Sveriges lantbruksuniversitet
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– investigation of differences between two genotypes

Gyltors respons vid beteendetester
– undersökning av skillnader mellan två genotyper

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Abstract

When the breeding with the Swedish Yorkshire (SY) breed ended in 2012, the Dutch Yorkshire (ZY) breed was introduced to Swedish pig producers. Swedish farmers have noticed behavioural differences between SY sows and ZY sows. Different breeding goals and selection environment for the two breeds (different production systems, e.g. single or group housing systems) and different management could cause such behaviour differences. Some behaviours of importance in pig production are aggressive behaviour towards unfamiliar pigs, response towards handling and adaption to environmental changes. The aim of this MSc thesis was to assess differences in reaction in behaviour tests between the breed crosses SY*Hampshire (H) and ZY*Hampshire (H). In total, five behaviour tests were performed: a back test, a human approach test, a novel object test, a suddenness test and an intruder test were performed on 60 gilts in three different age categories (20 individuals in each category): at 10-21 days of age, at 2.5 months of age and at 5 months of age. Half of the gilts were crossbreed SY*H and the other half were crossbreed ZY*H. The SY*H gilts had a tendency to adapt their behaviour patterns towards changing stimuli more easily. In addition, the ZY*H gilts showed tendencies to be more fearful of humans than the SY*H gilts. Knowledge about the behavioural differences between the breeds and the biological background of the differences are important to take into consideration in order to adapt management to the animal material being used.

Sammanfattning

Efter att den svenska yorkshire aveln avslutades 2012 började den nederländska yorkshire, även kallad för Z-linjen av Yorkshire, användas i Sverige. Svenska grisproducenter har noterat beteendeskillnader mellan korsningssuggorna (Y*L), beroende på om svensk Yorkshire (SY) eller nederländska Yorkshire (ZY) ingår. Detta kan indikera genetisk skillnad mellan de två raserna som påverkar grisarnas beteende. Dessa beteendeskillnader kan bero på till exempel olika avelsmål, olika selektionsmiljö, olika produktionssystem, djurvälfärdskrav och skötselrutiner i dessa länder. Två beteenden som kan vara av betydelse för utveckling av skötselrutiner i grisproduktion är aggressivt beteende gentemot andra grisar, reaktion gentemot skötare samt anpassning vid miljöombyten. Totalt genomfördes 5 beteendetester: fixerings test, mänsklig närvaro test, främmande föremål test, plötslighets test och inkräktar test på 60 gyltor. Gyltorna var från tre olika ålderskategorier; 10-21 dagar gamla, 2,5 månader gamla och 5 månader gamla. Hälften av gyltorna var av raskorsningen SY*Hampshire (H) och hälften var av raskorsningen ZY*H. Beteendeskillnaderna som påvisades mellan raserna var bland annat att SY*H gyltorna hade tendenser till att anpassa sitt beteende till en förändring i miljön lättare samt att ZY*H gyltorna tenderade till att vara mer rädda för människor än vad SY*H gyltorna var. Kunskap om beteendeskillnaderna samt de bakomliggande orsakerna till skillnaderna är viktiga att ta hänsyn till för att utveckla skötselrutiner som är anpassade för djurmaterialet som används.

Primär syftet med studien var att undersöka ifall det fanns någon skillnad i reaktion vid beteendetester mellan två olika genotyperna. Ett annat syfte var att undersöka ifall denna respons ändrades över tid inom varje enskilda test. Ett annat ändamål med studien var att utveckla beteendetester som kan genomföras rutinmässigt.

Abbreviation

Abbreviation	Complete concept
SY	Swedish Yorkshire
ZY	Dutch Yorkshire, Z-line
H	Hampshire
HR	High Resistant
LR	Low Resistant
HA	Human approach test
NO	Novel object test
SU	Suddenness test
IN	Intruder test
BT	Back test
IQR	Interquartile range
W-value	Kendall's coefficient of concordance
P-value	Probability value
Diff CI	Confidence interval for the differences

Preface

I often think back to the different choices I have made in life that has led me to where I am today. I have a tendency to never regret anything I have done because honestly, one cannot change the past we can only learn from it. I think it is funny to think back to the exact moment, the exact choice one made that changed so much. For instance, if I had never met my ex-boyfriend, I would never be where I am today. He was the one informing me about SLU and this education. If it were not for him, I would probably have been a nurse today, which is a choice I will never regret. If I had not had the internship and one of SLUs pig farms in 2014, I would never have known that pig is my passion, the production animal that I would love to work with most. I guess all I want to say is never have any regrets and never be afraid to try something new. Learn from your experiences, both good and bad, because you never know which exact path is the one that will lead you into a better future.

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Cecilia Anderberg, my beloved mother who never stopped believing in me, even when I stopped believing in myself. She has always pushed me to be as good as I can be and I would not be where I am today if it was not for her.

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1. Introduction

Today's production-pig is domesticated from the wild boar and shows behaviour patterns similar to it's ancestor. Pigs form stable maternal social groups both in the wild and under feral conditions where the only new members accepted are piglets. In these stable maternal groups, disputes over resources are solved through agonistic behaviour (Graves, 1984; Gonyou, 2001). Agonistic behaviour can lead to fear (Price, 2008). Fear is a reaction towards danger (Bossy, 1998) and can lead to stress. Long-term stress can have a negative effect on the immune system and the individuals' overall health (Forkman *et al.*, 2006). In addition, fear reactions from pigs can affect farmers' safety (Waiblinger, 2009; Hemsworth and Boivin, 2011; Jones and Boissy, 2011). The main effect of domestication on fear related behaviours is reduced fear of humans (Price, 2008). Nevertheless, a predator-avoidance reaction towards humans is often observed in domesticated pigs (Forkman *et al.*, 2006). In the wild, fear reaction can be an advantage as it protects the animal from danger (Price, 2008). The level of fear reaction towards unfamiliar objects, animals and humans is heritable (Price, 2008).

The breeding of the Swedish Yorkshire (SY) ended in 2012 (Hansson and Lundeheim, 2013), and the Dutch Yorkshire (ZY) was thereafter introduced to Swedish pig producers. According to the breeding company, the new breed should provide farmers with animals with a high genetic potential for longevity, litter size, piglet survival and appropriate temperament beneficial for production (Brink, 2013). However, a personal observation has been made after working on different pig facilities and after talking to different pig producers and workers that there is a behavioural change in sows after this switch of breeding material. Thus, the SY and the ZY might have behaviour differences important for pig production in Sweden.

1.1 Aim of the study

The primary aim of this study was to investigate differences in response to five behaviour tests between gilts of two breed crosses (SY *Hampshire (H) or (ZY*SY)*H). The secondary aim was to study if the behavioural response to the five tests change over time within each test for the growing finishing gilts. Another purpose of the project was to develop behaviour tests that can be performed routinely in the pig facilities at Swedish University of Agricultural Science (SLU)'s research herd Lövsta.

2. Literature survey

2.1. Social behaviour in pigs

Today's production-pig (*Sus Scrofa*) is domesticated from the wild boar and express behaviours typical for it ancestor (Graves, 1984; Špinka, 2009). It is beneficial to understand the pigs' natural behaviours and biological needs when handling domesticated pigs. Stimuli is a change in the animals' internal and/or external surroundings that can have different effect on the animals' behaviour (Price, 2008). Social behaviours are behaviours that either are stimulated by, or have effect on, another pigs (Scott, 1962). Social behaviour in pigs is highly developed (Graves, 1984). The two most frequently observed social interactions are conflict and contest where agonistic behaviour can occur (Price, 2008). Agonistic (to struggle) (Scott, 1962) behaviours includes different actions where the animal either show expressions of dominance or submission, act in an offensive or defensive fight, or express active or passive avoidance (Price, 2008). Pigs can differ in behavioural and physiological reactions when exposed to the same situation (Lawrence *et al.*, 1991) due to e.g. learning from previous experiences (Price, 2008). Animals can, and do, temporarily suppress or adjust their behaviours to a more appropriate one when a situation change occurs (Olsson *et al*., 2011). Pigs form stable social groups with strict linear dominance relationship around several females (and their offspring) where disputes over scarce resources and maintenance of the hierarchy system are resolved by agonistic behaviour (Gonyou, 2001; Price, 2008; Špinka, 2009). The primary benefit of dominance hierarchy is the stabilization made by weakening the interaction and therefore the psychological and physical stress (Price, 2008).

2.1.1. Social structure – in the wild

Sows isolate themselves from the group before farrowing and stay solitary with their litter during the first two weeks. The piglets create a bond to the sow and form a social dominance structure within the litter directly after birth. After two weeks, the sow introduces the piglets to the rest of the group and the sows nurse their piglets together. At nursing, piglets from different litters form a dominance relationship amongst themselves. This early relationship with other individuals often continues until adulthood. The recognition and communication between individuals are based on visual, olfactory clues and auditory such as grunts and snarls. (Graves, 1984).

2.1.2. Social structure – in production (housing)

Sows in Sweden are group housed from weaning until one week before estimated farrowing, which correspond to the social structure in the wild. When farrowing, the sow is individually housed in a pen with a piglet corner that functions as a nest for the piglets. After weening, the piglets either remain in the farrowing pen or are moved to a growing stable. At roughly ten weeks of age the piglets are moved to a growing finishing stable. The litters are often intact and no interaction with individuals from other litters occurs, which differ from the conditions in the wild. Baxter *et al*. (2010) states that agricultural practice should centre around the animals' biological needs but often focuses on management restriction instead, which compromises the biological needs of the pigs (Baxter *et al*., 2010). Biologically, pigs do not accept unfamiliar pigs to be introduced into a stable group. High stocking density and mixing of sows after weaning can therefore lead to aggressive behaviour where submissive animals are unable to escape the dominant ones to a full extent (Keeling and Jensen, 2009). The housing system can differ between herds and countries due to e.g. different ethical values and legislations.

2.1.2.1 The Swedish legislations regarding pig production and housing

The Swedish animal welfare laws are stricter than the EUs mutual regulations (LRF 2015). According to the Swedish Animal Welfare Ordinance, pigs shall be loose (14§) (fixating is not allowed other than temporary (15§)) and pens shall have straw or other comparable material (16§) (SFS 1988:539). Pigs shall also be housed and managed in an environment where the animals can express natural behaviours (4§) (SFS, 1988:534).

