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Difference in health and behaviour between two different pig line crosses

Skillnad i hälsa och beteende mellan två olika grislinje-korsningar

Jessica Vahlberg

Department of Animal Breeding and Genetics
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Jessica Vahlberg

Supervisor: Anna Wallenbeck, University of Agricultural Sciences, Department of Animal Breeding and Genetics and Department of Animal Environment and Health

Examiner: Nils Lundeheim, University of Agricultural Sciences, Department of Animal Breeding and Genetics

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Abstract

The most common housing system within the European Union for gestating sows and gilts have for many years been individual stalls while Sweden on the contrary has a long history, since the end of the 1980s, of group housing. The switch of breeding material in the beginning of the 2000ies in Sweden resulted in the end of breeding of the Swedish Yorkshire (SY), and instead the Dutch Yorkshire (ZY) was introduced to Swedish pig producers. Because the genetic selection of these two lines of Yorkshire pigs have been performed in different environments, this may have cause behavioural differences between them that may be important in group housing systems.

The overall aims of this MSc thesis study was to develop relevant protocols that could be used to record health and behaviour in pigs, but also to investigate if there are any differences in health and behaviour between the two line crosses of pigs in three different age categories; sows (N=16), piglets (N=38) and slaughter pigs (N=40) where piglets and slaughter pigs had Hampshire (H) as sire breed. The health and behaviour were recorded through direct observation on each individual focal animal. Scan sampling was used to record different variables of body posture, location in the pen and activity. Social interactions that involved the focal animals were observed continuously for five minutes for each pen. Lameness, locomotion and wounds on the body were investigated and recorded as measurements of health in the health assessment.

In general, the results showed that there were relatively few differences in behaviour and health between the different line crosses in the three different age categories. However, it was found in the health assessment that SY sows had significantly more wounds on the ears compared to ZY sows (P=0.016) and SY*H slaughter pigs had more wounds on the middle part of the body than ZY*H slaughter pigs (P=<0.0001). There was also a tendency (P=0.062) that ZY*H piglets had more wounds on the hindquarters compared to SY*H piglets. The results from scan sampling could not show any significant differences between the two different lines of sows. For piglets, significant interactions were found between line cross and age of the piglets regarding location in the pen. An interaction for slaughter pigs between line cross and group size was found regarding the body posture “standing”, were ZY*H pigs in small groups spent more time standing compared to SY*H pigs in small groups. Furthermore, the results did not show any significant differences in social behaviours between the two line crosses in the three different age categories.

The conclusion of this study is that there exist some differences between SY and ZY pigs. However, due to the small and limited data set available in this pilot study the results may not be representative for the whole population of the two line crosses of pigs and this should be considered when interpreting the results from this study.

Keywords: Swedish Yorkshire, Dutch Yorkshire, social interactions, behaviour, health

Sammanfattning

Det vanligaste inhysningssystemet inom den Europeiska unionen (EU) för dräktiga suggor och gyltor har i många år varit i individuella spiltor medan Sverige tvärtom har en lång historia, sedan slutet av 1980-talet, av grupphållning. Ändringen av avelsmaterial i Sverige i början på 2010-talet resulterade i att avelsarbetet på den svenska Yorkshiren (SY) lades ner och istället introducerades den holländska Yorkshiren (ZY) för de svenska grisproducenterna. Eftersom den genetiska selektionen av dessa två olika linjer av Yorkshirerasen har skett i olika miljöer kan detta orsaka att det finns skillnader i beteende mellan dem som kan vara viktiga i grupphållningssystem.

De övergripande målen med denna masterstudie var att utveckla relevanta protokoll som kan användas för att observera hälsa och beteende hos grisar, men också att undersöka om det finns några skillnader i hälsa och beteende mellan de två olika linjekorsningarna i tre olika åldersgrupper; sugga (N=16), smågris (N=38) och slaktgris (N=40), där smågrisarna och slaktsvinen hade Hampshire (H) som faderras. Hälsa och beteende registrerades genom direkt observation av varje individuellt fokaldjur. Scan sampling användes för att registrera olika variabler för kroppsposition, plats i boxen och aktivitet. Sociala interaktioner som involverade fokaldjuren observerades kontinuerligt i fem minuter för varje box. Rörelse hos grisen, hälta och sår på kroppen undersöktes och registrerades som mått på hälsa i hälsoundersökningen.

Generellt visade resultaten att det var relativt få skillnader i beteende och hälsa mellan de två olika linjekorsningarna i de tre olika åldersgrupperna. Det konstaterades dock i hälsoundersökningen att SY-suggor hade signifikant mer sår på öronen jämfört med ZY-suggor (P=0,016) och SY*H slaktsvin hade mer sår på kroppens mittersta del än vad ZY*H slaktsvin hade (P= <0,0001). Det fanns också en tendens (P=0,062) att ZY*H smågrisar har mer sår på bakdelen jämfört med SY*H smågrisar. Resultaten från scan sampling visade inte några signifikanta skillnader mellan de två olika linjekorsningarna av suggor. För smågrisar observerades signifikanta samspel mellan linjekorsning och åldern på smågrisarna gällande plats i boxen. För slaktsvin observerades ett signifikant samspel mellan linjekorsning och gruppstorlek gällande kroppspositionen att ”stå”, där ZY*H grisar i små grupper spenderade mer tid att stå jämfört med SY*H grisar i små grupper. Inga skillnader i sociala beteenden mellan de två olika linjekorsningarna i de tre olika åldersgrupperna kunde påvisas.

Slutsatsen av denna studie är att det finns några skillnader mellan SY och ZY grisar. På grund av den lilla och begränsade datamängden som fanns tillgänglig för pilotstudien är resultaten inte representativa för hela populationen av de två olika linjekorsningarna och detta bör beaktas vid tolkningen av resultaten från denna studie.

Nyckelord: Svensk Yorkshire, Holländsk Yorkshire, sociala interaktioner, beteende, hälsa

Preface

This Master thesis was conducted at the Department of Animal Breeding and Genetics at the Swedish University of Agricultural Sciences. A great interest in me has always been animal welfare and health, and that is one of the reasons why I started studying the Agricultural Science Programme in Animal Science to learn more about the subject. During my education, my interest in pigs has grown so when it was time to do my MSc thesis study, I was so delighted to be able to perform it on pigs and investigate their behaviour and health.

I would also like to thank the people who in any way helped me during the process:

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Abbreviations

H	Hampshire
LSM	Least square mean
SE	Standard error
Std	Standard deviation
SY	Swedish Yorkshire
ZY	Dutch Yorkshire

1 Introduction

The management of sows within the European Union (EU) has changed and there has been a transition from housing dry sows and gilts in individual stalls to group housing during the major part of the gestation period. This change has been enabled by a legislative initiative to improve the animal welfare of sows (EU Council Directive 2008/120/EC). Both housing systems has its advantages and disadvantages from an animal welfare and a production perspective. Stalls allow for individual housing of sows and gilts (McGlone *et al*., 2004), which have the benefit of protecting the animals against agonistic encounters (Anil *et al*., 2005), reduce the labour for producers, and to allow and monitor feed intake on an individual level (Anil *et al*., 2002). Consequently, housing sows in individual stalls leads to restrictions of movement and limited possibilities for social interactions with other individuals (McGlone *et al*., 2004; Anil *et al*., 2005), as well as restricting the sows from performing natural behaviours such as foraging and exploration (Rhodes *et al*., 2005). For sows housed in individual stalls, the lack of exercise leads to a reduction of muscle weight and bone strength compared to sows that are housed in groups (Marchant & Broom, 1996). Stereotypies are more often observed in individually housed sows compared to when sows are housed in groups (Arellano *et al*., 1992). The benefits with group housing are that it offers the animals freedom to move (Anil *et al*., 2005) and social contact with other individuals (Rhodes *et al*., 2005). There are however some associated welfare problems that may arise in group housing systems since aggressive interactions are commonly seen after mixing of unfamiliar sows (Arey & Edwards, 1998). These aggressive encounters often result in stress and injuries for the animals which give rise to welfare concerns (Chapinal *et al*., 2010). One study could show that sows housed in stalls had lower injury score compared to sows housed in groups (Anil *et al*., 2005). Furthermore, the proportion of removed and culled sows, mostly due to lameness, have shown to be higher in group housing system compared to system with individual housing

(Anil *et al*., 2005). Another disadvantage with group housing is that it can become more difficult to feed the sows individually (Anil *et al*., 2003; Chapinal *et al*., 2010).

In the year 2012, Nordic Genetics announced that they would stop the breeding of the Swedish Yorkshire (SY) as a consequence of the ended collaboration between Nordic Genetics and Norsvin (Lundeheim & Hansson, 2012). Instead, Norsvin decided to collaborate with the Dutch company Topigs and import Yorkshire from the Netherlands (Brink, 2012). According to Norsvin, the reason for the switch in breeding material is that the Dutch Yorkshire (ZY) will provide an increase in the number of weaned piglets per litter (Brink, 2013). The Dutch Yorkshire line is called the Z-line by the breeding company Topigs (Brink, 2013) and hence the abbreviation ZY is used. Over the years, housing sows in individual stalls have been the most common housing system for gestating sows and gilts within the EU (European Food Safety Authority (EFSA), 2007a). Because of this, sows have been selected according to their performance in individual stalls and this may lead to that these sows are not well suited for group housing (Horback & Parsons, 2016). However, housing dry sows in groups has been compulsory in Sweden since the end of the 1980s (Einarsson *et al*., 2014) and since the genetic selection of the SY has taken place under these conditions the animals are presumably adapted to this system. This may indicate behavioural differences between the SY breed and the ZY breed when group housed.

The study was carried out as a Master thesis and served as a minor pilot study for a larger Formas project; “Improving sow welfare in group housing systems”. The larger project aim is to develop sustainable and commercially relevant rearing and breeding strategies aiming for gilts adapted for group housing sow production systems focusing on the welfare of the animals. Formas is a Swedish government research council which aims to promote sustainable development and works with, among other things, research funding (Formas, 2019). In this study, protocols were developed to record health and behaviour, and tested on existing pigs at the Swedish University of Agricultural Sciences (SLU) Research Centre at Lövsta, Uppsala. Pigs of three different age categories (sow, slaughter pig and piglet) and of two different line crosses (SY and ZY) were included in the study. The overall aims of this MSc thesis study were to develop relevant protocols that could be used in the larger Formas project to record behaviour and health, and to investigate if there are any differences in health and behaviour between the two different line crosses of pigs in three different age categories.

The specific questions I aim to answer are:

- Are there a difference in health between the two different line crosses of pigs, and if so, how do they differ?
- Are there any differences in social behaviours between the two different line crosses of pigs?
- Are there any differences regarding level of activity, the pigs location in pen, and their body posture, between the two different line crosses of pigs?

2 Literature review

2.1 Legislation in the EU and Sweden

The pig production in the EU uses various housing and husbandry systems (EFSA, 2007a). The most common housing system for dry sows and replacement gilts within the EU was individual housing in stalls at the time of the report, but they can also be housed in either stable groups or large dynamic groups (EFSA, 2007a). However, to house pregnant sows and gilts in individual stalls is either banned or is in the process of being phased out in most member countries within the EU (EFSA, 2007a). As of January 1, 2013, loose housing of sows and gilts in groups within the EU is required in all holdings with more than ten sows during the period from four weeks after service and until one week before expected farrowing (EU Council Directive, 2008/120/EC). This means that it is still allowed to house sows and gilts individually during the insemination period and during the first month of pregnancy. The legislation regarding the partial ban of housing sows in individual stalls requires that sows and gilts are kept in groups during a specific part of their pregnancy was adopted within the entire EU already in 2001, which gave the member states within the EU a twelve year long transitional time for conversion to the new system (European Commission, 2012). The legislation began to apply for new buildings, rebuild buildings or buildings that were used for the first time after January 1, 2003 (EU Council Directive, 2008/120/EC). An inventory that investigated the implementation of EU Council Directive 2008/120/EC showed substantial differences between member states in the EU regarding the legislation for housing of pregnant sows and gilts (Mul *et al*., 2010). The EU Council Directive 2008/120/EC has been implemented into the legislation in each of the member states in the EU and there are only a few countries that have stricter legislation above the EU Council Directive

2008/120/EC on some specific aspects (Mul *et al*., 2010). For example, only Sweden, United Kingdom and the Netherlands has additional demands to the EU Council Directive 2008/120/EC regarding group housing of pregnant sows and gilts (Mul *et al*., 2010). In Sweden, the legislation requires that pregnant sows and gilts must always be kept loose housed in groups and in the Netherlands, sows must be group housed within four days from insemination, thus during the whole gestation (Mul *et al*., 2010).

In 1988, Sweden got a new animal welfare law (SFS 1988:534) and an animal welfare ordinance (SFS 1988:539), which complements the animal welfare law. The law states that all pigs must be kept loose-housed (SFS 1988:539 14§), either in groups or in pairs with the exception for sows and gilts that should be kept individually one week before farrowing and during the farrowing and lactation period (SJVFS 2017:25 Saknr L106 2 kap. 8§). The use of devices to confine or fixate pigs may only be used temporarily (SFS 1988:539 15§). However, it was a transitional period until the legislation against routine fixation of sows began to apply, and since the year of 1994 it has been prohibited to house sows and gilts in any type of confinement or fixation for longer period of times in Sweden (Jordbruksverket, 2012). During the farrowing and lactating period, the use of farrowing crates dominates within the EU, and the use of farrowing crates severely restrict the sows freedom to move (EFSA, 2007a). In member states where farrowing crates are not allowed, the use of individual pens for the sow and her piglets are common during this period (EFSA, 2007a). The Swedish legislation states that sows and gilts should be kept loose-housed in the farrowing pen and routine confinement in farrowing crates is not allowed during the farrowing and lactation period, but if necessary, confinement is only allowed for a short period of time (SFS 1988:539 15§). The farrowing pen should allow nesting behaviour (SJVFS 2017:25 Saknr L106 5 kap. 4§) and one week before expected farrowing time, sows and gilts should be given access to sufficient quantity of suitable material to allow them to perform nesting behaviour (SJVFS 2017:25 Saknr L106 4 kap. 5§).

