quite drowsy by the heat.

Access to silage of some kind has shown to make the pigs more active both in this study and in earlier studies (Presto *et al.*, 2009). Pigs in the control treatment spent more of their time lying down, less time nosing/rooting on pen floor and had a higher proportion of being inactive compared to the pigs given silage. Regarding rooting on pen floor, probably the chopped straw did not maintain the pigs' curiosity and search for novelty as much as for the pigs that also had some chicory or red clover silage dragged out on the pen floor. The silage seems to have offered a higher opportunity to perform foraging and rooting behaviour. In the control treatment biting in pen fittings was significant higher compared to the other two treatments and it is likely that those pigs redirected some of their exploratory behaviour towards pen fittings instead. The control pigs spent 3.8% (± 9.8%) of the daytime nosing and biting on pen fittings. Also Presto *et al.* (2013) could see a tendency that biting pen fittings decreased with access to silage. This is probably also an explanation to the difference in the pigs' location in the control treatment compared to the silage treatments. Pigs in the control treatment spent more time on the slatted area. In the slatted area the gates of metal bars are located, where the majority of the biting of pen fittings occurred. It is also in the slatted area where the pigs can have social interactions with pigs from other pens. Another possible explanation might have been that some pigs drink water/play with water at the water nipple in the slatted area as a redirected foraging behaviour, but this is not seen in the proportion of the time spend drinking. The time spent drinking is similar in all treatments.

The pigs in the control treatment did not seem to have redirected some of the exploratory behaviour towards other pigs. Considering the total number of social interactions it was highest in the control group but no significant difference was seen in number of nosings between treatments. This study did not show any incentive to a more aggressive behaviour in the control treatment compared to the silage treatments. Instead a significant difference was found in number of head knocks, a type of aggressive behaviour, where the chicory treatment had higher number of head knocks compared to the other treatments. Between chicory treatment and control treatment there was no difference in number of biting/nibblings, but in the red clover treatment number of bitings/nibblings was lower. In the receiving pig response no significant differences were found either. But once more there was a tendency that the chicory treatment had higher proportion of return approach to a performed behaviour. A return approach is to account as a more severe response. One likely explanation for these results is probably that the feeding space around the silage rack could sometimes have been limited when several pigs wanted to eat silage at the same time. Jensen & Pedersen (2010) reported that a reduced feeding space increased aggressive behaviour. There could also have been some competition for sorting out the most desirable part of the silage. This is probably the case in the chicory treatment. According to the staff subjective observations, there were more silage residues in the chicory treatment compared to the red clover treatment. In the study of Wallenbeck *et al.* (2014) it was discover that many of the silage residues were chewed on and that the most easily digestible parts probably were chosen first. The proportion of leaf and stem determine the digestibility (Ivarsson, 2012) and chicory have quite much stems compared to red clover. Other possible aspects to more residues could have been the result of the ensiling process. Jensen & Pedersen (2010) also showed that a restricted feeding gave rise to more aggression compare to *ad libitum* feeding. The silage fed pigs had 80% of a recommended feed ration, this could have per se led to more aggressive behaviour as well. However the control pigs were not fed ad libitum either. When considering the pigs' daily gain in the different treatments, it was lowest in the chicory treatment. This indicates that those pigs probably were hungrier than the others. Red clover silage on the other hand actually gave rise to less biting and nibblings in that treatment, but a tendency to more pushing than the control treatment.

The outcome of access to silage on social interactions between the pigs is probably very much depending on the way it is presented for them, i.e. the silage composition, the form of it, the serving place and access. The animal density with only four pigs in each pen (but with a smaller pen) may influence social behaviour compared to a normal production stable with more pigs in each pen. Presto *et al.* (2013) found that the pigs fed intact silage had the lowest number of wounds on their bodies (compared to the pigs fed chopped silage mixed with feed and control group), indicating that harmful social interactions were lowest in that group. The pelleted fed pigs in that study showed a tendency to stronger approach reactions to social interactions. Presto *et al.* concluded that intact silage could further reduce damaging social behaviour.