2.1.2.2. EUs legislation – The Pig Directive

Pig specific regulations established in 1991 states that all newly built stables from 2003 and all stables after 2013 must have group housing for sows and gilts from four weeks after service to one week before farrowing. Individually housing of pigs is only allowed when the pig is aggressive in groups, have been attacked by another pig and/or is injured or sick. From January 1st 2013, all holdings should have enough space so that all pigs can lie down, rest and stand up without difficulties. (EC No 834/2007).

2.2. Behaviour tests for pigs for measuring fear and aggressive behaviour

Fear associated reactions prepares the animal to cope with danger (Forkman *et al.*, 2006) and has a survival value for wild animals (Boissy, 1998). There are different behaviour tests designed to measure the animals' tendency to react aggressively or fearfully during a specific situation, such as when exposed to novel objects, humans or unfamiliar pigs (Olsson *et al.*, 2011). Most tests designed to measure fear response in pigs have a relative low inter-test correlation and are not well validated (Forkman *et al.*, 2006). Behaviour tests focused on agonistic behaviours reveals the difference between conflicts that include bodily contact and conflicts without a physical contact for understanding the true meaning of aggression (Price, 2008).

2.2.1 The Back test (BT)

The Back test (BT), also called tonic immobility test, is usually used with piglets to measure their level of fear (Hessing *et al.*, 1994). The results from the back test is later used to categorize piglets into different coping characteristics (Bolhuis *et al.*, 2003). The piglets' behavioural response during this test is believed to expose their "personality" or "coping style" (Hessing *et al.*, 1994). The piglets are categorised depending on their amount of struggle while being held down on their backs. The piglets that struggles more frequently during the test are referred to as "high-resisters" (HR) while the piglets that are more immobilised during the test are referred to as "low-resisters" (LR). Hessing *et al*. (1994) and Bolhuis *et al*. (2003; 2004; 2005) grouped piglets into the two coping categories and when the pigs were older, they found internal and behavioural differences within and between the two categories. Furthermore, studies on genetic influence on piglets' response in back tests show a breed difference between e.g. the Yorkshire and the Landrace (de Sevilla *et al.*, 2009) and between the Yorkshire*Landrace and the Chinese indigenous Mi pigs (Chu *et al*., 2016). There are however studies that dismiss the idea of dividing pigs into two different coping styles. For instance, Janczak *et al*. (2003) found none of the predicted correlations between the categorization of either HR or LR during the back test and the behaviour response to other tests later on in the pigs' life. They therefore state that the hypothesis regarding coping styles has a limited value in predicting the coping response of pigs as representing a whole population (Janczak *et al*., 2003).

2.2.2. Fear of humans - Human approach test (HA)

A reduction of fear against humans is considered to be main feature of domestication (Price, 2008). Nevertheless, predatory-avoidance reaction of humans is frequently observed in domesticated pigs (Forkman *et al.*, 2006). Predatory-avoidance can manifest itself as aggressive behaviour, which can lead to injuries for both animals and farmers (Boissy, 1998; Hessing *et al.*, 1994; Waiblinger, 2009; Hemsworth and Boivin, 2011; Jones and Boissy, 2011). An early association with humans might be as strong as the early association between littermates (Graves, 1984). Therefore, the pig's background might influence its confidence in human presence (Waiblinger, 2009). In addition, previous studies e.g. Hemsworth and Boivin (2011) and Scheffler *et al*. (2014) have shown that pigs fear of humans has a genetic origin and that individual differences regarding fear of humans exists (Hemsworth and Boivin, 2011;Scheffler *et al*., 2014). Moreover, results from e.g. Forde *et al*. (2002), Janczak *et al*. (2002) and Grandinson (2003) indicate that pigs that are fearful of humans have good mothering abilities, which might lead to a high piglet survival.

The Human approach test (HA) is one of the most frequently used tests for measuring fear response in pigs. The human approach test can either be performed on pigs individually or as a group. The human approach test involves a human presence and therefore combine the potential stressful feature of being handled by a human with the overall fear towards humans. During the human approach test, the technician can either stand outside the area/home pen or enter the area/home pen. The test is usually between one and five minutes long. (Hemsworth *et al*.,1981; Forkman *et al.,* 2006).

2.2.3. Fear of novelty - Novel object test (NO)

Fearfulness of novelty, startling stimuli and randomness are important evolutionary elements because they are main features of predatory attack and escaping them is adaptive (Shelton and Wade, 1979; Forkman *et al.*, 2006; Price, 2008). Humans have tried to depress this fearfulness through domestication process (Price, 2008) to enable management. Animals perform fear response to stimulus depending on the physical appearances when it introduces such as its movement, concentration, interval, suddenness or proximity (Boissy, 1998).

Introducing an animal to novelty in one of the most effective experimental circumstances leading to a negative emotional reaction in pigs (Boissy A., 1998). The novel object test (NO) is one of the most frequently used fear test in pigs (Forkman *et al.*, 2006) because novelty often elicits fear in animals (Jones *et al.*, 2000). The test can be performed in the home pen and the novel object, which can be either an object or an unfamiliar olfactory cue, can either be dropped from the ceiling or be combined with a human approach test by a technician introducing the object to the pig (Spoolder *et al*., 1996; Jones *et al*., 2000; Scheffler *et al*., 2014). Moreover, the latency to approach the novel object can be compared to e.g. the latency to approach the human in the human approach test for later analysing how the latency to approach might differ depending on the object (Spoolder *et al*., 1996). For instance Spoolder *et al*. (1996) noticed a latency difference for when the pigs approach their novel object and for when the pigs approach the human, where the latency to approach the object was significantly longer than the latency to approach the human.

2.2.4. Fear and aggression towards unfamiliar pigs – Intruder test (IN)

Unfamiliar pigs might lead to fear response in pigs (Forkman *et al.*, 2006) and agonistic behaviour (Price, 2008). The unfamiliar pigs may threaten the group's territory and resources and when certain resources (e.g. food) are limited, social dominance can lead to the resources assigns differentially amongst the members of the group (McCort and Graves, 1982). Agonistic behaviour between a stable group and an unknown pig occurs because the unknown pig may threaten the stable groups' territory and therefore threatens the groups' hierarchy and the supplies for e.g. food and shelter (Price, 2008).

An intruder test (IN) is when two unfamiliar pigs are introduced to each other. It is advantageous if the area where they are being introduced is one of the pig's territory. D'Eath and Pickup (2001) performed an intruder test on pigs and found that male pigs attacked more often than females. In addition, D'Eath (2002) found that the weight of the intruder pig had an effect on how much fighting and aggressive behaviour that occured during the mixing. Moreover, previous studies have indicated that an animal's level of aggressive behaviour might depend on the pigs breed or genotype. For instance, Chu *et al*. (2016) found that European Yorkshire*Landrace pigs are more aggressive than Chinese indigenous Mi pigs, and that the Chinese indigenous Mi pigs were less active.

2.2.5 Two different coping styles

According to previous researches, pigs can be divided into two different coping categories, (pro) active coping and high resistant (HR) or passive/reactive coping and low resistant (LR) depending on their response to different behaviour tests. (Pro)active or HR coping animals tend to rely on past experiences rather than current information and develop routines and habits more easily while ignoring minor environmental changes and are therefore less flexible to adapt when a change occurs (Bolhuis *et al.*, 2005). On the other hand, passive/reactive LR coping animals have a high tendency to observe their surroundings and adapt their behaviour to changing situations (Hessing *et al.*, 1994; Marchetti and Drent, 2000; Bolhuis *et al.*, 2004). Pigs living in social groups may disturb or support each other depending on their individual coping style (Hessing *et al.*, 1993), which could mean that quiet animals can calm the other individuals in the group. Behaviour tests most often used for dividing pigs into these different coping styles are the back test, the novel object test and the intruder test.

2.2.6. Testing area

Most behaviour tests can be executed in a testing area (Spoolder *et al*., 1996; D'Eath and Pickup, 2001; Forkman *et al.*, 2006). The degree of novelty in the testing area can be reduced by having the area similar to the animals' home pen with similar olfactory and auditory clues. However, when introducing animals to a new environment, once the initial fear response has ended, the animals will be motivated to explore and familiarize themselves to the area and the stimulus e.g. the human that has been introduced to them. Therefore, although the animal might be motivated to both explore and avoid the area and the stimulus, the animal's individual fearfulness of e.g. humans will influence its latency to approach the human. Consequently, when comparing animals in the same area, there will be a difference between fearful and non-fearful animals in terms of latency to approach the different stimulus. (Hemsworth and Coleman, 2011)

2.3. Breeding

The breeding goals for domesticated animals might differ depending on management routines, laws and values. Breeding of domesticated farm animals occurs with artificial selection, where humans decide the composition of the breeding stock depending on the animals' specific traits desired for the following generations (Price, 2008). Artificial selection can provide a long-term solution for reducing undesired social behaviours, e.g. aggressive behaviour, and is beneficial when the traits have a high heritability (Galindo *et al*., 2011). Reducing fearfulness (fear of e.g. novelty or startling stimuli) with artificial selection is believed to be possible and beneficial for pig husbandry (Forkman *et al.*, 2006). Estimated heritability in pigs for fear of humans or reactivity to handling varies between 0.2 to 0.4 depending on the age of the animal (Waiblinger, 2009; Scheffler *et al*., 2014).

2.3.1. Yorkshire

Yorkshire is a common dam breed in two- or three-way breeding schemes in pig production. Their popularity is due to the gilts soundness and the sow's mothering abilities and large litter sizes. Yorkshire exterior is a long distinct white muscular body with a more distinct frame than other breeds. It has a high quantity of lean meat and low back fat. (Nationalswine, 2017).

2.3.1.1. Swedish Yorkshire

Sweden imported live Yorkshire animals at the end of the 19th century, due to its feed efficiency and meat quality and begun an own breeding plan which resulted in the Swedish Yorkshire (SY). The breeding goals for Swedish Yorkshire were durable, high producing dams with good maternity qualities and good meat qualities of their offspring. The breeding goals were adapted so the pigs would be functional in a Swedish production system. The breeding of Swedish Yorkshire ended in 2012 due to financial decisions, which was the end of the over 100 years old breed. (Hansson and Lundeheim, 2013).