2.2 Pig behaviour

2.2.1 Social behaviour

The wild boar (*Sus scrofa*) is the ancestor of all domestic pigs (Špinka, 2009). Several studies have been performed on either domestic pigs that have been allowed to return to more natural conditions, or feral pigs, to investigate if domestication has affected their behaviour (Graves, 1984; Jensen, 1986; Stolba & Wood-Gush, 1989; Gustafsson *et al*., 1999). It has been shown that when a group of pigs that had been reared under intense conditions was released into a park with semi-natural environment, the pigs started to show a rich repertoire of behaviour after only one to six months in the park (Stolba & Wood-Gush, 1989). Despite domestication and rearing conditions, domestic pigs still possess behaviours that is very similar to the behaviours that is found in the European wild boar repertoire (Graves, 1984; Jensen 1986; Stolba & Wood-Gush, 1989; Gustafsson *et al*., 1999). The quantity of different behaviours has however been affected by domestication as domestic pigs are less cautious against possible predators, and are also both less aggressive and less active compared to their ancestor (Špinka, 2009). Differences in behaviour can be explained as a result to that domestic pigs have adopt to a life under human protection (Gustafsson *et al*., 1999).

Under natural conditions, pigs live in family groups which typically consist of up to four sows and their offspring (Graves, 1984). Boars generally live solitary (Graves, 1984) but may also form bachelor groups (Špinka, 2009), and a boar will only join the family group during the mating season (Graves, 1984). The pregnant female will separate herself from the group about 24 hours before farrowing and start to wander to find a suitable nest site (Jensen, 1986). The location of the nest is often secluded from the rest of the group and are usually situated with some form of natural shelter (Jensen, 1986). Nest-building begins instantly after the female pig has chosen a place for the nest and she builds a simple nest by digging out a shallow hole that are filled with suitable nesting materials (Jensen, 1986). Farrowing occur shortly after nest-building (Jensen, 1986). The days after farrowing, the sow and her piglets stay either in or near the nest and around eight to ten days after farrowing the nest gets abandoned and the sow returns to the rest of the group with her piglets (Jensen, 1986). Social dominance relationships begin to form shortly after birth between littermates (Graves, 1984), while the social integration of the piglets with the rest of the group takes place gradually (Jensen, 1986).

However, social interactions with piglets from other litters may occur earlier since parental duties are often frequently shared within the family group and litters may be combined between several sows (Graves, 1984). Relationships that are created early in life towards other individuals will often remain the same all the way through adulthood, especially among females (Graves, 1984). The older the piglets become, the more they begin to distance themselves from their mother and at around 14 to 17 weeks of age the piglets are weaned (Jensen, 1986).

Pigs are very social animals (Graves, 1984) and domestic pigs kept in group housing conditions will form a dominance hierarchy (Meese & Ewbank, 1973). Between each pair of pigs within a group, a strict dominance relationship is established (Špinka, 2009), and agonistic behaviour is necessary to achieve and maintain this dominant-subordinate relationship between individuals (Price, 2008). Avoidance behaviour is frequently used by subordinate animals to avoid aggressive interactions but also to diminish both the frequency and intensity of social interactions with dominant animals (Price, 2008). For both wild, feral, and domestic pigs, the social ranking plays an important role in settling disputes about access to different resources (Graves, 1984). A stable dominance hierarchy promotes social stability within the group where high-ranking animals get benefits such as better access to resources compared to low-ranking animals (Price, 2008). It is important that individuals can recognize each other to be able to maintain a stable dominance hierarchy (Price, 2008). Pigs seem to recognize and communicate with each other mostly by smell, but they also use vocal signals (Špinka, 2009). Hearing and the sense of smell is well developed in pigs and they have a high range of different vocal signals used for communication (Špinka, 2009). The scent is also important for pigs, it is mainly used to gather information, to recognize both familiar and unfamiliar pigs, and to remember individuals (Špinka, 2009). In modern production systems today, pigs are usually kept in larger groups than the group size formed under natural conditions (Gonyou, 2001). Aggression and oral manipulation of pen mates (e.g. ear biting, tail biting and belly nosing) are behaviours that are directed towards other individuals, which are often considered to be harmful social behaviours, as the expression of these can adversely affect either the animal welfare or profitability for producers (Turner, 2011). The space allowance influences the frequency of social interactions in pigs as it has shown that with decreasing space allowance per sow, the frequency of social interactions increased (Weng *et al*., 1998).

2.2.2 Foraging and exploratory behaviour

Exploratory behaviour can be divided into two types: extrinsic exploration and intrinsic exploration (Wood-Gush & Vestergaard, 1989). The motivation to perform extrinsic exploration can be due to a distinct purpose, e.g. finding food, while intrinsic exploration can be motivated by a general purpose, e.g. curiosity about the surrounding environment (Wood-Gush & Vestergaard, 1989) or boredom (Studnitz *et al*., 2007). Pigs are exploratory animals and a large part of their awaken time is spent on exploratory behaviours (Stolba & Wood-Gush, 1989; Bolhuis *et al*., 2005). For wild animals, exploration is important for their survival (Wood-Gush & Vestergaard, 1989). In order to explore and to get to know their environment, pigs will be rooting, sniffing, chewing and biting on different items (Studnitz *et al*., 2007). Under semi-natural conditions, pigs spend a large part of their active time for exploration and foraging (Stolba & Wood-Gush, 1989). Stolba and Wood-Gush (1989) found that for 52% of the observations during daylight, the pigs were occupied with foraging (rooting and grazing) and for 23% of the observations, the pigs were engaged with locomotion and exploration of the surrounding environment. Studies have found that when pigs were housed outdoors and were prevented to perform rooting by a nose ring, other exploratory behaviours (chewing, sniffing and manipulation behaviour) increased instead (Studnitz *et al*., 2003a; 2003b). The same studies could also show that when the nose ring was removed, the pigs instantly started to root, and the authors therefore proposed that the preferred exploratory behaviour in pigs are rooting (Studnitz *et al*., 2003a; 2003b).

The need to perform exploratory behaviour is high in domestic pigs (Studnitz *et al*., 2007) and the risk of frustration in pigs increases if there is a shortage of foraging material in the pen, especially if the pigs are fed restrictively (EFSA, 2007b). Abnormal behaviours may also arise if there is nothing to explore in the pen, which may lead to that the exploratory behaviour can be redirected towards pen fittings or other individuals in the pen (Bolhuis *et al*., 2005; Scott *et al*., 2006; Jensen & Pedersen, 2010). Within the EU, regulations demand that rooting material that enables investigation and manipulation activities should always be provided to all pigs in sufficient quantities (EU Council Directive, 2008/120/EC). According to the Swedish legislation, all pigs must have access to straw or similar rooting material (SFS 1988:539 16§), and the bedding material should be given in such amount that their need to explore can be met (SJVFS 2017:25 Saknr L106 4 kap. 4§). The bedding material should be complex, edible, changeable and manipulative to stimulate

exploratory behaviour for a longer period of time in pigs (Studnitz *et al*., 2007).

The positive effects of using straw as bedding material have been shown in several studies. Availability of straw in the housing environment stimulate more exploratory behaviour and activity in growing pigs compared to if the pigs are housed in a barren environment (Bolhuis *et al*., 2005; Scott *et al*., 2006). By providing access to straw, the occurrence of abnormal behaviour such as manipulation of pen fittings and pen mates in growing pigs can be reduced (Fraser *et al*., 1991; Scott *et al*., 2006). Another study could show that providing straw for growing pigs reduces abnormal behaviours directed towards pen mates, such as belly nosing, ear biting, tail biting and biting of other parts of the body (Bolhuis *et al*., 2005). In addition to straw, access to other bedding materials like wood chips (Jensen & Pedersen, 2010) and maize silage (Jensen *et al*., 2010) has been found to stimulate exploratory behaviour and reduce abnormal behaviour such as manipulation of pen mates and pen fittings in growing pigs. The space allowance also influences exploratory behaviour in pigs, where studies has shown that an increasing space allowance per animal increase the exploratory behaviour towards the bedding material in growing pigs (Jensen *et al*., 2010) and in sows (Weng *et al*., 1998). Additionally, the amount of bedding material that is provided to the pigs have also been shown to influence exploratory behaviour. One study found that the time the pigs spent on exploratory behaviour toward the bedding material, in this case straw, were increased with an increased amount of bedding material provided to the pigs (Day *et al*., 2002).

2.2.3 Agonistic and aggressive behaviour

Agonistic behaviour is when pigs interact with each other by using aggressive and submissive behaviour (Scheffler *et al*., 2016). Pushing (shovelling), head knocking, biting and lifting are typical agonistic behaviours seen in pig fighting (Špinka, 2009). Under commercial farm conditions, agonistic behaviours are often seen when unfamiliar pigs are mixed into new groups (Stukenborg *et al*., 2011) or when feed are given restrictively and in a limited space (Špinka, 2009). In group housing systems, aggressive encounters negatively affect the animal welfare and production (D'Eath *et al*., 2009; Špinka, 2009), as it often for example leads to skin lesions (McGlone, 1985; Turner *et al*., 2006; Stukenborg *et al*., 2011; Li *et al*., 2012; Tönepöhl *et al*., 2013) and increases the risk for lameness (EFSA, 2007a). Mixing of unfamiliar pigs leads to fighting and the most vigorous fighting usually ends within 24 hours

(Meese & Ewbank, 1973). Agonistic behaviour between unfamiliar pigs at mixing is necessary to develop a social hierarchy within a group (Krauss & Hoy, 2011), and the social hierarchy is established within 48 hours after mixing (Meese & Ewbank, 1973). Agonistic behaviour between pigs in established groups may on the other hand imply that the pigs are fighting about resources (Krauss & Hoy, 2011). For low-ranking animals in group housing systems, enough space in the pen to be able to avoid or escape aggressive situations is important for animal welfare (Weng *et al*., 1998; Špinka, 2009). The level of agonistic interactions may also vary depending on the time of the day, as there are generally more agonistic interactions during the daytime compared to during the night (Stukenborg *et al*., 2011). Another study found that in general, fewer agonistic behaviours were observed with an increasing age of the pigs (Scheffler *et al*., 2016).

The level of aggressive behaviour is influenced by several factors, such as social status (Elmore *et al*., 2011), age, parity (Strawford *et al*., 2008), space allowance (Weng *et al*., 1998; Stukenborg *et al*., 2011), body weight (Stukenborg *et al*., 2011; Scheffler *et al*., 2016), group size and familiarity (Stukenborg *et al*., 2011). Decreasing the space allowance per sow have been shown to lead to an increased frequency of aggressiveness within a group of sows (Weng *et al*., 1998). For weaning and growing pigs, it has been shown that pigs with a lower body weight were less aggressive compared to pigs with a higher body weight (Scheffler *et al*., 2016).

The social status of the pig is one factor that may affect the level of aggressiveness (Elmore *et al*., 2011), and in addition, there are also several factors that affect the social status. The weight and size of the sow influence the social rank (Edwards *et al*., 1994) and young sows are often subordinate compared to older sows (Li *et al*., 2012). Martin and Edwards (1994) have shown that social rank in sows is positively correlated with body weight. The social rank of the sow influences the level of aggression, where dominant sows are more aggressive than subordinate sows (Elmore *et al*., 2011). When mixing sows into new groups it has been shown that parity influence aggressiveness, where old sows (4^{th} parity or higher) were more aggressive than young (1^{st} parity) and intermediate (2^{nd} or 3^{rd} parity) sows since old sows initiated more aggressive encounters and spent more time fighting than younger sows (Strawford *et al*., 2008). However, one earlier study could not show that the level of aggression expressed by sows at mixing was related to parity, age and weight (Mount & Seabrook, 1993). On the other hand, Mount and Seabrook (1993) believe it is possible that parity, age and weight can be related

to if the sow are dominant or not. This is supported by Brouns and Edwards (1994), who could show that dominance is related with parity and weight. Another study found that when first-parity sows are kept together in pens with multiparous sows, first-parity sows won less fights compared to if first-parity sows are kept together with gilts (Li *et al*., 2012). In a comparison between dominant and subordinate pigs of two different age groups, where one age group consisted of weaned piglets (28 days old) and another group of growing pigs (68 days old), the results were similar for both age groups where it was shown that subordinate pigs were engaged in less agonistic interactions compared to dominant pigs (Stukenborg *et al*., 2011). Dominant pigs additionally initiated more fights and the total fight time per pig was longer compared to in subordinate pigs (Stukenborg *et al*., 2011). Another study investigated both the social rank and agonistic behaviour on piglets during 72 hours after weaning and found that piglets who were high in rank (rank position 1–3) initiated more fights compared to piglets who were lower in rank (rank position from 4–12) (Fels *et al*., 2012).

Aggressive behaviours that are expressed after mixing has been found to be heritable in sows (Løvendahl *et al*. 2005) and for growing pigs (Turner *et al*., 2008; 2009). Turner *et al* (2008; 2009) used the time the pig was involved in reciprocal aggression and the time the pig was either recipient or deliver of non-reciprocal aggression following mixing into new groups as behavioural traits associated with aggressive behaviour and estimated their heritabilities. The time the pig was involved in reciprocal aggression was found to have a heritability of h^2=0.46 (Turner *et al*., 2008) and h^2= 0.43 (Turner *et al*., 2009). The heritability for the time the pig delivered non-reciprocal aggression was h^2=0.37 (Turner *et al*., 2008) and h^2= 0.31 (Turner *et al*., 2009) while the heritability for the time the pig was recipient of non-reciprocal aggression was h^2=0.17 (Turner *et al*., 2008) and h^2= 0.08 (Turner *et al*., 2009). Another study by Løvendahl *et al*. (2005) investigated aggression in sows after mixing and used deliver of aggression and recipient of aggression as behavioural traits and estimated the heritability for these traits. The study could show that the heritability for delivery of aggression by sows was h^2= 0.17 to 0.24 while the heritability for being recipient of aggression was h^2= 0.04 to 0.06 (Løvendahl *et al*., 2005). A negative correlation between body weight of the pig and the time spent being recipient of non-reciprocal aggression were also found (Turner *et al*., 2006).