If comparing social behaviour in the beginning and in the end of the experiment, biting/nibbling, head knock and return approach as response decreased at the end of the experiment. It seems to have been a decrease in some aggressive behaviours during the rearing time. In the study of Presto *et al.* (2013) the time spent on eating and nosing other pigs decreased with age. This study did not show any differences in nosing other pig or rooting on pen floor over time, but there was a tendency to a decrease in eating silage in the second observation occasion. Maybe the silage lost some of its novelty over time. The time spent on nosing in feed trough did on the other hand increase so the pigs probably felt an increased hunger. Maybe that could be a reason for the increase in activity in the pigs' time budget in the end of the experiment. One should also have in mind that the experiment was performed during the last month of the rearing time of the pigs and it would therefore be reasonably to be less pronounced differences in behaviour compared to a longer experiment period.

The genotype analysis on social interactions did not show any significant differences. However Duroc cross pigs showed a tendency to perform more severe social interactions than Hampshire cross pigs, which is probably explained by the characteristics of the Duroc breed.

A more surprising result was that female pigs were more socially active and had a higher number of return approach as receiving behaviour compared to the castrated male pigs. The female pigs probably started to approach sexual maturity in this later rearing period which influenced their social behavior, especially towards males. In nature, female pigs force the male relatives away from the group when they approach sexual maturity. This is also reasoned to be one of the reasons for females performing more tail biting behavior than male pigs (Keeling *et al.*, 2012).

So which silage gave the best results? The number of times the pigs rooted/ate silage did not differ between the silage treatments. Presto *et al.* (2009) did not find any differences in time spent eating the three different silages either in that experiment. According to the production performance the pigs in the red clover treatment had a better daily gain than the pigs in the chicory treatment. Does the amount of eaten silage differ a lot or is it easier to digest red clover compared to chicory? It could be a combination of both, but there were more silage residues of the chicory silage so probably the silage consumption differed. As a result of the lower daily gain, the slaughter weight of the pigs in chicory treatment was lower compared to the other two treatments. One interesting trial would be to increase the commercial feed allowance to 90% of the recommended feed ration. Would it then be possible that the daily gain of those pigs could be the same as the daily gain of the control pigs, especially with red clover silage? In that case the FCR would still be improved and the slaughter weight and killing-out percentage maintained at high levels. Wallenbeck *et al.* (2014) showed that much of the daily gain can be improved only by the form of the silage (mostly depending on consumption).

Except from production performance red clover silage showed some more advantages. It reduced biting in pen fittings more than chicory silage, it tended to stimulate activity more and lead to a calmer social behaviour (less head knocks and bitings) than chicory silage.

Both silages contributed with energy and protein to the growth of the pigs. In excess of that both silages decreased the unwanted behaviour biting pen fittings, stimulated the pigs to be more active and locate the pigs to the lying area in a larger extent, red clover and chicory silage have an important role in crop rotations in the agriculture land, especially red clover with its nitrogen fixation ability.

Conclusion

Pigs with access to silage are more active and spend more time rooting in silage and the rooting material on the pen floor compared to pigs without access to silage. They also bite pen fittings significantly less. Access to silage does not on the other hand influence the number of social interactions between the pigs. The study did not show a reduction of aggressive behaviour when feeding silage to growing/finishing pigs. Depended on the circumstances around feeding and silage composition/form, social interactions can be influenced in different ways, some aggressive behaviour may even increase. The conclusion of this study is that even in this already enriched pig production system the animal welfare can be improved, by given a more meaningful occupation than pen manipulation. Both chicory and red clover silage do contribute to the pigs' energy and protein supply, but red clover silage gives a better daily gain and also has higher potential as roughage to improve the growing/finishing pigs' welfare.

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