2.3.1.2. Dutch Yorkshire (Z-line)

The use of Dutch Yorkshire (ZY) dams in Sweden begun when the breeding of Swedish Yorkshire ended. When the Dutch Yorkshire were introduced to Swedish pig farmers, it was expected to produce one extra weaned pig per litter compared to the Swedish Yorkshire. The Dutch Yorkshire has good fat reserves, which would provide durable gilts. The breeding goals for the Dutch Yorkshire are strong sows, high piglet survival, high growth and meat percentage and the sows should be easy for the farmers to handle. The production, selection and evaluation of the Dutch Yorkshire breeding dams occurs in the Netherlands under conditions similar to the ones in most EU countries. (Brink, 2013).

2.3.2. Hampshire

Hampshire (H) is a commonly used sire breed characterised by high growth, high meat percentage, and good feed efficiency. The meat quality of the Hampshire offspring is good due to its' unique, dominant RN-gene. The RN-gene provides a better growth, a higher meat percentage and gives more tender, juicy and sour meat. Drawback: somewhat increased process loss in meat processing plant. The RN-gene is dominant, thus most Hampshire offspring will receive one copy of this gene, and exhibit the RN meat-characteristic (also when crossed with other breeds). (HKScan Agri, 2015; Hansson, 2016).

3. Material & Methods

The Committee for Ethic use of Experimental Animals in Uppsala approved the study with application number C89/15.

3.1. Breeds

A switch of dam breeding material from Swedish Yorkshire (SY) to Dutch Yorkshire (ZY) occurred recently in the research herd where the study was carried out. The sire breed of the testing gilts was Hampshire. The dams for the SY*H testing gilts were 100% SY, while the dam breed for the ZY*H were 50% SY and 50% ZY, due to few generation spans after the switch of breeding material. To simplify further discussion regarding the breed crosses, the (ZY*SY)*H gilts will be referred to as ZY*H.

3.1.1 Animals

Female piglets and growing-finishing pigs that were either SY*H or ZY*H crosses were used in the study (Table 1). The testing age of the piglets in this study (10-21 days) was chosen based on previous studies regarding the back test by Bolhuis *et al*. (2003; 2004; 2005) and Hessing *et al*. (1993; 1994; 1995). The age of the 2.5 months old growing finishing gilts was chosen, since they had just been moved to the growing finishing stables. The age of the 5 months old growing finishing gilts were selected because they were close to slaughter and it was not possible to use any older growing finishing gilts in this study. All gilts in the age category were colour marked depending on their dam breed composition. The goal was to use one gilt from each litter, but due to lack of gilts, up to four gilts were picked from one litter (Table 1). Two litters of piglets were sold during the study, thus the number of piglets are not the same for all tests. The reason for why only ten gilts from each age and breed cross were selected was due to lack of animals with requested breed crosses and limited time for collection of data. The test gilts were not allowed to be undergoing any medical treatment nor having any known abnormalities.

Table 1. Number of pigs per breed and age that were included in the different tests (SY = Swedish Yorkshire dam; ZY = Dutch Yorkshire dam; H = Hampshire sire)

Breed	**Age**	**Birth litters**	**Total number of animals**	**Suddenness test**	**Novel Object test**	**Intruder test**	**Human approach test**	**Back test**
SY*H	10-21 days	3	10	-	-	8	-	10
ZY*H	10-21 days	4	10	-	-	8	-	10
SY*H	2.5 months	4	10	10	10	10	10	-
ZY*H	2.5 months	7	10	10	10	10	10	-
SY*H	5 months	3	10	10	10	10	10	-
ZY*H	5 months	7	10	10	10	10	10	-

In addition to the animals in Table 1, twenty additional gilts from respective age category were used as “intruder gilts” in the IN. The intruder gilts were of breed cross SY*H, ZY*H or SY*ZY. The breed of the intruder gilts were not taken into account when paired with the test gilts. The criteria for the intruder pigs were that they should be gilts and that they had roughly the same body size as the test gilt. Moreover, the intruder gilts were not allowed to be undergoing any medical treatment or having any known abnormalities. The intruder gilts were from the same stable and batch as the test gilts. However, the intruder gilt and the test gilt had their home pens on opposite sides of the middle alley in the stable so no earlier interactions would have occurred.

3.2. Housing and management

The study was performed at the pig facilities at Swedish University of Agricultural Science (SLU)'s research herd Lövsta. The herd includes approximately 110 sows in an integrated Specific Pathogen Free herd (SPF-herd). The primary purpose of SPF pigs is to improve the production by disease prevention (Safron and Gonder, 1997).

3.2.1. Housing and management - Piglets

Lövsta has a batch-wise production system with six to twelve farrowing sows every two weeks. The stable has seven farrowing stables with twelve individual loose-housed farrowing pens per stable (Figure 1), with automatic provision of chopped straw from a robot. Pregnant sows and gilts are weighed and undergo body condition scoring before they are moved to the farrowing stable one week before estimated farrowing. After farrowing, the piglets' gender are recorded and the piglets receive a unique tattoo in the right ear. When the piglets are four days old, they receive their first of two iron injections (the second one at two weeks of age) and a plastic ID tag in their left ear. The piglet's weight is recorded at birth, at three and nine weeks of age. The piglets receive supplemented feeding from feeders from two weeks of age. The piglets are weaned at five weeks of age, and the sows are moved back to the deep straw loose housing stable. (SLU, 2017).

3.2.2. Housing and management – Growing finishing pigs

At ten weeks of age (2.5 months), the pigs are moved to the growing finishing stable. In the herd, there are seven finishing stables with twelve pens per stable, where two of them are smaller treatment pens (Figure 2). The litters are, at this stage, maintained intact due to biosecurity and animal welfare reasons. When the pigs are moved into the growing finishing stables, the litters are often split as ten pigs per pen is the ideal. The fattening boars are immune castrated the first month after moving into the slaughter stable and then once again after four weeks. All pigs are weighed and slaughtered at approximately 115kg live weight (5 to 6 months old). The slaughter pigs receive dry or wet feed automatically three times per day. (SLU, 2017).

3.3. The behaviour tests

All the behaviour tests performed in this study were designed with the aim that one technician alone should be able to perform the tests. The animals included in the study were colour marked to indicate breed combination to enable behaviour analyses from the video. SY*H gilts were sprayed with a blue spray paint and ZY*H were sprayed with green spray paint. The intruder gilt for the IN were sprayed with both blue and green spray paint to simplify the separation of intruder and test gilts in the analyses of the videos from the IN. The gilts were marked over their hindquarters to enable visual from every angle, even when the animals were lying down. The choice of the marking area was so it would not interfere with the markings used for routine management. The gilts were coloured the day before testing to reduce the effect of colour marking on the test results and repeated if needed.

The testing area was located at the far end of the stable and had one entrance from the alley and one through the treatment pen (Figure 2). A gate was attached on the wall to the alley behind the boxes, and on the other side of the gate, the door to the sick box was open so the gilts could not see the alley. The intension of limiting the gilts visual contact to the alley was to try to make the gilts less susceptible to escape. The testing area was 116 cm x 425 cm in size. The piglets underwent the intruder test in the piglet corner with the gate to the sow closed.

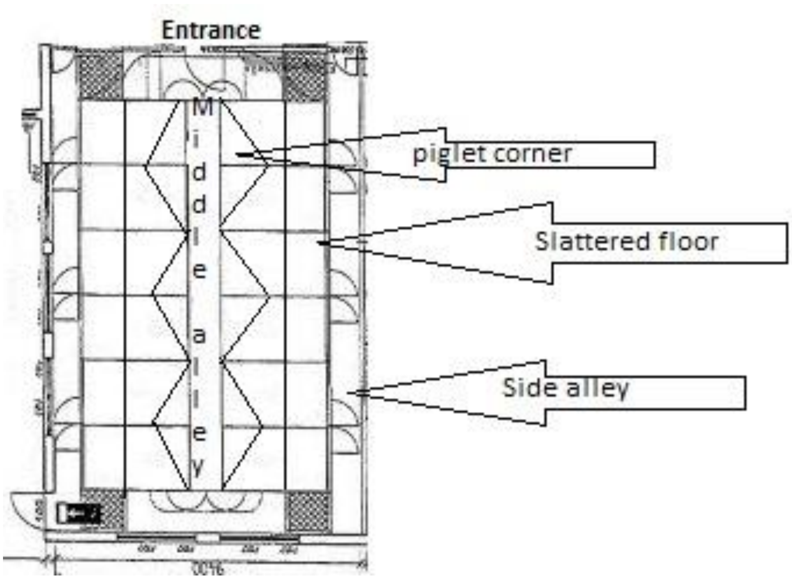

Figure 1. A drawing of one of the farrowing stables. There are 6 individual farrowing pens of each side. All pens have a piglet corner by the wall to the middle alley and a door at the end to the side alleys.

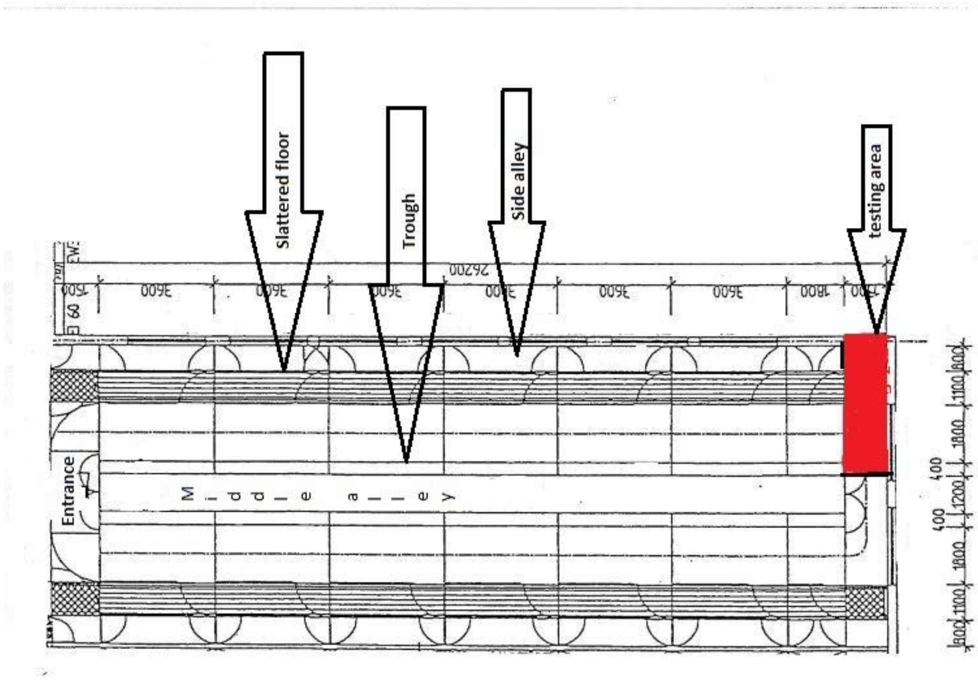

Figure 2. A drawing over the growing finishing stable. There are 6 normal sized pens and one treatment pen on each sie of the middle alley. The testing are was located at the far end of the stable (marked red on the drawing.).