To reduce aggression in group housing system, mixing of unfamiliar pigs should be avoided and it should also be avoided to mix pigs that is very different from each other in terms of age and size (EFSA, 2007b). In group housing systems, young sows are subordinate to older sows and therefore more vulnerable in this system (Li *et al*., 2012). It has been suggested to sort the sows according to their parity number to reduce aggression towards young sows at mixing and thus improve their welfare (Li *et al*., 2012). The study found that aggressive interactions may become less intense if first parity sows are kept together in pens with gilts compared if they are kept in pens together with multiparous sows (Li *et al*., 2012).

2.2.4 Abnormal behaviour and stereotypes

To determine what an abnormal behaviour is, it is important to understand the natural behaviour of the pig. Abnormal behaviour can be any behaviour that would deviate from the norm (Keeling & Jensen, 2009) and one definition of abnormal behaviour is when the behaviour occurs more frequently than normal or if the behaviour is performed out of context (Wood-Gush & Vestergaard, 1989). The risk of abnormal behaviour increases in housing systems where pigs are restricted to perform natural behaviour (Moinard *et al*., 2003). Abnormal behaviours in pigs are often directed towards pen mates or pen fittings (Broom & Fraser, 2015). One of the main abnormal behaviour that occur in pigs are tail biting (Moinard *et al*., 2003; Brunberg *et al*., 2011). Other abnormal behaviours seen in pigs and that are unwanted are vulva biting, ear biting, belly massage and mounting (Brunberg *et al*., 2011). The motivational background to tail biting, ear biting and belly nosing include some type of frustration or stress for the performing animal (Van Putten & Dammers, 1976; Dybkjær, 1992; Moinard *et al*., 2003; EFSA, 2007c), while vulva biting is regarded as an aggressive act (Van Putten & Van De Burgwal, 1990). The high motivation of pigs to perform foraging and exploration behaviour has been suggested as a major reason behind the development of tail biting (EFSA, 2007c), and one study found that the prevalence of tail biting was lower for pigs that had access to straw compared to pigs without straw (Taylor *et al*., 2010). Weaning age is one reason behind the development of belly nosing and occurs more frequently in pigs that has been weaned at an earlier age (Van Putten & Dammers, 1976; Gonyou *et al*., 1998; Worobec *et al*., 1999) and one study found that when weaning age decreased the frequency of belly nosing increased (Worobec *et al*., 1999). Another study has shown that the environment could also affect the prevalence of belly nosing, as a barren environment increase the risk for belly nosing compared to an enriched

environment (Dybkjær, 1992). Belly nosing (Straw & Barlett, 2001), tail biting, ear biting (Smulders *et al*., 2008; Taylor *et al*., 2010) and vulva biting (Van Putten & Van De Burgwal, 1990) often results in skin lesions on the affected animal.

One form of abnormal behaviour is stereotypies (Keeling & Jensen, 2009). Stereotypies was first discovered in animals held in zoos and laboratories (Arellano *et al*., 1992). Stereotypic behaviour is defined as a repetitive behaviour without any apparent aim and that serves no obvious function for the animal (Mason, 1991). Once established, stereotypic behaviour can become a need itself (Mason, 1991) and the animal may spend a large part of its awaken time with performing these behaviours (Keeling & Jensen, 2009). It has been suggested that stereotypies may develop when the animal is exposed to situations that lead to frustration, stress, fear or lack of control (Mason, 1991). Environments that are restrictive and have a lack of stimulation for the animal may also lead to development of stereotypies (Mason, 1991). Pigs are omnivores and in a natural environment, foraging behaviour consume much of their daytime activity (Stolba & Wood-Gush, 1989). Oral stereotypies, like chewing and biting, usually develops in animals that have a high feeding motivation (Keeling & Jensen, 2009). Therefore, oral stereotypies commonly develop in pigs who has a restricted feed intake and a behavioural restriction (e.g. cannot perform enough foraging behaviour) (Lawrence & Terlouw, 1993). Dry sows usually have a restricted feed intake (EFSA, 2007a) and may thus have an increased risk to develop oral stereotypies. A range of stereotypic behaviours can be seen in pigs and stereotypies that are evaluated in the Welfare Quality® Assessment Protocol for pigs (2009) is bar/trough/drinker biting, sham chewing, teeth grinding, tongue rolling and floor licking. In general, most stereotypies in pigs are performed after feeding (Terlouw *et al*., 1991). A study by Rushen (1984) on tethered sows found that the most common stereotypies performed before feeding were bar biting and head-waving while manipulation of drinkers often were performed after feeding. These stereotypies are considered to be associated with the feeding period whereas sham chewing is not considered to be associated with the feeding period since the frequency of the behaviour was equal both before and after feeding (Rushen, 1984). Both housing system and feeding level influence the occurrence of different stereotypies, where tethered gilts showed more stereotypies compared to loose-housed gilts, and the incidence of different stereotypies was higher in gilts that had a restricted feed intake compared to gilts that had a higher feeding level (Terlouw *et al*., 1991). Another study found that the frequency of stereotypies in sows increased with long-termed confinement

(Zhang *et al*., 2017). Stereotypic behaviour might serve as an indicator of poor animal welfare (Keeling & Jensen, 2009), but it is possible that an animal shows stereotypical behaviour even in an adequate environment as stereotypes may have been established in a previous inappropriate environment (Keeling & Jensen, 2009). In this way, stereotypic behaviour is a sign that the welfare of an animal has been reduced at some time in its life (Keeling & Jensen, 2009).

2.3 Health

The health of an animal is an essential part of animal welfare (Keeling & Jensen, 2009). Since 1946, the World Health Organization (WHO) has defined human health as "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 2018). In the Welfare Quality® Assessment Protocol for pigs (2009) a good health for pigs incorporates three aspects: absence of disease, absence of injuries, and absence of pain induced by management procedures.

2.3.1 Lameness

Lameness is a common health problem in pigs (EFSA, 2007a). The prevalence of lameness seems to vary greatly, and studies have reported a prevalence of lameness in sows ranging from 5.9% (Pluym *et al*., 2013), 8.8% (Heinonen *et al*., 2006), 9.7 % (Pluym *et al*., 2011) and 16.9% (KilBride *et al*., 2009). For finishing pigs, studies have reported a prevalence of lameness ranging from 2.0% (Van den Berg *et al*., 2007), 2.2% (Petersen *et al*., 2008) to 19.7% (KilBride *et al*., 2009). In the Welfare Quality® Assessment Protocol for pigs (2009), lameness is one of the animal-based measures that is used to assess animal welfare, and it is described as when the pig cannot use one or more of its limbs in a normal manner and the severity of lameness can vary greatly. Several causes behind lameness have been identified in sows, such as; arthrosis, infectious arthritis (Dewey *et al*., 1993), osteochondrosis, foot lesions (Dewey *et al*., 1993; Heinonen *et al*., 2006) and infected skin lesions (Heinonen *et al*., 2006). Lameness is an important welfare issue and may adversely affect animal welfare since it might indicate that the animal feel pain or discomfort when moving or standing (KilBride *et al*., 2009). Additionally, lameness causes behavioural changes in affected animals since lame sows has proven to be more passive, show less exploratory behaviour, stand less and lying down more compared to non-lame sows (Ala-Kurikka *et al*., 2017). This

may be due to either pain, reduced locomotion, discomfort or sickness behaviour (Heinonen *et al*., 2013). Even though lameness is a welfare problem it can also indicate that there are problems in the environment for the affected animal (Heinonen *et al*., 2013). Risk factors in the environment found to affect the prevalence of lameness is inappropriate flooring and social challenges (EFSA, 2007a). Housing with slatted floor increases the risk of sows being lame compared to housing with solid floors (Heinonen *et al*., 2006). Another study showed that housing pregnant sows and finishing pigs on slatted floor increase the incidence of lameness compared to if the pigs are housed on solid concrete floor with deep bedding (KilBride *et al*., 2009). Aggression between sows at mixing is a social challenge that increases the risk for lameness (EFSA, 2007a). Lameness is an important concern for pig producers as it also affects the economy negatively since treatment of lameness increase both the workload (Pluym *et al*., 2011; Heinonen *et al*., 2013) and the medical costs (Pluym *et al*., 2011) for producers. Lameness may also lead to loss of slaughter income and extra costs for destruction if the sow is severely affected and is euthanized at the farm (Pluym *et al*., 2011). Furthermore, lameness is a common reason for unplanned and early culling of sows, thus have an unfavourable impact on sow longevity (Engblom *et al*., 2008; Pluym *et al*., 2013).

2.3.2 Skin lesions

Through social interactions between pigs, skin lesions may arise and are often seen as a result after fights between pigs at mixing (McGlone, 1985; Turner *et al*., 2006). When pigs fight, the bites appear to be mainly targeted toward the ears, face and neck of the opposing pig (McGlone, 1985). This is supported by Stukenborg *et al*. (2011) which found that after mixing of growing pigs, the lesion score was higher on the front part compared to the middle and the rear part of the body. A pig will also target the bites towards the rear part of the body when the opponent pig tries to retreat from the fight (Meese & Ewbank, 1973). A skin lesion score methodology is often used to measure aggression in pigs after mixing (Turner *et al*., 2006; Stukenborg *et al*., 2011). A study by Turner *et al*. (2006) found positive correlations between two different behaviours in pigs and the location of skin lesions on the body. It was found that pigs involved in reciprocal fighting sustain more skin lesions on the front part of the body (head, neck, shoulders and front legs) compared to pigs that were recipient of non-reciprocal aggression which sustain more skin lesions on the rear part of the body (rump, hind legs and tail) (Turner *et al*., 2006). An increased skin lesion score could be seen in more aggressive pigs after mixing, where they would have more fights per pig, initiate more fights,

and an overall longer fight time (Stukenborg *et al*., 2011). Another study found that when first-parity sows were kept in pens together with multiparous sows, first-parity sows got a higher lesion score and sustained more skin lesions on the rear part of the body after mixing compared to first-parity sows that were kept together with gilts (Li *et al*., 2012). The authors suggest that the location of the injuries on first-parity sows kept together with multiparous sows implies that they are low in rank (Li *et al*., 2012). A higher skin lesion score has been found among sows that are being attacked more frequently, and the authors suggest that a higher skin lesion score indicate low-ranking sows (Tönepöhl *et al*., 2013). In addition, skin lesions may also indicate less vital sows, as a negative relationship was found between lesion score and reproductive performance e.g. total born piglets (Tönepöhl *et al*., 2013). Other factors that have been found to influence the number of skin lesions in pigs are parity (Tönepöhl *et al*., 2013), body weight (Turner *et al*., 2006), space allowance per pig (Weng *et al*., 1998) and social rank (Martin & Edwards, 1994). For growing pigs, the number of skin lesions increased with an increased body weight (Turner *et al*., 2006). The incidence of skin lesions is affected by the pen size and it could be shown that skin lesions increased on sows with a decreasing space allowance per pig (Weng *et al*., 1998). For sows, social rank is positively correlated with parity and body weight (Arey, 1999) and the social rank has been shown to be negatively correlated with the scoring of skin lesion, meaning that a higher incidence of skin lesions is found on low-ranking sows compared to high-ranking sows (Martin & Edwards, 1994). Furthermore, one study found that the housing management strategy, stage of gestation and familiarity did not affect the lesion score or the scoring of other injuries when mixing sows into new groups, but first-parity sows tended to sustain more lesions compared to older sows (2^{nd} parity or higher) (Strawford *et al*., 2008).

The location of skin lesions caused by aggression during mixing have been found to be heritable in growing pigs (Turner *et al*., 2009). The estimated heritability for skin lesions on the front, central and rear part of the body was 0.26, 0.25 and 0.21, respectively (Turner *et al*., 2009). In addition, Turner *et al*. (2009) estimated genetic correlations between different location of skin lesions measured 24 hours after mixing and if the pig was either involved in reciprocal fighting or where recipient of non-reciprocal aggression. The estimated genetic correlation for skin lesions on the front part was 0.67 and 0.70 for being involved in reciprocal fighting and being recipient of non-reciprocal aggression (Turner *et al*., 2009). Skin lesions on the central and rear part of

the body were mainly associated with being recipient of non-reciprocal aggression and the estimated genetic correlation was 0.80 and 0.79 for skin lesions on the central and rear part, respectively (Turner *et al*., 2009). Another study by Turner *et al*. (2008) estimated genetic correlation between skin lesions and being involved in reciprocal fighting to be 0.76, 0.77 and 0.72 for the front, central and rear part of the body, respectively. The estimated genetic correlation between skin lesions and delivery of non-reciprocal aggression were 0.56, 0.69 and 0.60 for the front, central and rear part of the body, respectively (Turner *et al*., 2008). The same study by Turner *et al*. (2008) could however not show any genetic correlation between skin lesions on different parts of the body and being recipient of non-reciprocal aggression.

3 Material and methods

This study was performed at the Research Centre of the Swedish University of Agricultural Sciences at Funbo Lövsta outside Uppsala. The data recording and collection in this study was performed between 19th and 26th of June 2017.

Protocols were developed to investigate health and behaviour, and used on pigs of two different line crosses, SY and ZY (piglets and slaughter pigs had Hampshire as sire breed), in three different age categories: sow, slaughter pig, and piglet. The ethogram used for behaviour recording was developed based on the ethogram by Nihlstrand (2016). In addition, more behaviours were added to the ethogram and their definitions came from different studies (Xin *et al*., 1989; Loijens *et al*., 1999; De Leeuw & Ekkel, 2004; Welfare Quality®, 2009; Smith, 2013). From the ethogram, protocols were created which was later used in the data collection for behaviour (Appendix 1 and 2). The health assessment was conducted with a modified protocol based on protocols and definitions from Welfare Quality® (2009) and Eliasson (2013), to investigate the health and welfare of the individual pig, by examining lameness, locomotion and wounds on body (Appendix 3). Any signs of stereotypic behaviour in the pen during the observation was also noted (Appendix 2 and 3). All protocols were designed so that registrations of health and behaviour could be done on an individual level in the pigs' home pen. Direct behavioural observations were performed on each individual animal. Different variables for body posture, location in pen and activity was recorded with scan sampling (the number of performed scans depended on the number of observed pens in the unit). Social interactions were recorded in each pen for five minutes with continuous observations.