3.3.1. Video recording

All behaviour tests were video recorded for further analyses. The camera was Wi-Fi connected to a smartphone and attached to the pen fixtures in an angle, which allowed recording of the whole testing area. The camera were either started manually, by voice command or by the attached smartphone and recorded the entire test event, from a few seconds before the test started until a few seconds after the test ended.

3.3.2. The order of the tests and the criteria for pig behaviour before and between tests

The behaviour tests were carried out in the same sequence for all gilts, starting with the HA test followed by the NO, the SU and the IN (Figure 3). For each test, a criteria for pig behaviour before the test could start was set up. The time between the tests varied between pigs as the time to fulfil the criteria for each test differed between tests. The criteria that the gilt had to fulfil before the next test started were: Calm down, as much as possible, if the gilt showed stress signs due to being alone, the tests moved on. However, if the gilt showed stress signs connected to the previous test, she received more time. In addition, the gilt had to perform "normal behaviour" (e.g. sniffing floor or interior) and not behaviours connected to the technician or the entering door.

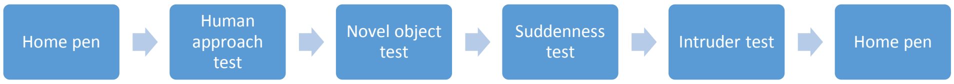

Figure 3. The order of the behaviour tests that the growing finishing gilts underwent from when they were moved from their home pen until they were let back into their home pen.

3.3.3. Back test (BT)

The piglets were randomly selected from the litter. A trolley with an easy clean rubber mat was used for this test, where the rubber mat was placed on the trolley and the piglet was placed on the mat. The trolley was placed in the middle alley of the farrowing stable right outside the individual testing gilts home pen. The technician's right hand was placed on the piglet's thorax, with the left foreleg of the piglet between the thumb and index finger and the right foreleg between the index and the middle finger. The technician's left hand was used to stretch and move the piglet's hind legs downwards and maintained the position with a loose grip during the test. The camera recorded from when the technician had a secure grip on the piglet until the piglet was let loose after one minute. When the test was over, the piglet was returned to its home pen. Ten piglets from each breed cross were used for this test (Table 1). The BT was 60s long. The latency to the first escape attempt was registered. In addition, the frequency of behaviours performed were recorded continuously and registered in a specific recording sheet (Appendix 2).

3.3.4. Human approach test (HA)

The gilts were moved to the testing area (Figure 2) with the help of a solid panel. A solid panel appears as a dead end for the pigs, which makes them move in the opposite direction and protect the handler from leg injuries (Price, 2008). The gilts were allowed time to adjust to the new environment (explore the entire area and settle down). The HA was based on methods described by Hemsworth *et al.* (1981). The technician entered the area and stood still in the middle of the test area during the entire test to let the gilts interact with the technician as they pleased. The technician slowly exited the area after three minutes. The camera recorded the tests from when the technician opened the pen door until the technician left the area. Ten piglets from each breed cross were used for this test (Table 1). The technician wore black overalls and rubber boots similar to those worn by the regular stable staff. The HA was three minutes long. The latency to approach the human was registered. In addition, the frequency of behaviours performed were recorded continuously and registered in a specific recording sheet (Appendix 1).

3.3.5. Novel object test (NO)

The gilts were allowed time to readjust to the area after the human approach test. The NO was based on methods described by Spoolder *et al*. (1996) and Scheffler *et al*. (2014) but the novel object was a dog toy instead of a bucket. The novel object, which was a tire shaped tog toy (Appendix 6) was gently introduced to the gilt by tossing it into the testing area. The gilt was left to respond to the novelty as she pleased. The testing time was three minutes and when the time was up the technician removed the object. The camera recorded the test from when the toy was introduced until the technician opened the pen door to retrieve the toy. Ten piglets from each breed cross were used for this test (Table 1). The latency to approach the novel object was registered. In addition, the frequency of behaviours performed were recorded continuously and registered in a specific recording sheet (Appendix 3).

3.3.6. Suddenness test (SU)

In addition to the NO, a suddenness test (SU) was performed as animals perform fear response to stimuli depending on the physical appearances when it introduces such as its movement, concentration, interval, suddenness or proximity. The SU was therefore used to study if the gilts responded differently to a novel object depending on how the object was introduced to them. The gilts were allowed time to readjust to the testing area after the NO until the criteria for pig behaviour were fulfilled (5-15 minutes). The object used in this test (a hard yellow ball, Appendix 6) was thrown into the pen over the gilts head, and it made a loud sound when it landed on the concrete floor. The gilt was left to react to the object as she pleased for three minutes and when the time was up, the technician retrieved the object. The camera recorded from when the object was thrown until when the technician opened the pen door. Ten piglets from each breed cross were used for this test (Table 1). The latency to approach the novel object was registered. In addition, the frequency of behaviours performed were recorded continuously and registered in a specific recording sheet (Appendix 4).

3.3.7. Intruder test (IN)

The gilt were allowed time to readjust to the area after the suddenness test. The IN was based on methods described by D'Eath and Pickup (2001). The intruder pigs were of the same gender and size as the test gilts due to results from D'Eath and Pickup (2001) and D'Eath (2002) findings. The camera recorded from when the intruder pig was introduced in the testing area until the technician separated the two gilts. The IN was three minutes long. Ten piglets from each breed cross were used for this test (Table 1). The latency to approach the intruder was registered. In addition, the frequency of behaviours performed were recorded continuously and registered in a specific recording sheet (Appendix 5).

3.4. Statistical Analysis

Mann-Whitney U tests (MINITAB Statistical Software, version 18, 2017) to assess differences in behaviour responses between breed crosses were performed. The Mann-Whitney U test is a non-parametric test of the null hypothesis that there are no differences between medians of the groups (e.g. breed cross or minute). This test was chosen for the statistical analyses for all five behaviour tests (BT, HA, NO, SU and IN) due to the data not being normally distributed and the sample being small. The condition that has to be met for the Mann-Whitney U test is that all observations from both groups are independent of each other. Moreover, Mann-Whitney U tests are suitable for frequency variances. The behaviour responses used for the statistical analyses for the HA, NO, SU and IN are categorizations of the behaviours registered from the videos (Table 3) and the behaviour responses used for the statistical analyses for the BT are listed under "3.4.1.1. back test".

Table 2. Ethogram over the behaviours that were included in the analyses, in what test the certain behaviour was recorded and the description of the behaviour. The number of times each behaviour were performed were recorded for each minute of observation.

Behaviour	**Behaviour tests**	**Description**
Laying	Human approach, novel object, suddenness and intruder test	Position change to lying on side or belly without performing any other behaviour
Sitting	Human approach, novel object, suddenness and intruder test	Position change to sitting or kneeling without performing any other described behaviour
Standing	Human approach, novel object, suddenness and intruder test	Position change to standing without performing any other described behaviour
Nosing head	Intruder test	Touching or sniffing any part of the head of another pig/human
Nosing body	Intruder test	Touching or sniffing any part of the body except the head of another pig/human
Head knocking	Intruder test	Ramming or pushing another pig or human with the head without biting
Biting	Intruder test	Ramming or pushing another pig or human with the head and biting
Fighting	Intruder test	Mutual pushing or ramming, or lifting other pig
Nosing floor	Human approach, novel object, suddenness and intruder test	Sniffing, touching or rooting floor
Nosing fixtures	Human approach, novel object, suddenness and intruder test	Sniffing, touching or rooting part of the pen above floor level
Manipulating fixtures	Human approach, novel object, suddenness and intruder test	Nibbling, chewing or biting part of the pen above floor level
Belly noosing	Intruder test	Rubbing belly of another pig or human with up and down movements of the snout
Manipulating ears	Intruder test	nibbling, sucking or chewing on another pig’s ear
Manipulating tails	Intruder test	nibbling, sucking or chewing on another pig’s tail
Manipulating other	Intruder test	nibbling, sucking or chewing on any part of another pigs or human except ear or tail
Running away	Human approach, novel object, suddenness and intruder test	Turn backside towards another pig or human and trying to get away from the other pig or human
Shove	Intruder test	Press its body against another pig or human which makes the receiver move away
Jump out	Human approach, novel object, suddenness and intruder test	The pig is leaving the testing area by jumping over the wall
Front legs on wall	Human approach, novel object, suddenness and intruder test	The pig is trying to leave the testing area, the pig stands on it hind legs with the front legs over the wall
Break out	Human approach, novel object, suddenness and intruder test	The pig is trying to leave the testing area by trying to break the door or gate. Difference between nosing fixture is that a sound from the fixtures moving is made when the pig is trying to break out
Manipulating pants	Human approach test	Nibbling, sucking or chewing on the technician’s pants

Manipulating foot	Human approach test	Nibbling, sucking or chewing on the technician's shoes
Nosing toy/object	Suddenness test, Novel object test	Sniffing or lightly touching the toy or object with the snout.
Biting toy/object	Suddenness test, Novel object test	Placing the toy or object in the mouth and chew on it
Shove toy/object	Suddenness test, Novel object test	Move the toy or object over the floor by using the snout with closed mouth.
Throw toy/object	Suddenness test, Novel object test	All or parts of the toy/object leaves the floor by force from the pig. Either the pig pick is up in its mouth or flips it by its snout.
Escape attempt	Back test	When the piglet struggle with at least one of its legs. The escape attempt is over when the piglet is still again.

Table 3. Categorization of behaviours used for statistical analyses. The behaviours were recorded as numbers of performed behaviours during the 3 minute long observation.

Categorization of behaviour	**Behaviours included in category**	**The behaviour tests in which the behaviour is included**
Inactive behaviour	Sitting, lying, walking	Human approach, novel object, suddenness and intruder test
Nosing	Nosing head, nosing body	Intruder test
Aggressive behaviour	Head knocking, biting, shove	Intruder test
Fighting	Fighting	Intruder test
Manipulating fixtures	Nosing floor, nosing fixtures, manipulating fixtures	Human approach, novel object, suddenness and intruder test
Belly nosing	Belly nosing	Intruder test
Manipulating	Manipulating ears, manipulating tail, manipulating other	Intruder test
Vocalization	Vocalization	Human approach, novel object, suddenness and intruder test
Escape behaviour	Running away, jump out, break out, front legs on wall	Human approach, novel object, suddenness and intruder test
Manipulating human	Manipulating foot, manipulating pants	Human approach test
Manipulating Toy	Nosing toy/object, biting toy/object, shove toy/object, throw toy/object	Novel object test
Manipulating Object	Nosing toy/object, biting toy/object, shove toy/object, throw toy/object	Suddenness test

3.4.1. Primary aim – Investigate differences in response between two breed crosses

For this analysis, the differences between the breed crosses were assessed based on the total frequency of each behaviour in addition to their latency to approach the different novelties e.g. the human or the intruder pig. For the back test, the latency to the first escape attempt (in seconds), the total duration of escape attempts (in seconds), number of performed escape attempts, high pitch vocalization and grunts were analysed. For the other tests, the variables registered from each behaviour test for this statistical analyses are listen in Table 3.

3.4.2. How the behaviour response change over time within tests

For this analysis, the differences between the breed crosses were assessed based on their behaviour frequency performed for each behaviour during minute one and minute three. The behaviour tests involved in these analyses are the HA, the NO, the SU and the IN. The tests were three minutes long and the frequency of each behaviour was registered for each minute during the test (minute 1and 3 respectively). Differences in behaviour between minute one and minute three of the test was statistically analysed. For example, differences in frequency of inactive behaviour performed during minute one and minute three was analysed. The variables registered from each behaviour test used for this statistical analyses are listed in Table 3.

3.4.3. Differences in latency to approach between different novelty tests

For this analysis, the latency to approach from the different tests were used to assess differences in approach to different novelties (e.g. human or plastic ball) between the tests. The reason for why this type of analysis was of interest was due to Spoolder et al. (1996) findings were they found a difference in latency to approach the human in the HA and the object in the NO.

4. Results

4.1 Responses to the behaviour tests – differences between breed crosses

The latency to approach (in seconds) and the frequency of performed behaviours are compared between the two breed crosses (SY*H or ZY*H). Results are presented in Median and Inter Quartile range (IQR). Confidence interval (CI) for the differences, Kendall's coefficient of concordance (W-value) and probability value (P-value) are given for each tested difference.

4.1.1. Piglets

4.1.1.1. Back test

A piglet was categorised as High resistant (HR) if it struggled ≥4 times and categorised as Low Resistant (LR) if it struggled ≤1 time. For the BT, two of the SY*H piglets and four of the ZY*H piglets were scored as HR and one ZY*H gilt was scored as LR. All HR piglets had 4 escape attempts each (Table 4). When comparing the two breed crosses, no significant differences in frequency of behaviour response, in latency or duration were found (Table 5).

Table 4. Classification by breed cross of the piglets based on the number of escape attempts during the back test (≤1 =LR and ≥4 =HR).

	HR		LR	
	SY*H[1]	ZY*H[1]	SY*H	ZY*H
N	2	4	-	1
Number of escape attempts	4	4	-	1

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

Table 5. Differences between breed crosses in response to the back test.

Behaviour	**SY*H[1]**		**ZY*H**		**Diff CI**	**W-value**	**P-value**
	Median	**IQR**	**Median**	**IQR**			
Number of animals	8	-	8	-	-	-	-
Number of escape attempts	2.0	1.25	2.5	2.00	-2;1	100.0	0.734
Total duration of escape behaviour (seconds)	11.5	6.75	13.5	10.50	-7;4	99.0	0.678
Latency to first escape attempt (seconds)	10.0	10.25	2.0	27.00	-20;10	109.5	0.762
Number of high pitch vocalization	24.0	26.50	26.0	32.25	-18;14	101.0	0.791
Number of grunts	19.0	12.50	17.0	17.50	-8;11	108.5	0.821

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.1.2. Intruder test

The piglets had no significant differences in terms of behaviour response between the two breed crosses (SY*H or ZY*H) during the intruder test (Table 6).

Table 6. Differences between breed crosses in response to the intruder test

Behaviour	SY*H[1]		ZY*H		Diff CI	W-Value	P-value
	Median	IQR	Median	IQR			
Latency to interact (seconds)	13.0	10.75	18.5	16.00	-16;7	59.5	0.401
Inactive behaviour	11.5	7.00	14.0	3.50	-6;2	56.5	0.248
Nosing intruder	4.0	2.00	4.0	3.50	-1;3	75.5	0.462
Escape behaviour	8.5	2.00	5.0	11.75	-6;8	77.5	0.345
Manipulating Fixtures	10.5	5.75	11.5	10.75	-6;7	67.0	0.958
Aggressive behaviour	4.5	10.50	3.0	1.00	-2;10	71.0	0.793
Fight	0.0	0.00	0.0	0.00	-1;0	61.5	0.529
Belly nosing	0.0	0.00	0.0	0.00	-1;0	65.0	0.793
Manipulating intruder	0.0	0.00	0.0	0.00	0;1	68.0	1.000

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.2. Growing finishing gilts (2.5 months old)

4.1.2.1. Human approach test

The 2.5 months old growing finishing gilts did not have any significant differences in behaviour response between the two breed crosses (SY*H or ZY*H) during the human approach test (Table 7).

Table 7. Differences in frequency behaviour between breeds for 2.5 months old gilts in human approach test

Behaviour	SY*H[1]		ZY*H		Diff CI	W-Value	P-value
	Median	IQR	Median	IQR			
Latency to interact (seconds)	112.0	125.30	56.0	72.30	0;107	131.0	0.054
Inactive behaviour	13.0	6.50	16.0	6.50	-5;1	93.5	0.406
Manipulating human	1.0	3.00	3.5	1.75	-4;1	83.5	0.112
Escape behaviour	1.0	2.75	3.0	2.25	-3;1	84.0	0.121
Manipulating Fixtures	17.0	3.00	17.5	4.75	-5;1	91.5	0.326

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.2.2. Novel object test

The 2.5 months old growing finishing gilts did not have any significant differences in behaviour response between the two breed crosses (SY*H or ZY*H) during the novel object test (Table 8).

Table 8. Differences in frequency behaviour (number) between breeds for 2.5 months old gilts in novel object test

Behaviour	SY*H[1] N=10		ZY*H N=10		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Latency to interact (seconds)	6.00	9.00	9.50	45.80	-19;3	96.0	0.521
Inactive behaviour	12.50	8.50	16.50	8.25	-7;3	95.0	0.473
Manipulating toy	11.00	10.25	8.00	12.50	-7;7	104.0	0.970
Escape behaviour	6.00	2.50	3.50	3.75	-0;6	130.5	0.059
Manipulating Fixtures	16.50	4.25	16.50	5.75	-4;1	94.0	0.427

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.2.3. Suddenness test

The 2.5 months old growing finishing gilts did not have any significant differences in behaviour response between the two breed crosses (SY*H or ZY*H) during the suddenness test (Table 9). The data from one of the SY*H gilts was not included in the results because she escaped from the testing area within the first 30 seconds of this test

Table 9. Differences in frequency behaviour between breeds for 2.5 months old gilts in suddenness test

Behaviour	SY*H[1] N=9		ZY*H N=10		Diff CI	W-value	P-value
	Median	**IQR**	**Median**	**IQR**			
Latency to interact (seconds)	10.00	13.00	6.00	8.50	-1;13	109.5	0.121
Inactive behaviour	14.00	8.50	16.50	9.75	-7;5	87.5	0.870
Manipulating object	6.00	3.50	5.50	5.25	-4;2	86.5	0.806
Escape behaviour	5.00	4.50	6.00	6.50	-4;4	93.0	0.838
Manipulating Fixtures	17.00	4.50	17.00	6.50	-4;4	93.5	0.806

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.2.4. Intruder test

The 2.5 months old growing finishing gilts did not have any significant differences in behaviour response between the two breed crosses (SY*H or ZY*H) during the intruder test (Table 10).

Table 10. Differences in frequency behaviour between breeds for 2.5 months old gilts in intruder test

	SY*H[1] N = 10		ZY*H N=10		Diff CI	W-Value	P-value
	Median	**IQR**	**Median**	**IQR**			
Latency to interact (seconds)	9.50	5.50	9.50	7.25	-3;4	113.5	0.545
Inactive behaviour	6.00	5.00	2.50	3.25	-0;6	129.5	0.070
Nosing intruder	6.50	6.50	4.50	4.00	-1;5	115.0	0.473
Escape behaviour	0	2.00	0	2.25	-1;1	104.0	0.970
Manipulating Fixtures	4.50	7.25	6.50	7.00	-5;4	100.5	0.762
Aggressive behaviour	10.00	11.5	12.50	10.00	-8;6	101.0	0.791
Fight	0.50	3.50	3.00	5.00	-4;1	96.5	0.545
Belly nosing	2.00	1.50	0.50	1.25	-0;2	125.0	0.140
Manipulating intruder	2.00	2.25	1.00	4.25	-2;2	112.5	0.597

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.3. Growing finishing gilts (5 months old)

4.1.3.1. Human approach test

The 5 months old growing finishing gilts did not have any significant differences in frequency of behaviour response between the two breed crosses (SY*H or ZY*H) during the human approach test (Table 11).

Table 11. Differences in frequency behaviour between breeds for 5 months old gilts in human approach test

	SY*H[1] N=10		ZY*H N=10		Diff CI	W-value	P-value
	Median	**IQR**	**Median**	**IQR**			
Latency to interact (seconds)	43.50	67.75	24.50	95.30	-48;41	106.5	0.940
Inactive behaviour	2.00	4.25	6.00	8.00	-7;-0	81.5	0.082
Manipulating human	2.00	9.25	6.50	7.00	-6;3	92.0	0.345
Escape behaviour	-	-	-	-	-	-	-
Manipulating Fixtures	10.00	9.25	9.50	6.50	-4;3	102.0	0.850

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.3.2. Novel object test

For the NO, the ZY*H used significantly more time before interacting with the object than the SY*H did (Table 12).