3.1 Animals

Three different age categories (sow, slaughter pig and piglet) of pigs and two different line crosses (SY or ZY) were included in this study. Sows was either SY or ZY. However, because of the recent switch of breeding material from SY to ZY in the pig herd this has led to that ZY sows are not purebred but instead is 50% ZY and 50% SY and to simplify further reading these sows will be referred as ZY. Pigs in the age category of piglets and slaughter pigs were crossbreeds of SY x Hampshire (SY*H) or ZY x Hampshire (ZY*H). A total of twelve Hampshire boars were used as sire breed to the piglets and slaughter pigs included in this study. In total 94 pigs were included in this study, were 46 of the pigs were of breed SY or SY*H and 48 pigs were of breed ZY or ZY*H. The number of pigs that were observed within each age category and line cross are presented in Table 1.

Table 1. *Number of animals observed within each age category and line cross.*

	SY (SY*H for slaughter pigs and piglets)	**ZY (ZY*H for slaughter pigs and piglets)**
Sow	8	8
Slaughter pigs	22	18
Piglet	16	22
Total	46	48

For piglets and slaughter pigs, all pens contained both females and males, but only females were included in this study. This was because the main study that this pilot study is connected to is focused on gilts and sows. Only pens with intact litters were chosen for this study, and pens that contained pigs from different litters, perhaps to even out the litter size, where the different line crosses may have been mixed were not included in this study. In addition, only piglets and slaughter pigs that had the sire breed Hampshire were used. The animals that were observed in this study were chosen randomly in each pen by the observer and are known as focal animals.

3.1.1 Sows

A total of 16 sows were included in this study, with eight sows of each line. Data from a total of four pens with focal animals was used. The group size, in which the sows were kept in, varied from five to nine sows in a group. For both lines, the group size was on average 7.2 ± 1.53 (Mean ± SD). In addition,

the sows included in this study were in different parities (see Figure 1), and for both lines together, the average parity number were 4.1 ± 1.61 (Mean ± SD). However, sows of line SY were either in parity four, six or seven, and had an average parity of 5.4 ± 1.19 (Mean ± SD), while sows of line ZY only were in parity two or three and had an average parity of 2.7 ± 0.46 (Mean ± SD). Gestation in days at observation varied between the sows, as seen in Figure 2. Gestation in days were on average 50.8 ± 16.32 (Mean ± SD). Furthermore, for both SY and ZY sows, gestation in days were 50.8 ± 16.80 and 50.7 ± 16.99, respectively (Mean ± SD).

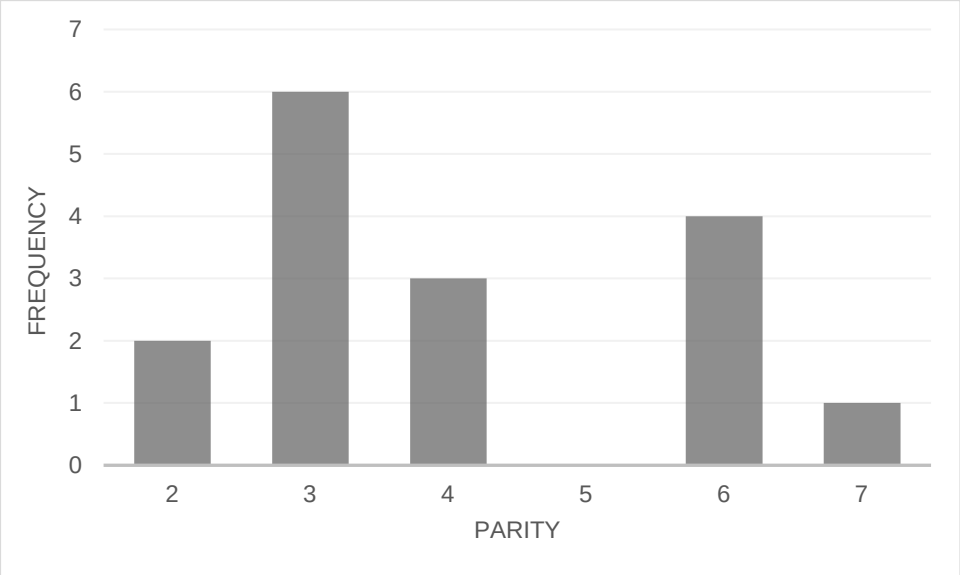

Figure 1. Frequency of sows (total number of animals) in different parities (N=16).

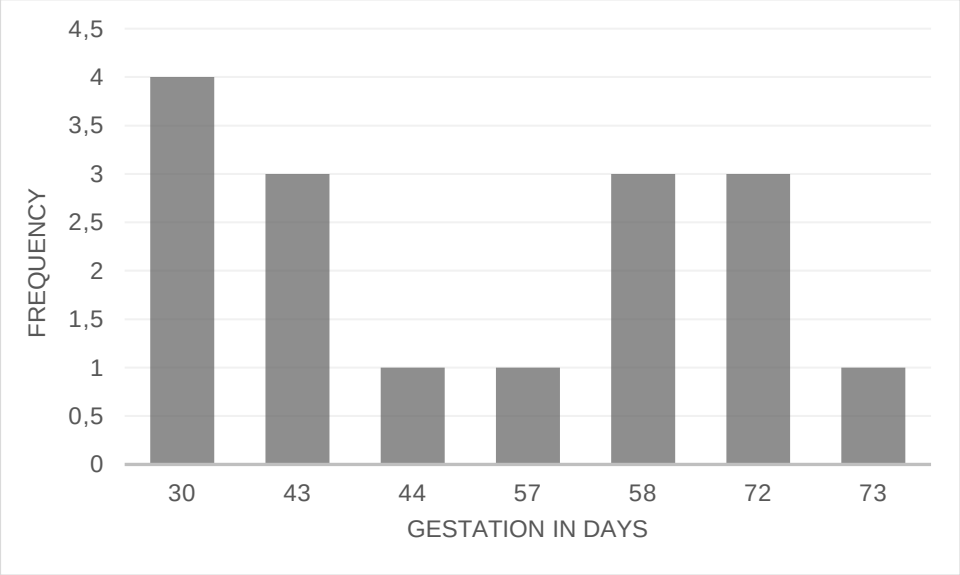

Figure 2. Frequency of sows (total number of animals of both lines) according to gestation in days at observation (N=16).

3.1.2 Piglets

A total of 38 piglets were included in this study, where 16 were of the SY*H cross and 22 were of the ZY*H cross. Data from a total of 19 pens with focal animals was used, where eight pens contained pigs of the SY*H cross and eleven pens contained pigs of the ZY*H cross. The age at observation ranged from 14 to 27 days for both line crosses, with an average of 20.9 ± 4.12 days (Mean ± SD). For piglets of SY*H and ZY*H line cross, the average age at observation were 21.2 ± 3.38 and 20.6 ± 6.65, respectively (Mean ± SD). The group size in which the piglets were kept in varied from seven up to 14 piglets per group, see Figure 3, with an average group size of 11.1 ± 1.99 (Mean ± SD) for both crosses. For piglets of SY*H and ZY*H line cross, group sizes consisted of 10.1 ± 1.96 and 11.8 ± 1.74 piglets, respectively (Mean ± SD).

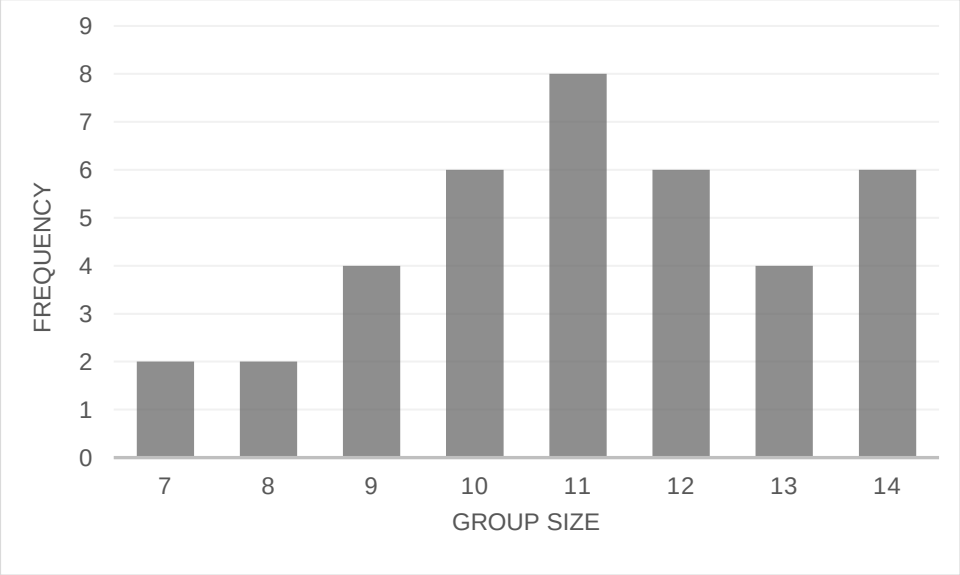

Figure 3. Frequency of piglets (total number of animals) in different group sizes (N=38).

3.1.3 Slaughter pigs

A total of 40 slaughter pigs were included in this study, where 22 were of the SY*H cross and 18 were of the ZY*H cross. Data from a total of 20 pens with focal animals was used, where eleven pens contained pigs of the SY*H cross and nine pens contained pigs of the ZY*H cross. Age at observation ranged from 103 to 137 days for both line crosses, with an average of 119.2 ± 11.30 days (Mean ± SD). The average age at observation were 122.4 ± 9.82 and 115.2 ± 11.98 (Mean ± SD) for SY*H and ZY*H line cross, respectively. The group size in which the slaughter pigs were kept in varied, consisting of groups from five to twelve slaughter pigs per group, see Figure 4. The average group size for both line crosses were 8.8 ± 1.71 (Mean ± SD) pigs per group, with a group size for each SY*H and ZY*H line cross being 8.4 ± 1.65 and 9.2 ± 1.73, respectively (Mean ± SD).

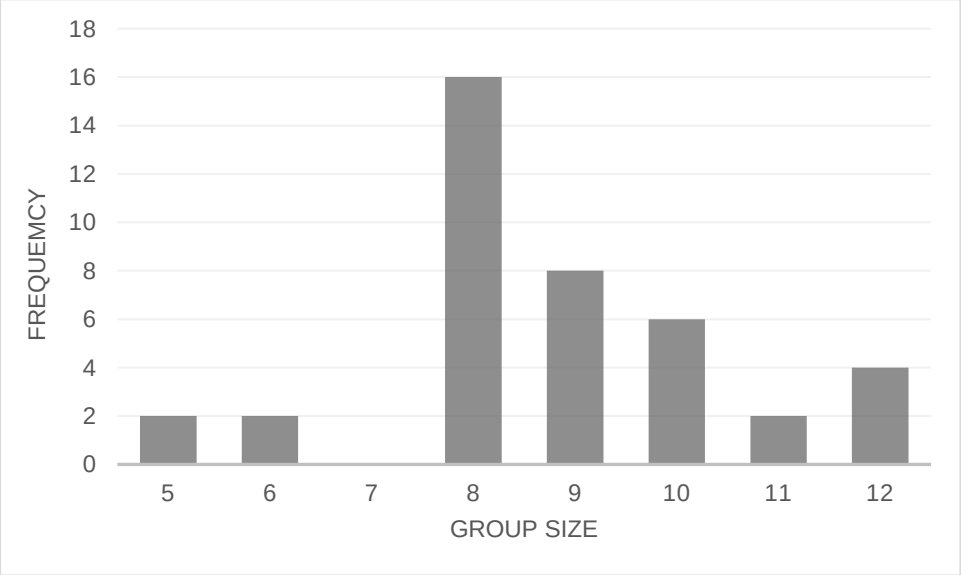

Figure 4. Frequency of slaughter pigs (total number of animals) in different group sizes (N=40).

3.2 Housing and management

The pig herd at the Research Centre of the Swedish University of Agricultural Sciences is a Specific Pathogen Free (SPF) herd.

The sows included in this study were dry sows, which was kept loose-housed in groups on deep straw bedding. The pens total area was 32.5 m^2 and consisted of deep straw bedding, a row of feeding stalls and one water station. The bedding material that was used was un-cut straw. The sows were kept on deep straw bedding and no cleaning was done on the observation day or the days before, but the pens were cleaned after the observation had taken place. Each sow received individual feeding with dry feed and were fed manually by the staff two times a day with the first feed allowance around 8:00 in the morning and around 13:00 in the afternoon. The first feed allowance was given at least an hour before the start of the observation and the second feed allowance was given only after the observation was complete. Water was available *ad libitum* from drinking nipples (Swedish University of Agricultural Sciences, 2017).

The piglets in this study was observed before weaning and they were housed with the sow in individual loose-housed farrowing pens. The pens consisted of a lying area with concrete floor, a dunging area of slatted floor and an area

which only the piglets had access to with a heat lamp, known as the piglet corner. The lying area was 2.0 m x 2.05 m and the slatted area was 2.0 m x 1.20 m giving that the total area of the pens was 6.50 m^2. The pens were manually cleaned by the staff at the stable during the morning and straw was provided after cleaning and this was done at least an hour before the observation began. The sows were feed automatically with dry feed and was given feed two or three times a day. The first feed allowance was given at least an hour before the start of the observation and the second feed allowance was given only after the observation was complete. When the piglets reach an age of two to three weeks, dry feed adapted for piglets is provided through a feed dispenser. Water was available *ad libitum* from drinking nipples (Swedish University of Agricultural Sciences, 2017).