Table 12. Differences in frequency behaviour between breeds for 5 months old gilts in novel object test

	SY*H[1] N=10		ZY*H N=10		Diff CI	W-value	P-value
	Median	**IQR**	**Median**	**IQR**			
Latency to interact (seconds)	3.00	5.50	6.50	31.00	-26;0	78.0	0.045
Inactive behaviour	7.00	7.00	5.00	10.50	-6;5	104.5	1.000
Manipulating toy	18.00	34.00	20.50	20.25	-14;20	100.5	0.762
Escape behaviour	0.50	1.25	0.00	3.25	-3;1	101.0	0.791
Manipulating Fixtures	9.50	10.00	11.00	8.75	-3;6	103.0	0.910

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.3.3. Suddenness test

The 5 months old growing finishing gilts did not have any significant differences in behaviour response between the two breed crosses (SY*H or ZY*H) during the suddenness test (Table 13).

Table 13. Differences in frequency behaviour between breeds for 5 months old gilts in suddenness test

Behaviour	**SY*H[1] N=10**		**ZY*H N=10**		**Diff CI**	**W-value**	**P-value**
	Median	**IQR**	**Median**	**IQR**			
Latency to interact (seconds)	6.0	2.25	5.00	4.50	-1;3	123.5	0.174
Inactive behaviour	4.5	5.25	5.50	8.25	-5:4	105.0	1.00
Manipulating object	9.0	23.75	24.00	35.25	-26;1	80.5	0.070
Escape behaviour	0.0	3.50	0.50	2.50	-2;2	103.0	0.910
Manipulating Fixtures	13.5	13.25	10.00	11.50	-2;11	105.0	0.174

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.1.3.4. Intruder test

For the IN, a significant difference for the frequency of escape behaviour between the SY*H and the ZY*H was seen, where the SY*H gilts tried to escape a larger number of times than the ZY*H gilts (Table 14).

Table 14. Differences in frequency behaviour between breeds for 5 months old gilts in intruder test

Behaviour	SY*H[1] N=10		ZY*H N=10		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Latency to interact (seconds)	5.50	9.00	5.00	3.75	-3;5	106.5	0.940
Inactive behaviour	5.00	5.75	4.00	7.25	-2;5	120.0	0.273
Nosing intruder	4.50	5.50	8.00	6.00	-6;3	91.5	0.326
Escape behaviour	2.00	2.50	0	1.25	0;2	131.5	0.049
Manipulating Fixtures	6.00	5.50	4.50	4.75	-2;4	118.5	0.326
Aggressive behaviour	7.00	5.75	11.00	7.75	-7;4	93.0	0.385
Fight	0.00	1.50	0.00	1.00	-0;1	112.0	0.623
Belly nosing	1.00	1.25	3.00	3.00	-2;1	87.5	0.199
Manipulating intruder	1.00	2.00	2.00	1.25	-1;1	104.0	0.970

[1]Swedish Yorkshire dam (SY), Dutch Yorkshire dam (ZY), Hampshire sire (H).

4.2. Change of behaviour response over time within test

To answer the secondary aim of how the behaviour response might alter over time within each tests, an analysis of the frequency of each behaviour were performed for minute one and minute three. If the frequency of behaviour response changed significantly between minute one and minute three, is there an indication that the gilts alter their behaviour response over time.

4.2.1. Piglets

4.2.1.1. Intruder test

During the piglets' intruder test, the frequency of the behaviour response increased significantly over time for aggressive behaviour and decreased for nosing intruder for the SY*H piglets (Table 15). The ZY*H did significantly decrease the behaviour response rate over time for nosing intruder (Table 16).

Table 15. Changes in behaviour response over time within for the SY*H piglets. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 8 piglets.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Aggressive behaviour	0.00	0.00	1.00	3.75	-5;-1	42.5	0.009
Nosing intruder	3.00	1.00	0	1.00	1;3	98.5	0.002
Escape behaviour	2.00	4.00	2.50	4.50	-4;2	59.0	0.372
Manipulating intruder	-	-	-	-	-	-	-
Belly nosing	-	-	-	-	-	-	-
Fighting	-	-	-	-	-	-	-
Inactive behaviour	4.00	3.75	4.00	3.00	-3;2	66.0	0.870

Table 16. Changes in behaviour response over time within test for the ZY*H piglets. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 8 piglets.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Aggressive behaviour	0.00	1.00	0.50	1.75	-1;1	62.5	0.600
Nosing intruder	2.00	1.50	0.50	1.00	0;2	89.5	0.027
Escape behaviour	1.50	4.00	2.00	3.00	-3:2	68.0	1
Manipulating intruder	-	-	-	-	-	-	-
Belly nosing	-	-	-	-	-	-	-
Fighting	-	-	-	-	-	-	-
Manipulating fixtures	3.00	2.50	4.00	3.50	-3;2	63.5	0.674
Inactive behaviour	4.00	4.00	5.00	2.75	-3;2	65.5	0.834

4.2.2. Growing finishing gilts (2.5 months old)

4.2.2.1. Human approach test

The SY*H had no significantly difference in behaviour response (Table 17). The ZY*H gilts had a significantly increasing of escape behaviour (Table 18).

Table 17. Changes in behaviour response over time within test for the 2.5 months old SY*H gilts' human approach test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	5.50	1.25	6.00	2.25	-2;1	90.0	0.273
Escape behaviour	0.00	0.00	0.50	2.25	-2;0	86.0	0.162
Manipulating human	0.00	1.25	0.00	0.25	0;1	109.5	0.762
Inactive behaviour	4.00	2.75	4.00	2.50	-1;2	105.5	1.000

Table 18. Changes in behaviour response over time within test for the 2.5 months old ZY*H gilts' human approach test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	7.50	3.00	6.00	2.25	-1;3	124.5	0.151
Escape behaviour	0.00	0.25	1.50	1.25	-2;1	65.0	0.003
Manipulating human	0.50	2.00	1.00	2.00	-2;1	95.5	0.496
Inactive behaviour	6.00	1.50	5.00	1.75	-1;3	116.0	0.427

4.2.2.2. Novel Object test

The SY*H gilts increased their behaviour response frequency significantly over time (between minute 1 and minute 3) for the manipulating toy behaviour and decreased their behaviour response frequency for manipulating fixtures (Table 19). The ZY*H gilts did not change their behaviour frequency significantly between minute one and three (Table 20).

Table 19. Changes in behaviour response over time within test for the 2.5 months old SY*H gilts' novel object test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	4.00	2.00	5.50	1.25	-3;0	75.0	0.026
Escape behaviour	1.00	1.50	2.50	1.25	-2:-0	85.0	0.140
Manipulating toy	6.00	11.00	0.50	2.50	1;12	139.5	0.010
Inactive behaviour	4.00	2.00	3.50	4.25	-2;2	111.5	0.650

Table 20. Changes in behaviour response over time within test for the 2.5 months old d ZY*H gilts' novel object test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	5.00	3.00	6.00	2.50	-2;1	99.5	0.705
Escape behaviour	0.50	2.25	2.00	2.25	-2;1	92.5	0.364
Manipulating toy	5.00	7.00	1.00	9.00	-2;6	117.5	0.364
Inactive behaviour	5.50	3.00	5.00	5.25	-3;3	103.0	0.910

4.2.2.3. Suddenness test

Both SY*H and ZY*H decreased their behaviour frequency significantly for behaviour manipulating object between minute one and minute three (Table 21 and Table 22). One SY*H gilt was not included in the results because she escaped from the testing area during the first 30 seconds of the test.

Table 21. Changes in behaviour response over time within test for the 2.5 months old SY*H gilts' suddenness test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 9 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	5.00	2.00	6.00	1.50	-2;1	68.5	0.145
Escape behaviour	1.00	2.00	2.00	2.00	-2;1	73.0	0.289
Manipulating object	4.00	4.00	0.00	1.00	1;6	120.0	0.003
Inactive behaviour	6.00	3.50	5.00	4.00	-1;4	96.5	0.354

Table 22. Changes in behaviour response over time within test for the 2.5 months old ZY*H gilts' suddenness test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N=10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	5.00	2.00	6.00	1.50	-2;1	94.5	0.450
Escape behaviour	2.00	2.00	1.50	2.00	-1;1	102.0	0.850
Manipulating object	4.00	4.00	1.00	1.00	2;7	144.5	0.003
Inactive behaviour	7.00	3.50	4.50	4.00	-1;4	117.0	0.385

4.2.2.4. Intruder test

The SY*H had a significantly increase of frequency of behaviour response for aggressive behaviour over time and a decrease for belly nosing and nosing intruder (Table 23). The ZY*H gilts increased their frequency of behaviour response over time for inactive behaviour and fighting and decreased for manipulating intruder and nosing intruder (Table 24).

Table 23. Changes in behaviour response over time within test for the 2.5 months old SY*H gilts' intruder test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	2.00	2.00	0.50	2.00	-2;2	113.5	0.545
Escape behaviour	0.00	0.00	0.00	1.25	-1;0	94.0	0.427
Manipulating intruder	-	2.00	-	-	-	-	-
Inactive behaviour	1.50	2.00	2.00	2.00	-1;1	100.5	0.762
Belly nosing	1.00	0.25	0.00	0.25	-0;1	136.0	0.021
Fighting	0.00	0.00	0.50	3.25	-3;-0	85.0	0.140
Aggressive behaviour	1.00	3.00	5.00	9.00	-10;-1	66.0	0.004
Nosing intruder	4.00	2.25	1.00	2.00	2;4	149.0	0.001

Table 24. Changes in behaviour response over time within test for the 2.5 months old ZY*H gilts' intruder test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	2.00	1.75	0.50	4.00	-1;3	117.0	0.385
Escape behaviour	-	-	-	-	-	-	-
Manipulating intruder	1.00	1.25	0.00	0.25	-0;1	132.0	0.045
Inactive behaviour	1.00	0.50	2.00	1.75	-1;1	94.0	0.427
Belly nosing	-	-	-	-	-	-	-
Fighting	0.00	0.00	1.50	3.00	-3;-0	77.5	0.041
Aggressive behaviour	3.50	3.25	4.50	3.50	-3;1	91.5	0.326
Nosing intruder	3.50	1.00	0.00	0.25	3;4	152.5	0.000

4.2.3. Growing finishing gilts (5 months old)

4.2.3.1. Human approach test

The 5 months old gilts (both SY*H and ZY*H) did not alter their frequency of behaviour response significantly over time during the human approach test (Table 25 and 26).

Table 25. Changes in behaviour response over time within the human approach test for the 5 months old SY*H gilts. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	3.00	2.25	3.00	2.25	-1;2	110.5	0.705
Escape behaviour	-	-	-	-	-	-	-
Manipulating human	1.00	5.25	1.00	3.25	-2;3	104.0	0.970
Inactive behaviour	0.00	2.00	1.50	2.25	-2;0	91.0	0.307

Table 26. Changes in behaviour response over time within the human approach test for the 5 months old ZY*H gilts. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	2.50	3.25	2.50	3.25	-2;2	107.5	0.880
Escape behaviour	0.00	0.00	0.00	0.00	-1;-0	98.5	0.650
Manipulating human	2.50	5.25	1.50	4.25	-2;3	109.5	0.762
Inactive behaviour	3.25	2.00	2.00	1.50	-2;1	103.5	0.938

4.2.3.2. Novel object test

The 5 months old gilts (both SY*H and ZY*H) did not alter their frequency of behaviour response significantly over time during the novel object test (Table 27 and 28).

Table 27. Changes in behaviour response over time within the novel object test for the 5 months old SY*H gilts. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	1.50	2.25	3.50	5.25	-5;-0	84.0	0.121
Escape behaviour	-	-	-	-	-	-	-
Manipulating toy	11.50	9.50	2.00	12.00	-1;12	127.5	0.096
Inactive behaviour	0.00	2.50	2.00	4.00	-3;0	79.5	0.059

Table 28. Changes in behaviour response over time within the novel object test for the 5 months old ZY*H gilts. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	3.00	2.00	2.50	6.25	-4;1	102.0	0.850
Escape behaviour	0.00	0.00	0.00	2.25	-2;0	88.5	0.226
Manipulating toy	8.50	6.25	2.50	18.00	-8;9	116.5	0.406
Inactive behaviour	1.50	5.50	3.00	3.25	-2;3	102.5	0.880

4.2.3.3. Suddenness test

The SY*H gilts had a significant decrease in behaviour response between minute one and minute three for the behaviour manipulating object (Table 29). The ZY*H gilts did not significantly change their behaviour over time (Table 30).

Table 29. Changes in behaviour response over time within test for the 5 months old SY*H gilts' suddenness test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	4.00	3.25	4.00	6.25	-3;2	102.0	0.850
Escape behaviour	0.00	0.25	0.00	1.00	-1;0	99.0	0.678
Manipulating object	7.00	5.50	0.50	4.75	1;8	133.5	0.034
Inactive behaviour	2.00	2.25	1.00	1.50	0:2	122.0	0.212

Table 30. Changes in behaviour response over time within test for the 5 months old ZY*H gilts' suddenness test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	2.00	3.00	4.00	5.50	-4;0	83.5	0.112
Escape behaviour	0.00	0.25	0.00	2.00	-2;0	97.0	0.571
Manipulating object	10.50	7.50	1.50	19.00	-4;13	128.0	0.089
Inactive behaviour	1.50	2.00	2.00	5.25	-3;1	96.0	0.521

4.2.3.4. Intruder test

The SY*H gilts increased their frequency of behaviour response significantly for manipulating fixtures, escape behaviour and inactive behaviour and decreased for belly nosing and aggressive behaviour (Table 31). The ZY*H gilts decreased their frequency of behaviour response significantly for nosing intruder (Table 32).

Table 31. Changes in behaviour response over time within test for the 5 months old SY*H gilts' intruder test. Swedish Yorkshire dam (SY), Hampshire sire (H). N = 10 gilts.

Behaviour	Minute 1		Minute 3		Diff CI	W-value	P-value
	Median	IQR	Median	IQR			
Manipulating fixtures	2.00	1.25	3.50	3.00	-3;0	77.5	0.041
Escape behaviour	0.00	0.00	2.00	3.00	-3;-0	78.5	0.049
Manipulating intruder	0.00	1.00	0.00	0.25	0;1	116.0	0.427
Inactive behaviour	0.50	2.00	3.50	3.25	-4;-1	71.0	0.011
Belly nosing	1.00	1.00	0.00	0.00	0;1	135.5	0.023
Fighting	0.00	0.00	0.00	0.25	0;0	100.0	0.734
Aggressive behaviour	2.50	2.25	1.00	2.25	-0;3	127.5	0.096
Nosing intruder	3.00	3.50	1.00	2.00	1;4	142.5	0.005

Table 32. Changes in behaviour response over time within test for the 5 months old ZY*H gilts' intruder test. Dutch Yorkshire dam (ZY), Hampshire sire (H). N = 10 gilts.

	Minute 1		**Minute 2**		**Diff CI**	**W-value**	**P-value**
Behaviour	**Median**	**IQR**	**Median**	**IQR**			
Manipulating fixtures	1.00	1.00	2.00	1.00	-4;1	91.0	0.307
Escape behaviour	0.00	0.25	0.00	1.00	-1;-0	101.5	0.821
Manipulating intruder	1.00	1.00	0.00	1.00	0;1	114.5	0.496
Inactive behaviour	0.00	1.00	2.00	4.00	-3;0	84.0	0.121
Belly nosing	1.00	1.50	0.00	1.25	0;1	128.5	0.082
Fighting	-	-	-	-	-	-	-
Aggressive behaviour	2.00	3.00	3.00	4.50	-3;1	94.0	0.427
Nosing intruder	3.00	2.50	1.00	2.00	-0;3	136.5	0.019

4.3. Differences in latency to approach between different novelty tests

4.3.1. Growing finishing gilts (2.5 months old)

The 2.5 months old gilts (not grouped by breed cross) had a significant difference in latency to approach the human compared to the latency to approach the other novelties (P-value < 0.001). They required more time to approach the human compared to the other novelties (Figure 4).

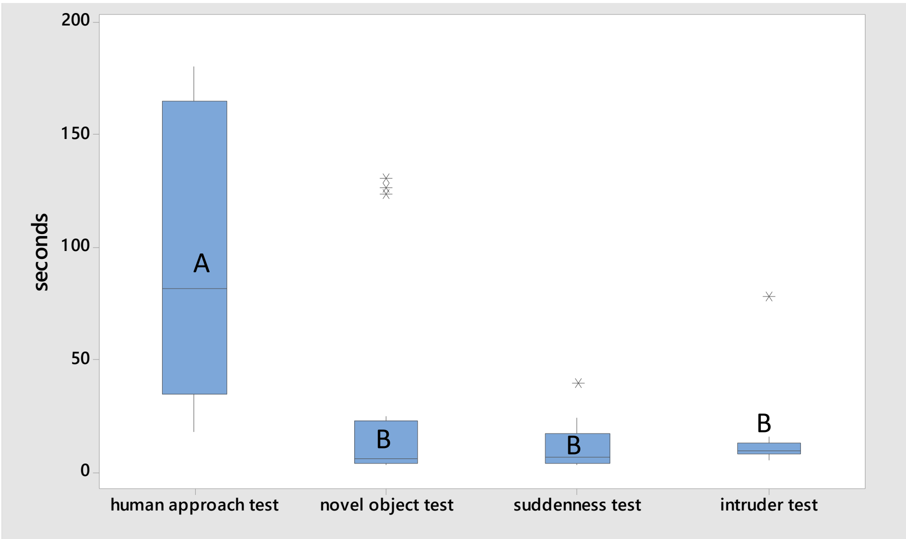

Figure 4. Differences in latency to approach the novelties for the 2.5 months old gilts during the different behaviour tests. 20 gilts were used in each test. Different letters indicate significant pairwise differences of p<0.001.

*4.3.1.1. SY*H gilts*

The results show a significant difference in latency to approach the human compared to the latency to approach the other novelties (p-value < 0.05) for the 2.5 months old SY*H gilts (Figure 5).

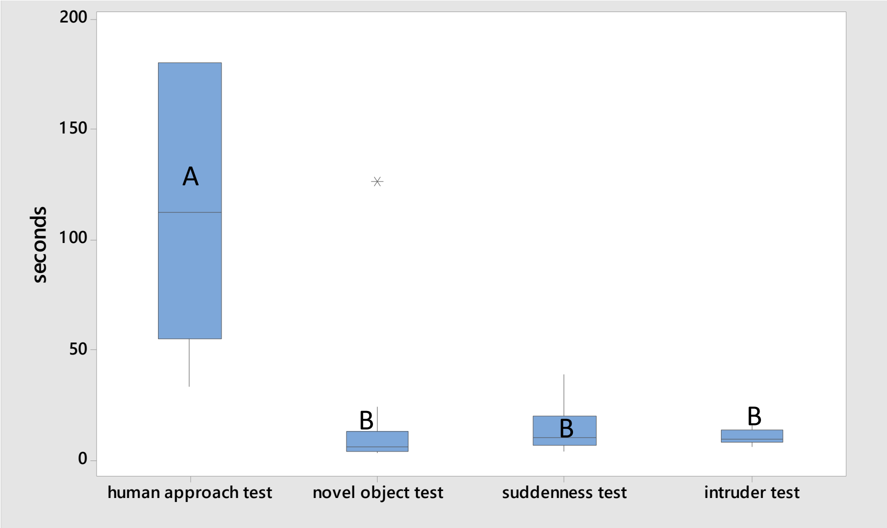

Figure 5. The 2.5 months old gilts of Swedish Yorkshire dam and Hampshire sire differences in latency to approach the novelties during the different tests. 10 gilts were used in each test. Different letters indicate significant pairwise differences of p<0.05.

*4.3.1.2. ZY*H gilts*

The results show a significant difference in latency to approach the human compared to the latency to approach the other novelties (p-value < 0.05) for the 2.5 months old ZY*H gilts (Figure 6).