The pen, in which the slaughter pigs were housed, consisted of concrete floor in the feeding and lying area, and the dunging area had slatted floor. The feeding and lying area was 3.6 m x 2.20 m and the slatted area was 3.6 m x 1.0 m giving that the total area of the pens was 11.52 m^2 The slatted area was one third of the pen area. Cleaning of the pen was done manually by the staff in the morning and chopped straw was provided automatically after cleaning and this was done at least an hour before the observation began. Pigs received either dry or wet feed and it was given automatically three times per day. The first feed allowance was given at least an hour before the start of the observation and the second feed allowance was given only after the observation was complete. Water was available *ad libitum* from drinking nipples (Swedish University of Agricultural Sciences, 2017).

3.3 Study design

3.3.1 Behaviour recording

The behaviour of the pigs was recorded through direct observations and was made by the author by standing outside the pen, thus no contact with the animals was needed. The observations where performed during a total of five days, and each individual animal was observed once, and the same person performed all the behaviour recordings. In each pen, the animal that were observed is known as focal animals. The recording of the behaviour of the pigs lasted for approximately three hours per observation day and was per-

formed daytime, between 9:00-12:00. The reason for performing the observations during daytime was that the pigs are usually more active during the day compared with evening, and a previous study also found that there was more agonistic behaviour during the day compared to during the night (Stukenborg *et al*., 2011). Moreover, the behavioural recordings occurred between morning and afternoon feeding and after provision of bedding material.

Social interactions were recorded with continuous observation while scan sampling was used to record different variables of body posture, location in the pen and activity, according to an ethogram that are presented in Table 2.

To investigate how the pigs' spend their time, variables of body posture, location in the pen and activity were recorded for each focal animal at each scan sampling. During the scan sampling, observations were taken of what the animal were doing at one specific time and this was repeated at different intervals. The definitions of the different variables in the scan sampling are described in Table 2. The number of scans that were performed depended on the number of pens with focal animals in the stable. For the continuous observation, each pen was observed continuously for five minutes for different social interactions that involved the focal animals (either as a performing or receiving pig) and the behaviour and vocalization of both the performing pig and receiving pig were recorded for each social interaction and the definitions are described in Table 2. In addition, if there were any signs of stereotypic behaviour in the pen, this was also noted, and definitions of the different stereotypies are described in Table 2.

Table 2. *Ethogram of behaviours*

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 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	Pig in the lying area
	Slatted area	Pig in the slatted area, at least one leg on the slatted area (only growing pigs and piglets)
	Piglets corner	Pig in the piglet area, at least one leg in the piglet corner (only piglets)

	Sow feeding stall	Pig on feeding stall, at least one leg on the feeding area (only sows)
Activity	Eating feed	Snout in feed through
	Drinking	Snout touching water nipple
	Suckling	Snout touching nipple on sow (only piglets)
	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)
	Exploring enrichment material	Pig play/investigate straw or other enrichment material with snout
	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
	Vulva biting	Snout touching/biting other pig's vulva
	Ear biting	Having another pig's ear 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 on or 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 is nosing, sucking and/or massaging another pig's belly or throat with snout (not piglets on sow's teat)
	Nosing teat/suckling	Pig's snout touching the sow's teat (only piglets)
	Vocalisation	Scream and squeals is high vocalisation and low vocalisation is grunting and barking

Receiving pig	No reaction	No change in body position or activity of the receiving pig
	Avoiding	Pig's head turning away or pig moving away from the performing pig
	Return approach	Receiving pig approaching the performing pig with head/snout
	Other pen	Interaction were the receiving pig is from other pen, no reaction recorded
	Vocalisation	Scream and squeals is high vocalisation and low vocalisation is grunting and barking
Stereotypes	Sham chewing	The pig performs chewing without anything in the mouth, sometimes with heavy saliva production
	Bar/through/drinker biting	Pig bite or chew the bars and through. Manipulate drinkers and perform apparent drinking.
	Tongue rolling	Pig is rolling its tongue/playing with tongue: exposing the tongue in an unusual fashion while stretching the lower jaw horizontally
	Teeth grinding	Continuous and rhythmical audible grinding of teeth, without actual chewing
	Floor licking	The pig is licking the floor

For piglets and slaughter pigs two animals in each pen randomly were chosen by the observer. But because of the low number of available animals for the sows, four animals were chosen randomly by the observer in each pen for the sows. Hence, each pen contained four focal animals in the sow stable while in the stable with piglets and slaughter pigs, each pen contained two focal animals. Furthermore, only females were included in this study. In order to enable an individual recording of behaviour and health, the focal animals were individually marked on the back with a commercial animal marker (either pen or spray) on the morning before the observation began. After marking, the pigs were left alone for about 45 minutes to an hour before the observation began. Each observation began with the observer having an acclimatization period allowing the pigs to get used to the observer. During this period, the observer was standing outside the different pens in the unit and the observation started when all animals were accustomed and did not give any attention to the observer. If there was need for more acclimatization after the observation had started, the observation was paused until the pigs once again lost interest to the observer.

For piglets and slaughter pigs, the behavioural observation started with a scan sampling of the focal animals in each pen in the unit. One round of scan sampling started with the first pen on the left side in the stable and ended on the last pen on the right side in the stable. When the round of scan sampling was finished, the continuous observation started in the first pen on the left side in the stable. The continuous observations lasted for five minutes in each pen and social interactions was recorded on the two focal animals during this time. If the animals were lying down when the continuous observation started, the animals were awakened by the observer by clapping the hands once. The pig that were initiating different kinds of social interactions is called performing pig and the pig receiving the social interaction is called receiving pig. All social interactions where at least one of the focal animals in pen were involved in, either as a performer or receiver, were recorded. The focal animals where therefore seen as both as a potential performing pig and as a potential receiver. A new social interaction was considered when there was a pause in an interaction for at least 15 seconds. After the continuous observation was done in the first pen, a new round of scan sampling occurred in all pens, with the same order as previously, and after that the continuous observation could start in the second pen on the left side. Then the observations proceeded in this way throughout the unit until all focal animals had been observed with one continuous observation and a number of scan samplings (the number of scans depends on how many observed pens it was in each unit). The observation started with a round of scan sampling and ended with a round of scan sampling. After each continuous observation, a health assessment was done on each focal animal in the pen.

For the sows, scan sampling and continuous observation was done differently compared to for the piglets and slaughter pigs, due to the low number of sows available with requested line. A total of four pens were used with the sows and each pen contained four focal animals. The four focal animals in the sow pen always consisted of two SY sows and two ZY sows, thus the pens contained pigs of the two different line crosses. This meant that the scan sampling and continuous observations was done with a different approach. All SY sows were observed first and then all ZY sows. The first scan sampling started with the two focal animals of line SY in pen one and ended in the fourth pen, and after all SY sows had been observed the scan sampling proceeded in pen one, but now on the focal animals that were of the line ZY, and the scan sampling continued on the ZY sows until the fourth pen. When the whole round of scan sampling was finished, the continuous observation started in the first pen on

the SY sows and had the same order as scan sampling regarding the focal animals.

The time between each scan sampling varied because the time for continuous observation and health assessment varied, sometimes the animals were required to wake up before the continuous observation could start and sometimes more time for acclimatization were needed, and this meant that the time of scan samplings occurred at different intervals. The different number of scans on each day within the different age categories and both the smallest and largest interval between the different scan samplings within that batch are shown in Table 3.

Table 3. *Number of scan samplings and interval in each batch*

Batch	Date	Age category	Number of scans	Shortest interval (minutes)	Longest interval (minutes)
1	19-06-2017	Slaughter pig	12	15	22
2	20-06-2017	Piglet	10	13	24
3	21-06-2017	Sow	9	16	22
4	22-06-2017	Slaughter pig	10	16	19
5	26-06-2017	Piglet	11	12	23

3.3.2 Health assessment

A health assessment was performed on each focal animal that was included in the study. Lameness, locomotion and wounds on body were measurements that was assessed to investigate health and welfare on the individual pig. The health assessment was made by standing outside the pen, thus no contact with the animals was needed. The same person performed the health assessment on all pigs. Signs of stereotypic behaviour in the pen was also noted. Signs of stereotypic behaviours that could occur and that were evaluated was vulva lesions, tail biting, sham chewing, tongue rolling, teeth grinding, bar/trough/drinker biting and floor licking. The assessment for lameness, wounds on body and signs of stereotypic behaviour was performed using a modified version of the Welfare Quality® protocol (2009). The assessment was simplified for the present experiment by changing the number of skin lesions on the different scoring scales and adding the tail zone as a region on the pig for the data collection. The scoring scale for lameness was simplified to only yes or no instead of three different scoring scales. The assessment was

also modified so that it was suited to be performed on an individual level. The assessment of locomotion was performed using a modified version of a protocol by Eliasson (2013), where the scoring scale for locomotion was simplified to only yes or no instead of different scoring scales. Skin lesions, lameness and locomotion were assessed by visual inspection and examination, which was made from outside of the pen by the observer. Scoring for lameness, locomotion and skin lesion was obtained for each focal animal.

Lameness was scored as either a yes or no, where no=normal gait, or the animal has difficulties walking but is still using all its legs, the stride may be shortened and/or there may be a swagger of the caudal part of the body when walking, and yes=the animal is severely lame, it puts a minimum of weight on the affected limb (asymmetric walking) or there is no weight-bearing on the affected limb, or the animal is unable to walk. Locomotion was scored as either normal or not normal, where normal=the pig has very wormly movements with long steps or a regular locomotion with flexible movements and no lameness, and not normal=the pig has stiff and tripping movements with short steps. The assessment for wounds on body combined scores of 0 to 2 from six surface regions on the body of each animal; ears, front, middle, hindquarters, legs and tail zone. Each region was scored according to the following scoring system: 0=no visible skin injuries, 1=1 to 5 skin lesions visible, and 2=more than 5 skin lesions visible. Both healed and fresh skin lesions were included in the scoring. Wounds on the body were evaluated from only one side of each pig as in the Welfare Quality® protocol (2009).

3.4 Statistical analyses

The statistical analyses of the data were performed by using SAS version 9.4 (SAS Institute, Inc., 2011) and Minitab 18 (Minitab Inc., 2017). Minitab was used for the overall descriptive statistics of the animals. SAS was used for further descriptive statistics of the behavioural observations (both scan sampling and continuous observation) and health assessment by using procedures FREQ or MEANS. Minitab was used for the statistical analyses of health and social interactions by using the two-proportion test. The statistical analyses of the data from scan sampling was made with the general linear model procedure (GLM) in SAS.

The response variables (y-variables) chosen to be investigated in the statistical analyses were the different variables recorded for activity, body posture

and location in the pen at scan sampling (y-variables expressed as proportion of scans each animal performed the specific behaviour), and the different variables for performing and receiving pig for continuous observations (the y-variable expressed as 0/1 variable where each animal performed or did not performed the behaviour), see Table 2. The chosen response variables for health assessment were lameness, wound at different locations on the body as well as locomotion (the y-variable expressed as 0/1 variable where each animal was affected or not). The selected response variables for the three different observations in this study (i.e. scan sampling, continuous observation and health assessment) that were investigated were tested against different predictor variables (x-variables) of interest to this study. The statistical analyses were performed separately for each animal category (sow, slaughter pig and piglet) and the main aim was to assess differences between line crosses (SY and ZY) and were performed in Minitab 18 or procedure GLM in SAS. To investigate health and social interactions, Minitab 18 was used for the analysis using the two-proportion test. In the two-proportion test for each age class, the proportions that were tested were between the two different line crosses and the occurrences of the different variables that were investigated. To investigate differences in pigs time budget between the two line crosses, procedure GLM in SAS was used for the analysis. During the building of the models used in the GLM analyses, each response variable was tested against relevant predictor variables (Table 4, 5 and 6). Furthermore, least square means and standard errors for LSM were estimated for all significant effects to investigate the direction of the difference.

For the analyses, some of the predictor variables were classified into two groups. For sows, the predictor factor group size was divided into two classes; group size of seven sows or less, and group size with eight sows or more. Parity number was also divided into two classes; sows in parity three or less, and sows that were in parity four or higher, however, this factor was found to not be significant, and were therefore not included in any further analyses. For the analyses of piglets, the predictor variables age in days and group size were divided into two classes. For age in days, one class consisted of piglets that were ≤19 days old while the other class consisted of piglets that were ≥20 days old. For group size; one class were groups that consisted of ≤10 piglets while the other class where groups that consisted of ≥11 piglets. Regarding analyses for the slaughter pigs, the predictor variables age in days and group size were also divided into two classes. For age in days, one class consisted of pigs that were ≤120 days old, while the other class consisted of pigs that

were ≥121 days old. For group size; one class were groups that consisted of ≤7 pigs while the other class where groups that consisted of ≥8 pigs.

3.4.1 Health

For the health data, SAS was used for the descriptive statistics using procedures FREQ, and Minitab was used for the analysis using the two-proportion test.

Lameness and locomotion were scored as binary traits while the scoring of the different variables for wounds on the body combined scores from 0 to 2. In the statistical analysis, the different variables for wounds on the body were converted into a binary trait, thus score 1 and 2 was combined. This way, all variables for health were handled as a binary trait and the frequency show the prevalence of the different variables. In addition, a new variable for all wounds on the body (wounds on the ears, front, middle, hindquarters, legs and tail) was created, with the name total wounds on the body, and this new variable was also converted into a binary trait, thus score 1 and 2 was combined. No signs of stereotypic behaviour were observed and was therefore not analysed.

A chi-square test was performed to test differences between health regarding the variables for lameness, wounds on body and locomotion between the two line crosses. However, because the cells in the matrix of the chi-square test had fewer than five observations the results were only approximately, thus may not be a valid test. Therefore, Minitab was used with the procedure “two proportion test” to investigate health of the two different line crosses within the different age categories. The proportions that were tested was between the occurrences (event) of the different variables between the two different line crosses in the three different age categories.

The null hypothesis is that they are similar; H_o: $p_1 - p_2 = 0$, and the alternative hypothesis is that they are not similar; H_1:$p_1 - p_2 \neq 0$, thus indicating a significant difference between the line crosses.

3.4.2 Scan sampling

For the scan sampling data measuring the different variables of activity, body posture and location in the pen (Table 2), SAS was used for both the descrip-

tive statistics and statistical analysis. In the descriptive statistics for scan sampling, the procedure MEANS was used by line cross and age category to obtain the mean and standard deviation of the repeated scans over total number of animals observed within each line cross and age category.

The statistical analysis was made using the SAS software with the general linear model procedure (GLM). For the statistical analysis and during the building of the different models, relevant predictor variables and different interactions (e.g. line*age, line*group size, and age* group size) were tested and those that were not significant for the response variables was deleted from the model. P-values for the significant or biologically relevant effects included in the models are given in Table 4, 5 and 6 for sows, piglets and slaughter pigs respectively.

The final statistical models that were used was:
For sows:
Y= line cross + group size + line cross*group size + e
For piglets:
Y= line cross + age + group size + age*group size + line cross*age + e
For slaughter pigs:
Y= line cross + age + group size + day of observation + line cross*group size + e
Where Y is the different response variables and e is random residual.

Table 4. *P-values for the predictor variables for each response variable from the final model for sows. N = 16*

Response variable	**Line cross**	**Group size**	**Line cross*Group size**
Body posture			
Lying on side	0.2908	0.9043	0.5507
Lying on belly	0.7768	0.3085	0.9246
Sitting	0.4536	0.4536	0.4536
Standing	0.2919	0.2919	0.4245
Location in pen			
Lying area	0.1205	0.0637†	0.5877
Slatted area	-	-	-
Piglets corner	-	-	-
Sow feeding stall	0.1205	0.0637†	0.5877
Activity			
Eating	-	-	-
Drinking	0.3370	0.3370	0.3370
Suckling	-	-	-
Nosing/rooting pen floor	0.2563	0.6981	0.2563
Nosing/biting pen fitting	0.3177	0.1701	0.3177
Nosing/biting other pig	0.3370	0.3370	0.3370
Exploring enrichment material	1.0000	0.2577	0.5635
Nothing	0.2860	0.1881	0.5869

*** = $p < 0.001$ ** = $p < 0.01$ * = $p < 0.05$ † = $p < 0.1$ (tendency to significance)

- = if the location in pen was not available for the specific age category of animal, or if the activity or body posture did not occur during observation

Table 5. *P-values for the predictor variables for each response variable from the final model for piglets. N = 38.*

Response variable	**Line cross**	**Age**	**Group size**	**Age*Group size**	**Line cross*Age**
Body posture					
Lying on side	0.7394	0.9407	0.7880	0.1699	0.2489
Lying on belly	0.5494	0.0065**	0.0138*	0.4131	0.3965
Sitting	0.1048	0.7921	0.3619	0.3619	0.7990
Standing	0.6011	0.0111*	0.0486*	0.0223*	0.7078
Location in pen					
Lying area	0.5828	0.7245	0.6470	0.0016**	<.0001***
Slatted area	0.3289	0.1391	0.1114	0.0003***	<.0001***
Piglets corner	0.8265	0.1300	0.0885†	0.8065	0.7001
Sow feeding stall	-	-	-	-	-
Activity					
Eating	-	-	-	-	-
Drinking	1.0000	0.0006***	0.0025**	0.0025**	1.0000
Suckling	0.8875	0.1298	0.6142	0.0526†	0.1468
Nosing/rooting pen floor	0.5189	0.0524†	0.6579	0.6086	0.4034
Nosing/biting pen fitting	0.5919	0.4383	0.3695	0.3695	0.4398
Nosing/biting other pig	0.9349	0.7719	0.8253	0.1747	0.6662
Exploring enrichment material	0.3791	0.5020	0.8952	0.8952	0.3791
Nothing	0.6606	0.0096**	0.2468	0.0108*	0.3028

*** = $p < 0.001$ ** = $p < 0.01$ * = $p < 0.05$ † = $p < 0.1$ (tendency to significance)

- = if the location in pen was not available for the specific age category of animal, or if the activity or body posture did not occur during observation

Table 6. *P-values for the predictor variables for each response variable from the final model for slaughter pigs. N = 40.*

Response variable	**Line cross**	**Age**	**Group size**	**Day of observation**	**Line cross*Group size**
Body posture					
Lying on side	0.1640	0.9856	0.9856	0.7290	0.1806
Lying on belly	0.8908	0.8252	0.7784	0.2918	0.5548
Sitting	0.7923	0.8417	0.7477	0.7896	0.3856
Standing	0.0890†	0.7844	0.8251	0.3012	0.0483*
Location in pen					
Lying area	0.9696	0.0820†	0.1948	0.2460	0.0904†
Slatted area	0.9696	0.0820†	0.1948	0.2460	0.0904†
Piglets corner	-	-	-	-	-
Sow feeding stall	-	-	-	-	-
Activity					
Eating	0.6367	0.3837	0.9329	0.5170	0.6367
Drinking	0.8685	0.1476	0.1476	0.0189*	0.8685
Suckling	-	-	-	-	-
Nosing/rooting pen floor	0.1485	0.4971	0.2420	0.1438	0.0784†
Nosing/biting pen fitting	0.4771	0.5434	0.1169	0.6141	0.7181
Nosing/biting other pig	0.6606	0.3826	0.0200*	0.0361*	0.6468
Exploring enrichment material	0.4563	0.1293	0.8755	0.0078**	0.6278
Nothing	0.2014	0.5354	0.0955†	0.0739†	0.1168

*** = $p < 0.001$ ** = $p < 0.01$ * = $p < 0.05$ † = $p < 0.1$ (tendency to significance)

- = if the location in pen was not available for the specific age category of animal, or if the activity or body posture did not occur during observation

Furthermore, least square means and standard errors were estimated for all significant effects in each of the models to investigate the direction of the difference.

3.4.3 Continuous observation

For the continuous observation data, SAS was used for the descriptive statistics by using procedure FREQ by age category when investigating the reaction of receiving pigs to the behaviour of the performing pig. Furthermore, procedure FREQ was also used by age category and line cross to obtain frequencies of each performed social behaviour by the total number of animals within each age category and line cross.

Due to low incidence on all variables investigated in the continuous observation (Table 2), except for nosing and head knock, the variables were merged together, and new variables were created. The new variable biting was created and consisted of the variables nibbling/biting, tail biting, vulva biting and ear biting. The new variable climb consisted of the variables climbing and riding. The new variable push consisted of the variables lifting and pushing. The variables of belly massage and nosing teat/suckling was merged to new variable named nosing belly region.

The GLIMMIX procedure in SAS was used for the statistical analysis but did not work due to the small variation and limited data set. Therefore, Minitab was used for the analysis with the procedure “two proportion test” to investigate social interactions of performing pigs of the two different line crosses and in different age categories. The proportions that were tested was between the occurrences (event) of the different variables between the two different line crosses in the three different age categories.

The null hypothesis is that they are similar; H_o: $p_1 - p_2 = 0$, and the alternative hypothesis is that they are not similar; H_1:$p_1 - p_2 \neq 0$, thus indicating a significant difference between the line crosses.

4 Results

The protocols that were developed and used for data collection are presented in Appendix 1, 2 and 3.

4.1 Health

No signs of stereotypic behaviours (sham chewing, bar/trough/drinker biting, tongue rolling, teeth grinding and floor licking) could be observed on any of the animals.

Neither the SY or the ZY sows showed any signs of lameness, wounds on the tail or not normal locomotion (Table 7). The line crosses had different proportions of sows that showed signs of wounds on the ears, while wounds on the middle part of the body and on the legs were only found among ZY sows. When comparing the two line crosses, no significant differences of the health variables were found except for the variable wounds on ears, were SY sows had significantly more wounds on the ears compared to ZY sows (Table 7).

Table 7. *Total number of sows observed in each line cross and proportion (%) of sows that showed lameness, wounds on body and not normal locomotion. Results from the two proportion test regarding Z-value and P-value.*

	SY	**ZY**	**Z-value**	**P-value**
N	8	8		
Lameness	0.0	0.0	-	-
Locomotion	0.0	0.0	-	-
Wounds on body – ears	87.5	37.5	2.41	0.016
Wounds on body – front	87.5	75.0	0.65	0.516
Wounds on body – middle	0.0	25.0	-1.63	0.102
Wounds on body – hindquarters	37.5	37.5	0.00	1.000
Wounds on body – legs	0.0	12.5	-1.07	0.285
Wounds on body – tail	0.0	0.0	-	-
Total wounds on the body	100.0	100.0	-	-

Neither the SY*H and ZY*H piglets showed any signs of having wounds on the tail. When comparing the two line crosses, no significant differences in the different health variables were found, but a tendency (P=0.062) for higher proportion of ZY*H piglets with wounds on the hind quarters compared to SY*H piglets could be found, see Table 8.

Table 8. *Total number of piglets observed in each line cross and proportion (%) of piglets that showed lameness, wounds on body and not normal locomotion. Results from the two proportion test regarding Z-value and P-value.*

	SY*H	**ZY*H**	**Z-value**	**P-value**
N	16	22		
Lameness	0.0	4.5	-1.02	0.306
Locomotion	0.0	4.5	-1.02	0.306
Wounds on body – ears	6.2	4.5	0.23	0.820
Wounds on body – front	37.5	36.4	0.07	0.943
Wounds on body – middle	6.2	13.6	-0.78	0.437
Wounds on body – hindquarters	6.2	27.3	-1.87	0.062
Wounds on body – legs	6.2	0.0	1.03	0.302
Wounds on body – tail	0.0	0.0	-	-
Total wounds on the body	50.0	50.0	0.00	1.000

When comparing slaughter pigs of the two line crosses, a significant difference could be found regarding wounds on the middle part of the body, where SY pigs had more wounds than ZY pigs had, see Table 9.

Table 9. *Total number of slaughter pigs observed in each line cross and proportion (%) of slaughter pigs that showed lameness, wounds on body and not normal locomotion. Results from the two proportion test regarding Z-value and P-value.*

	SY*H	**ZY*H**	**Z-value**	**P-value**
N	22	18		
Lameness	4.5	5.5	-0.14	0.885
Locomotion	9.1	22.2	-1.14	0.256
Wounds on body – ears	9.1	5.5	0.43	0.665
Wounds on body – front	90.9	88.9	0.21	0.834
Wounds on body – middle	72.7	22.2	3.70	<0.0001
Wounds on body – hind-quarters	27.3	50.0	-1.50	0.133
Wounds on body – legs	13.6	16.7	-0.27	0.791
Wounds on body – tail	0.00	0.00	-	-
Total wounds on the body	100.00	94.44	1.03	0.303

4.2 Scan sampling

The mean and standard deviation for the time spent in the different variables of body posture, location in the pen and activity were estimated per line cross and age category that were recorded during the scan sampling is shown in Table 10. There were no significant differences between SY and ZY sows for any of the variables (Table 11).

Table 10. *Frequency table for scan sampling. Mean and standard deviation (std) of proportion (%) of scans (and thus time) spent in different body postures, location in pen and activity over total number of animals observed within each age category and line cross.*

	Piglet		**Piglet**		**Slaughter pig**		**Slaughter pig**		**Sow**		**Sow**	
Line cross	SY*H		ZY*H		SY*H		ZY*H		SY		ZY	
N – animals	16		22		22		18		8		8	
Body posture	mean	std	mean	std	mean	std	mean	std	mean	std	mean	std
Lying on side	23.9	15.44	21.5	14.99	33.7	13.63	29.5	19.05	26.4	19.64	13.9	22.81
Lying on belly	40.6	19.69	45.2	14.82	38.9	16.68	46.7	24.86	55.6	27.86	59.7	27.82
Sitting	0.0	0.00	1.7	4.70	4.1	7.57	2.4	4.92	5.6	8.40	2.8	5.14
Standing	35.5	16.49	31.5	17.51	22.9	12.92	21.4	16.91	12.5	13.85	23.6	24.81
Location in pen												
Lying area	55.3	20.07	58.5	20.72	54.5	24.61	67.7	22.13	94.4	11.88	81.9	19.64
Slatted area	23.6	18.17	24.6	15.73	45.4	24.61	32.3	22.13	0.0	0.00	0.0	0.00
Piglets corner	21.0	14.79	16.9	16.29	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Sow feeding stall	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	5.6	11.88	18.1	19.64
Activity												
Eating feed	0.0	0.00	0.0	0.00	2.1	4.02	1.7	5.15	0.0	0.00	0.0	0.00
Drinking	1.2	3.42	0.0	0.00	1.9	3.57	0.9	2.69	0.0	0.00	1.4	3.93
Suckling	20.3	10.96	17.8	12.33	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Nosing/rooting pen floor	2.4	5.70	3.1	6.42	5.4	7.56	4.4	7.58	2.8	5.14	6.9	8.27
Nosing/biting pen fitting	2.9	5.62	1.2	4.26	5.9	7.31	5.6	7.02	4.2	8,27	11.1	17.82
Nosing/biting other pigs	11.9	9.57	12.5	9.92	12.1	9.69	9.3	8.77	1.4	3.93	0.0	0.00
Exploring enrichment material	10.2	7.62	7.3	7.70	5.8	6.04	8.5	7.32	12.5	9.27	12.5	9.27
Nothing	50.9	17.19	58.0	15.79	66.8	9.24	69.6	13.79	79.2	12.51	68.1	25.50

Table 11. *LSM and SE for sows (%) within each line-cross. Number of observations read and used: 16*

	SY		**ZY**			
Response variable	LSM	SE	LSM	SE	P	F
Body posture						
Lying on side	26.4	7.99	13.9	7.99	0.2908	1.22
Lying on belly	55.5	10.16	59.7	10.16	0.7768	0.08
Sitting	5.5	2.54	2.8	2.54	0.4536	0.60
Standing	12.5	7.13	23.6	7.13	0.2919	1.22
Location in pen						
Lying area	94.4	5.29	81.9	5.29	0.1205	2.79
Slatted area	0.0	0.00	0.0	0.00	-	-
Piglets corner	0.0	0.00	0.0	0.00	-	-
Sow feeding stall	5.55	5.29	18.1	5.29	0.1205	2.79
Activity						
Eating	0.0	0.00	0.0	0.00	-	-
Drinking	0.0	0.98	1.4	0.98	0.3370	1.00
Suckling	0.0	0.00	0.0	0.00	-	-
Nosing/rooting pen floor	2.8	2.47	6.9	2.47	0.2563	1.42
Nosing/biting pen fitting	4.2	4.71	11.1	4.71	0.3177	1.09
Nosing/biting other pig	1.4	0.98	0.0	0.98	0.3370	1.00
Exploring enrichment material	12.5	3.31	12.5	3.31	1.0000	0.00
Nothing	79.2	7.04	68.1	7.04	0.2860	1.25

To analyse the direction of the difference, least square means and standard errors were estimated for all significant effects in each of the models. For piglets, a significant interaction between line cross and age of the piglets were found regarding location in the pen, SY*H piglets of the younger age class (19 days or younger) spent more time in the lying area compared to ZY*H piglets of the same age class (0.7 ± 0.06 compared with 0.5 ± 0.05 (LS-mean

± SE), P = <0.0016). In the older age class (20 days or older), on the contrary, ZY*H piglets that spent more time located in the lying area compared to SY*H piglets in the same age class (0.8 ± 0.07 compared with 0.4 ± 0.05 (LS-mean ± SE), P = 0.0009). A significant interaction between line cross and age of the piglets were also found regarding time spent located in the slatted area, as ZY*H piglets of the younger age class (19 days old or younger) spent more time in the slatted area compared to SY*H piglets of the same age class (0.3 ± 0.04 and 0.1 ± 0.04 respectively (LS-mean ± SE), P = 0.0006). However, SY*H piglets of the older age class (20 days old or older) spent more time located in the slatted area compared to ZY*H piglets in the same age class (0.3 ± 0.04 and 0.0 ± 0.06 respectively (LS-mean ± SE), P = <.0001).

The age of the piglets influenced the body posture as piglets of the younger age class (19 days or younger) spent more time lying on belly, compared with piglets of the older age class (20 days or older). Piglets of the older age class did however spend more time standing compared to younger piglets. The time spent in performing different activities were also affected by the age of the piglets. Piglets of the younger age class spent more time performing nothing compared to older piglets, and piglets of the older age class spent more time performing drinking behaviour compared to younger piglets. Furthermore, the group size affected the piglets body posture as piglets in a larger group (eleven piglets or more) spent more time lying on belly compared to piglets in a smaller group (ten piglets or less). However, piglets in the smaller group class spent more time standing compared to piglets in the larger group class. The group size also influenced the drinking activity, since piglets in the smaller group size performed more drinking behaviour compared to piglets in the larger group class. In addition, there were a significant interaction between age of the piglets and group size regarding body posture, as piglets of the older age class spent more time standing compared to piglets of the younger age class when kept in the small group class. Significant interactions were also found between age of the piglets and group size regarding location in pen, as piglets of the older age class kept in the smaller group class spent more time in the lying area compared to piglets of the younger age class kept in the same group class. Piglets of the younger age class kept in the larger group class spent more time in the lying area compared to piglets of the older age class in the same group class. Younger piglets spent more time in the slatted area compared to older piglets when kept in a small group size while older piglets spent more time in the slatted area compared to younger piglets when kept in a larger group size. Moreover, a significant interaction was found between age of the piglets and the group size regarding activity. Older

piglets in the small group size spent more time performing drinking behaviour compared to younger piglets in the same group size. Younger piglets in the small group size spent more time doing nothing compared to older piglets in the same group size.

For slaughter pigs, a significant interaction between line cross and group size was found regarding the body posture, showing that slaughter pigs of cross ZY*H in the smaller group size (seven pigs or less) spent more time standing compared to SY*H slaughter pigs in the same group size (0.3 ± 0.11 compared with 0.1 ± 0.11 (LS-mean ± SE), P = 0.0496). Furthermore, group size was found to affect the activity of the slaughter pigs, as pigs kept in larger group sizes (eight pigs or more) performed more nosing or biting on other pigs compared to pigs kept in smaller group sizes (seven pigs or less). The day of observation also influenced the activity of the slaughter pigs as more pigs performed drinking behaviour and nosing or biting on other pigs during the first observation day compared to the second observation day. On the second day of observation, more slaughter pigs explored the enrichment material compared to the first observation day.

4.3 Continuous observations

The proportion of pigs within each line cross that performed different social behaviours is shown in Table 12 for sows, Table 13 for piglets, and in Table 14 for slaughter pigs. In addition, when comparing the two line crosses, no significant differences for performing social behaviours were found for either sows (Table 12), piglets (Table 13) or slaughter pigs (Table 14).

Table 12. *Total number of sows observed within each line-cross and proportion (%) of sows that performed behaviour nosing, biting, head knock, climb, push or nosing in the belly region. Results from the two proportion test regarding Z-value and P-value.*

	SY	**ZY**	**Z-value**	**P-value**
N	7	6		
Nosing	57.1	66.7	-0.35	0.723
Biting	28.6	16.7	0.52	0.603
Head knock	0.0	16.7	-1.10	0.273
Climb	14.3	0.0	1.08	0.280
Push	71.4	33.3	1.48	0.139
Nosing belly region	0.0	0.0	-	-

Table 13. *Total number of piglets observed within each line-cross and proportion (%) of piglets that performed behaviour nosing, biting, head knock, climb, push or nosing in the belly region. Results from the two proportion test regarding Z-value and P-value.*

	SY	**ZY**	**Z-value**	**P-value**
N	16	22		
Nosing	87.5	72.7	1.17	0.241
Biting	43.7	45.4	-0.10	0.917
Head knock	31.2	31.8	-0.04	0.970
Climb	37.5	45.4	-0.49	0.621
Push	18.7	27.3	-0.63	0.531
Nosing belly region	18.7	4.5	1.32	0.185

Table 14. *Total number of slaughter pigs observed within each line-cross and proportion (%) of pigs that performed behaviour nosing, biting, head knock, climb, push or nosing in the belly region. Results from the two proportion test regarding Z-value and P-value.*

	SY	**ZY**	**Z-value**	**P-value**
N	21	15		
Nosing	52.4	60.0	-0.46	0.648
Biting	52.4	46.7	0.34	0.735
Head knock	14.3	20.0	-0.44	0.656
Climb	14.3	13.3	0.08	0.935
Push	23.8	26.7	-0.19	0.846
Nosing belly region	0.0	6.7	-1.04	0.301

The reaction of receiving pigs towards different behaviours performed by another pig is shown in Table 15 for sows, Table 16 for piglets and Table 17 for slaughter pigs.

Table 15. *Frequency table for sows that shows proportion (%) of the reaction by the receiving pig to the performing pig behaviours nosing, biting, head knock, climb, push and nosing belly region. N shows the total number of times each behaviour was observed.*

Performing pig behaviour	**N**	**No reaction**	**Avoid reaction**	**Return approach**	**Pig in other pen**
Nosing	17	94.12	0.00	0.00	5.88
Biting	6	16.67	16.67	16.67	50.00
Head knock	2	0.00	50.00	50.00	0.00
Climb	2	100.00	0.00	0.00	0.00
Push	10	20.00	60.00	20.00	0.00
Nosing belly region	-	-	-	-	-

Table 16. *Frequency table for piglets that shows proportion (%) of the reaction by the receiving pig to the performing pig behaviours nosing, biting, head knock, climb, push and nosing belly region. N shows the total number of times each behaviour was observed.*

Performing pig behaviour	**N**	**No reaction**	**Avoid reaction**	**Return approach**	**Pig in other pen**
Nosing	52	92.31	5.77	1.92	0.00
Biting	31	38.71	22.58	38.71	0.00
Head knock	29	20.69	34.48	44.83	0.00
Climb	31	54.84	32.26	12.90	0.00
Push	20	20.00	70.00	10.00	0.00
Nosing belly region	6	100.00	0.00	0.00	0.00

Table 17. *Frequency table for slaughter pigs that shows proportion (%) of the reaction by the receiving pig to the performing pig behaviours nosing, biting, head knock, climb, push and nosing belly region. N shows the total number of times each behaviour was observed.*

Performing pig behaviour	**N**	**No reaction**	**Avoid reaction**	**Return approach**	**Pig in other pen**
Nosing	38	81.58	10.53	0.00	7.89
Biting	61	55.74	21.31	16.39	6.56
Head knock	14	7.14	42.86	50.00	0.00
Climb	10	0.00	70.00	30.00	0.00
Push	18	16.67	61.11	22.22	0.00
Nosing belly region	2	100.00	0.00	0.00	0.00

5 Discussion

The overall aim of this MSc thesis was to develop protocols for recording of behaviour and health and to investigate if there are any differences in health and behaviour between the two different line crosses of pigs in three different age categories (sow, slaughter pig and piglet). Both health and behaviour were recorded with direct observations and was performed by the same person. Scan sampling was used to record the different variables of body posture, location in pen and activity and social behaviour was recorded with continuous observation. In the health assessment, lameness, locomotion and wounds on the body were investigated. Furthermore, registration of health and behaviour was done on an individual level in the pigs' home pen. A total of 94 pigs were included in this study, where 46 of the pigs was of line cross SY or SY*H and 48 was of line cross ZY or ZY*H. In addition, the pigs were divided into three different age categories, which resulted in a low number of pigs within each line cross and age category and should be considered when interpreting the results from this study.

5.1 Health assessment

For sows, no significant differences between the two different line crosses were found for any of the health variables (binary) except for the variable wounds on the ears. It was found that SY sows had significantly more wounds on the ears compared to ZY sows. The ears are one of the body parts that is primarily the target when pigs fight (McGlone 1985) and the result that showed that SY sows had more wounds on the ears compared to ZY sows may indicate that SY sows are involved in more fights compared to ZY sows. SY sows were also in a higher parity compared to ZY sows, the average parity was 5.4 ± 1.19 (Mean ± SD) and 2.7 ± 0.46 (Mean ± SD) for SY and ZY sows

respectively. Parity is one factor that can affect the level of aggressive behaviour in pigs and one study found that sows in high parity (4th parity or higher) initiated more fights and spent more time fighting compared to sows in lower parity (3rd parity or lower) (Strawford *et al*., 2008). Parity is positively correlated with social rank (Arey, 1999) and this may mean that the SY sows included in this study are likely to be high in rank while ZY sows are low in rank when considering their parity number. The scoring of skin lesions has been found to be negatively correlated with social rank (Martin & Edwards, 1994) and since the SY sows had more wounds on the ears compared to ZY sows, this can therefore indicate that SY sows may not be so high in rank. Moreover, social rank is also positively correlated with body weight of the sow (Arey, 1999), and the ZY sows maybe had a higher body weight than the SY sows and was therefore higher in rank. In the results from scan sampling, there is a difference in the mean values regarding the variable "nosing or biting on other pig" as SY sows performed this behaviour while this could not be seen on ZY sows (Table 10). Similar results could be seen in the results from the continuous observation were more SY sows performed biting behaviour compared to ZY sows (Table 12). However, this could not be proven to be significant different in the statistical analysis but may suggest that SY performed more biting behaviour compared to ZY sows which can lead to fighting and thus explain the wounds on the ears. In general, biting seemed to be a harmful social behaviour in this study because receiving pigs often respond to this behaviour either by avoidance or by returning the approach. It can also be assumed that the SY sows are being attacked more than the ZY sows because of the difference in wounds on the ears, as one study found a higher lesion score on sows that are being attacked more frequently (Tönepöhl *et al*., 2013). In addition, ear biting is an abnormal behaviour (Brunberg *et al*., 2011) that is harmful since it can adversely affect the animal welfare (Turner, 2011). SY sows had more wounds on the ears compared to ZY sows and this can imply that they are receiver of ear biting since this behaviour usually leads to skin lesions on the affected pig (Smulders *et al*., 2008; Taylor *et al*., 2010). Perhaps it is the ZY sows that is performer of the ear biting behaviour, but this could however not be proven in the statistical analysis for the behavioural observations. Furthermore, three of SY sows and one ZY sow included in this study had fresh and bleeding wounds on the ears on the day of observation, and it can be interpreted that there may be ongoing problem with either ear biting or fighting in the pen.

Furthermore, none of the SY and ZY sows included in this study showed any signs of lameness, wounds on the tail or not normal locomotion, and in the

statistical analysis no significant difference in the different variables for wounds on the body, except for the ears, could be proven (Table 4). Aggressive encounters between pigs often results in wounds (McGlone, 1985; Turner *et al*., 2006) and increase the risk for lameness (EFSA, 2007a). Fighting between pigs are usually caused by mixing unfamiliar pigs (Meese & Ewbank, 1973, Stukenborg *et al*., 2011), over different resources (Krauss & Hoy, 2011) or when the feed is given restrictively and in a limited space (Špinka, 2009). The sows included in this study were not mixed prior to the observation and since a social hierarchy is established within 48 hours after mixing (Meese & Ewbank, 1973) it can therefore be assumed that the sows have already formed a stable hierarchy at the time for this study which can explain the low levels of aggressive behaviour and why the sows was not affected by wounds, lameness or not normal locomotion to a greater extent. In addition, every sow had access to its own feeding stall and did not have to compete over feed. All sows were also kept on a deep straw bedding which provides opportunities for exploration and foraging. Since the sows in this study were fed restrictively, access to foraging material is especially important to decrease the risk of frustration (EFSA 2007b). Frustration can lead to development of some abnormal behaviours (Van Putten & Dammers, 1976; Moinard *et al*., 2003; EFSA, 2007c) which in turn can results in wounds on the receiving pig (Van Putten & Van De Burgwal, 1990; Straw & Barlett, 2001; Smulders *et al*., 2008; Taylor et al., 2010). Inappropriate flooring is also a factor that influence the prevalence of lameness (EFSA, 2007a). The sows in this study was kept on a deep straw bedding and housing with deep bedding has been found to decrease the incidence of lameness compared to housing with slatted floor (KilBride *et al*., 2009). Hence it can explain why none of the sows in this study showed any signs of lameness and not normal locomotion.

For piglets, no significant differences in health could be found between the two different line crosses except for a tendency for a higher proportion of ZY*H piglets with wounds on the hindquarters compared to SY*H piglets. This may indicate that ZY*H piglets are less aggressive or lose more fights than SY*H piglets because when a pig tries to retreat from a fight, the opponent pig will target the bites against the rear part of the body (Meese & Ewbank, 1973) and pigs that are being recipient of non-reciprocal aggression sustain more skin lesions on the rear part of the body (Turner *et al*., 2006). The results of behaviour recording can however not support this since the difference in mean values in scan sampling for different behaviours are relative similar between the two line crosses (Table 10) and the same results can

be seen in the results from continuous observation (Table 14). Furthermore, none of the SY*H piglets included in this study showed any signs of lameness and not normal locomotion.

For slaughter pigs, no significant differences could be found between the two line crosses of pigs for the health variables except for wounds on the middle part of the body. It was found that SY*H slaughter pigs had significantly more wounds on the middle part of the body. One study found a high positive genetic correlation between being recipient of non-reciprocal aggression and skin lesions on the middle part of the body (Turner *et al*., 2009). However, another study by Turner *et al*. (2008) found a high positive genetic correlation between being involved in reciprocal fighting and skin lesions on the middle part of the body. This study cannot answer if the SY*H pigs have wounds on the middle part of the body because they are being recipient of non-reciprocal aggression or if they are being involved in reciprocal aggression. The results of the behavioural observations cannot support any of these statements since the difference in mean values in scan sampling for different behaviours are relative similar between the two line crosses (Table 10) and the same results can be seen in the results from continuous observation (Table 13). Furthermore, the slaughter pigs of both line crosses included in this study was generally very dirty on the legs which made it difficult to see and thus count any wounds on the legs. Because of this, pigs with dirty legs were scored with a 0 which causes the result for this variable to be misleading as wounds may be underneath the dirt.

None of the pigs included in this study showed any signs to be affected by wounds on the tail. Tail biting is an abnormal behaviour that may occur in pigs (Brunberg *et al*., 2011) and frustration or stress for the animal is often the underlying cause of this behaviour (Moinard *et al*., 2003, EFSA 2007c). Tail biting can be triggered by several factors but the high motivation to perform both foraging and exploratory behaviour is one of the major reasons behind the development of this behaviour in pigs (Moinard *et al*., 2003, EFSA 2007c). If there is a shortage of foraging material in the pen the risk for frustration increases (EFSA, 2007b). All pigs in this study had access to straw and straw has been found to lower the prevalence of tail biting compared to if the pig does not have access to straw (Taylor *et al*., 2010). It makes sense that the access of foraging material, in this case straw, promotes exploratory and foraging behaviour for the animals and thus decrease the risk of develop abnormal behaviours, and may explain why none of the SY or ZY pigs in all

three age categories did not showed any signs to be affected by wounds on tail.

5.2 Social behaviour

This study could not show any significant differences in social behaviours between the two different line crosses of pigs within the three different age categories. The descriptive statistics about the reaction of receiving pigs towards different social behaviour performed by another pig show that head knock, push and biting behaviour is more severe social behaviours in sows (Table 15) since the reaction of the receiving pig to these behaviours often is to avoid the performing pig or to return the approach. The same results can be found for piglets (Table 16) and slaughter pigs (Table 17) were severe social behaviours are head knock, push, climb and biting behaviour. These behaviours are often seen when pigs fight (Špinka, 2009). For all age categories, nosing behaviour of the performing pig seemed to be the most common social interaction and usually do not give any reaction of the receiving pig and can therefore be assumed to not be a harmful social behaviour.

5.3 Activity, body posture and location in pen

For sows, no significant differences between the two different line crosses for any of the variables of body posture, location in pen and activity were found. This can be due to that the number of sows included in this study are too low to be able find any significant differences between the two line crosses.

For piglets, significant interactions between line cross and age of the piglets were found regarding time spent in different locations in the pen. In the younger age class of piglets (19 days or younger), SY*H piglets spent more time in the lying area compared to ZY*H piglets but the in the older age class (20 days or older) it was ZY*H piglets that spent more time in the lying area compared to SY*H piglets. For time spent in the slatted area, ZY*H piglets in the younger age class spent more time in this area compared to SY*H piglets in the same age class. In the older age class, it was the opposite results, SY*H piglets spent more time in the slatted area compared to ZY*H piglets. This mean that when the piglets are 19 days or younger, SY*H piglets spend more time in the lying area and less in the slatted area compared to ZY*H piglets which spend more time in the slatted area and less in the lying area but when they grow older this change to the opposite.

For slaughter pigs, a significant interaction between line cross and being kept in the smaller group size (seven pigs or less) regarding the variable “standing” were found as ZY*H slaughter pigs spent more time standing compared to SY*H in the same group size. It is difficult to interpret what this result means more than that ZY*H slaughter pigs spent more time standing than SY*H pigs. In this case, standing was measured as the body posture of the pig and what the pig was doing while standing could not be shown in these results and standing can be comprised with all the different activity behaviours investigated during scan sampling.

In general, ZY sows and ZY*H slaughter pigs seem to be more active compared to SY sows and SY*H slaughter pigs according to the mean values regarding the variable for activity “nothing” given from the results from scan sampling (Table 10). On the contrary, SY*H piglets seem to be more active than ZY*H piglets. However, this could not be proven to be significant different in the statistical analysis.

5.4 Method

The small sample size in this study is not representative for the whole population of SY and ZY pigs and a larger number of animals included in the study would be preferred to be able to draw significant conclusions if there are any differences in health and behaviour between SY and ZY pigs. However, the ending of breeding SY pigs was announced in the year 2012 (Lundeheim & Hansson, 2012) and this has caused that SY pigs is no longer available and those SY pigs that remain is either old or mixed with others lines of pigs. In this study the SY sows were older than the ZY sows since SY sows was either in parity four, six or seven while ZY sows was in parity two or three. Hence, almost complete confounding parity within line cross. The slaughter pigs and piglets in this study was not purebred but had all Hampshire as sire breed and this may also have affected the results and it would have been interesting to use animals of the same age and animals that were purebred. Additionally, since twelve different boars was used as sire breed to the piglets and slaughter pigs included in this study this may have affected their behaviour in different ways and hence the result in this study.

In this study, scan sampling was used to record different variables of body posture, location in the pen and activity, and continuous observation was used

to record social interaction. In this study, all recording for health and behaviour were only performed on one day for every focal animal. To get more accurate results it may have been a good idea to repeat the behavioural observations numerous times on each focal animal. Furthermore, to have a longer recording time than five minutes for the continuous observation could also have been preferred in order to be able to observe more behaviours that may have a low frequency, such as abnormal behaviours and stereotypies. The short observation period for the continuous observation (five minutes) and the fact that it was only performed once on each focal animal can explain why no stereotypies could be observed in this study. All observations were made in the pigs' home pen and it may have influenced the result. It can be hard to visualize the pigs' movements and detect any signs of lameness or not normal locomotion when sows are kept on a deep straw bedding, or when piglets and slaughter pigs are walking on slatted floor. Perhaps the pigs' movement should have been investigated in an alley with solid floors and with no obstruction in form of other pigs' or deep bedding to get the most accurate assessment. Wounds on the body can also be missed, especially if they are small or if the animal is located far from the observer which is a risk when investigating the pig from outside the pen. In this study, only one side of the pig were evaluated when counting the wounds and it would have been interesting to investigate both sides of the animals since a skin lesion score for both sides could have given a more truthful result. Both lameness and locomotion were scored as binary traits, and in the statistical analysis the different variables for wounds on the body were also converted into binary traits. By doing in this way, it does not consider the severity of the traits which could have been of interest. Additionally, by doing the behavioural observations in the pigs' home pen there is no need for interaction with the animals, which can disturb them and alter their behaviour, and in this way the impact of the observer was reduced as much as possible. But still there was human presence in this study that may affect the behaviours being studied.

Relatively few significant differences were found in this study and it is possible that the observed differences are due to chance. Because of the small sample size in this study, it is difficult to say if the significant differences are due by chance or not, and a more reliable result would be obtained if the sample size was larger as it is then more likely that the observed differences have not occurred by chance. There is also a possibility that behaviour and health can differ between individuals, regardless of line cross, and it makes it more difficult to say if the chance may have given rise to the difference or not. The lack of significant results in this study may be caused by either the

small sample size or because there is no difference between the two line crosses regarding behaviour and health.

6 Conclusion

In general, no differences were found in health between the two different line crosses in neither of the three different age categories except for SY sows that had significantly more wounds on the ears compared to ZY sows and SY*H slaughter pigs had more wounds on the middle part of the body than ZY*H slaughter pigs. There was also a tendency that ZY*H piglets had more wounds on the hindquarters compared to SY*H piglets. When the different variables of body posture, location in pen and activity were analysed, no differences were found between SY and ZY sows. Significant interactions were also found between line cross and age of the piglets regarding their location in pen. For slaughter pigs, only one significant interaction was found between the line cross and being kept in a small group size regarding the body posture "standing", were ZY*H pigs spent more time standing compared to SY*H pigs in that small group size. Furthermore, no differences in social behaviours could be found between the two different line crosses in the three different age categories.

Due to the small and limited data set available in this pilot study, it was difficult to examine if there are any differences in health and behaviour between SY and ZY pigs and the results that were found in this study may not be representative for the whole population of the two different line crosses of pigs and that should be considered. However, another aim of this MSc thesis study was to develop and test relevant protocol that could be used in the larger Formas project: "Improving sow welfare in group housing systems", and it was successful.

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Appendix 1: Scan sampling

The protocol for scan sampling that was created from the ethogram (Table 2) and used in the data collection for behaviour recording e.g. on foraging- and exploration behaviour.

Date: Category of animals: Section: Pen: Litter size: Sow:

Individual 1; Individual 2;
Colour (ID-number): Colour (ID-number):

Scan	Time	Individual	Body posture				Location in pen				Activity							
			Lying on side	Lying on belly	Sitting	Standing	Lying area	Slatted area	Piglets corner	Sow feeding stall	Eating feed	Drinking	Suckling	Nosing/rooting pen floor	Nosing/biting pen fitting	Nosing/biting other pig	Exploring enrichment material	Nothing
1		Individual 1																
		Individual 2																
2		Individual 1																
		Individual 2																
3		Individual 1																
		Individual 2																
4		Individual 1																
		Individual 2																
5		Individual 1																
		Individual 2																
6		Individual 1																
		Individual 2																
7		Individual 1																
		Individual 2																

Scan	Time	Individual	Body posture				Location in pen				Activity							
			Lying on side	Lying on belly	Sitting	Standing	Lying area	Slatted area	Piglets corner	Sow feeding stall	Eating feed	Drinking	Suckling	Nosing/rooting pen floor	Nosing/biting pen fitting	Nosing/biting other pig	Exploring enrichment material	Nothing
8		Individual 1																
		Individual 2																
9		Individual 1																
		Individual 2																
10		Individual 1																
		Individual 2																
11		Individual 1																
		Individual 2																
12		Individual 1																
		Individual 2																
13		Individual 1																
		Individual 2																
14		Individual 1																
		Individual 2																
15		Individual 1																
		Individual 2																
16		Individual 1																
		Individual 2																

Appendix 2: Continuous sampling

The protocol for the continuous sampling that was created from the ethogram (Table 2) and used in the data collection for behaviour recording e.g. on social behaviours.

Date: Start time: Stop time: Category of animals: Section: Pen: Litter size: Sow:

Colour (ID-number): Colour (ID-number):

Performing pig behaviour												Vocalisation			Focal animal's role		Receiving pig behaviour				Vocalisation		
Nosing	Nibbling/ biting	Tail biting	Vulva biting	Ear biting	Head knock	Climbing	Riding	Lifting	Pushing	Belly massage	Nosing teat/ suckling	Low vocalisation	Scream	No	Performing pig	Receiving pig	No reaction	Avoiding	Return approach	Other pen	Low vocalisation	Scream	No

Comments:

Stereotypes – note all occurrence, on all animals in the pen. Yes: No:

If yes, note which kind of stereotype and number of pigs performing them:

Appendix 3: Health protocol

The health protocol that was used in the data collection to investigate health and welfare of the individual pig. The protocol was based on protocols and definitions from Welfare Quality® (2009) and Eliasson (2013). Any signs of stereotypic behaviour in the pen during the observation was also noted.

Colour (ID-number):

Lameness		Wounds on body						Locomotion	
Yes	No	Ears	Front	Middle	Hind-quarters	Legs	Tail zone	Normal	Not normal

Colour (ID-number):

Lameness		Wounds on body						Locomotion	
Yes	No	Ears	Front	Middle	Hind-quarters	Legs	Tail zone	Normal	Not normal

Comments (note if problems with stereotypies and abnormal behaviours occurs in the pen and on how many pigs):

Lameness (sow, growing pigs, piglets)

Method description: the assessor must ensure that, before starting the observation, that the pig has been walking a certain distance.

The pig is observed from the front, side or back, and the assessor is observing from outside the pen.

Additionally, the assessor should ensure that there is a clear and unobstructed view as possible of the moving animal.

Classification:

No - Normal gait, or the animal has difficulties walking but is still using all its legs, the stride may be shortened and/or there may be a swagger of the caudal part of the body when walking

Yes - The animal is severely lame; it put a minimum of weight on the affected limb (asymmetric walking) or there is no weight-bearing on the affected limb, or the animal is unable to walk

Wounds on body (sows, growing pigs, piglets)

Method description: wounds on the body are visually assessed by inspecting on side of the animal's body. Choose the side with the optimal view for observation. Each body region will be assigned with a score. Wounds on the body can be scratches (surface penetration of the epidermis) or wounds (penetration of the muscle tissue). Where scabs have formed, they will count as a single lesion if they form a continuous line. When assessing the size of a wound, consider its largest dimension.

Classification:

0 – No visible skin injuries 1 – 1 to 5 lesions visible 2 – > 5 lesions visible

Locomotion (sow, growing pigs, piglets)

Classification: Normal if the pig has a regular locomotion with flexible movements and no lameness. Not normal if the pig has stiff and tripping movements with short steps.