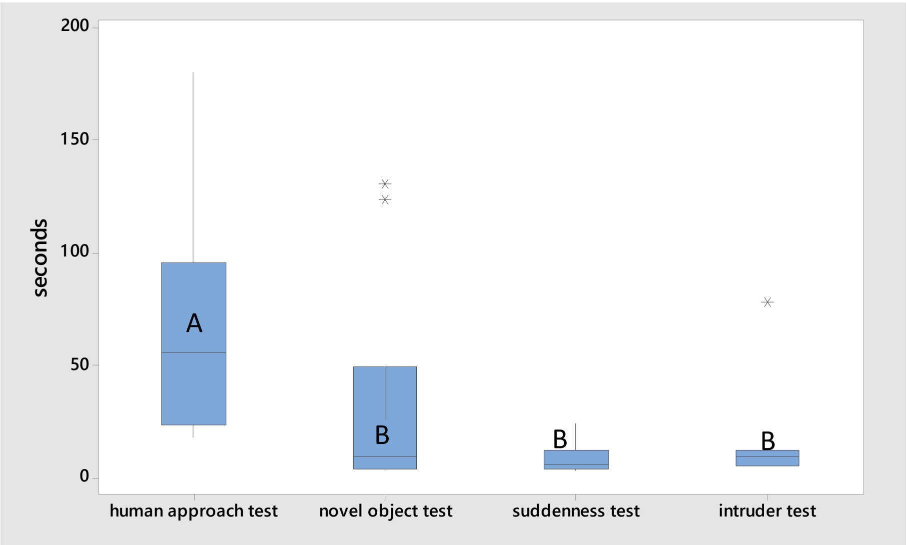

Figure 6. The 2.5 months old gilts of Dutch Yorkshire dam and Hampshire sire differences in latency to approach the novelties during the different tests. 10 gilts were used in each test. Different letters indicate significant pairwise differences of p<0.05.

4.3.2. Growing finsishing gilts (5 months old)

The results show a significant difference in latency to approach the human compared to the latency to approach the other novelties (p-value < 0.05) for the 5 months old not divided by breed cross (Figure 7).

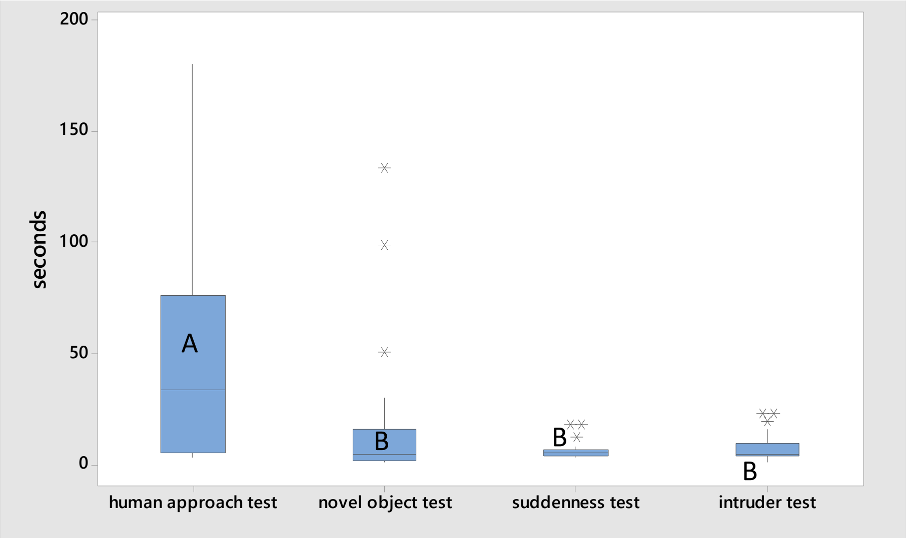

Figure 7. Differences in latency to approach the novelties for the 5 months old gilts during the different tests. 20 gilts were used in each test. Different letters indicate significant pairwise differences of p<0.05.

*4.3.2.1. SY*H gilts*

The results show a significant difference in latency to approach the human compared to the latency to approach the other novelties (p-value < 0.05) for the 5 months old SY*H gilts. There was also a difference between the NO and the SU (p-value < 0.05) (Figure 8).

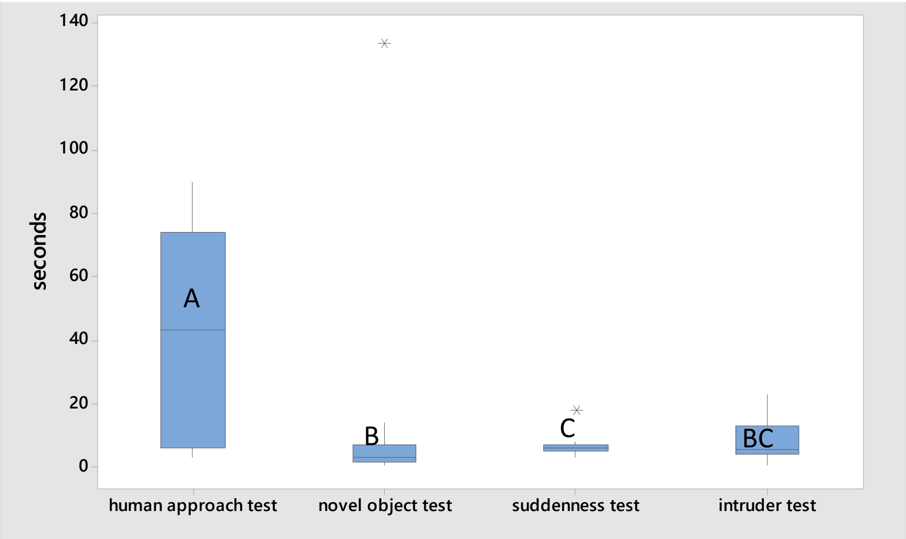

Figure 8. The 5 months old gilts, of Swedish Yorkshire dam and Hampshire sire, differences in latency to approach the novelties during the different tests. 10 gilts was used in each test. Different letters indicate significant pairwise differences of p<0.05.

*4.3.2.2. ZY*H gilts*

The results show a significant difference in latency to approach the human compared to the latency to approach the novel object in the NO and SU (p-value < 0.05) for the 5 months old ZY*H gilts (Figure 9).

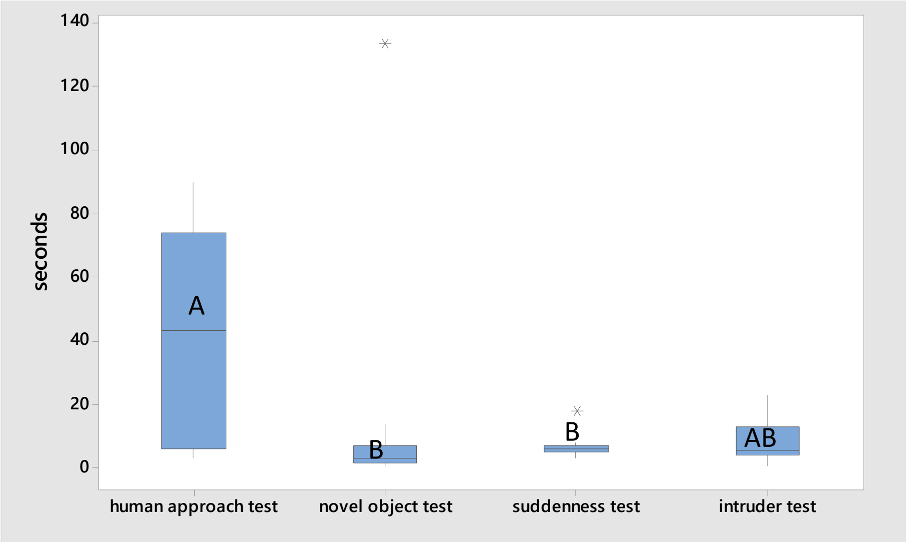

Figure 9. The 5 months old gilts of Dutch Yorkshire dam and Hampshire sire differences in latency to approach the novel subjects during the different tests. 10 gilts was used in each test. Different letters indicate significant pairwise differences of $p<0.05$.

5. Discussion

5.1. Responses to the behaviour tests – differences between the breed crosses

The primary aim of this study was to investigate differences in response to five behaviour tests between gilts of two different breed crosses.

5.1.1. Back test (BT)

No significant difference between breed crosses were found for any of the behaviour responses analysed. Grouping the piglets into cooping categories (LR or HR) resulted in two SY*H HR piglets, four ZY*H HR piglets and one ZY*H LR piglet. Hessing *et al*. (1994) and Bolhuis *et al*. (2003; 2004; 2005) grouped piglets into the two coping categories and when the pigs were older, they found internal and behavioural differences within and between the two categories. However, they did not investigate differences between breeds. However, their studies indicates that individual differences exist amongst pigs. Studies on genetic influence on piglets' response in back tests show a breed difference between e.g. the Yorkshire and the Landrace (de Sevilla *et al.,* 2009) and between the Yorkshire*Landrace and the Chinese indigenous Mi pigs (Chu *et al*., 2016). In this study, the two different coping styles (LR and HR) resulted in a larger number of ZY*H piglets being categorised as HR than SY*H piglets. However, no significant differences between the breed crosses in terms of behaviour response were found in this study, which indicates that the two breed crosses react similar to the BT. Only seven out of twenty piglets were categorized as HR and LR while the majority of the piglets either had two or three escape attempts. Thus, the number of animals categorized as either HR or LR are too small for any clear conclusion if there are any differences in coping styles according to this detention between these breed crosses.

The results from the BT is commonly used to predict behaviour differences on pig later in life e.g. their aggressiveness or coping ability when exposed to unfamiliar stimuli (Bolhuis *et al*., 2004). De Sevilla *et al.* (2009) found that the results from Yorkshire piglets' BT predicted the response to other behavioural tests better than from the Landrace. This might indicate that the breed should be considered when using these types of test. Differences between two breeds or breed crosses might be more difficult when the breed or breed crosses are closely related, like the SY*H and ZY*H. Moreover, in the present study the gilts of both breed crosses had the same sire breed, which might have influenced the results and lead to similar behaviour reactions. In addition, the ZY dams at SLU's research herd were only 50% ZY and 50% SY due to shortens of generation spans since the switch of breeding material. Thus, the genetic differences between the two breed crosses was not as large as when two completely different breeds are being compared, which might have been a reason for why there were no significant differences in terms of frequency of behaviour response between the breed crosses during the BT.

5.1.2. Human approach test (HA)

There were no significant differences in terms of latency nor frequency of behaviour response between the breed crosses during the HA. Other studies e.g. Hemsworth and Boivin (2011) and Scheffler *et al*. (2014), found that pigs fear of humans has a genetic origin and that individual differences regarding fear of humans exists. The reason for why no differences in terms of latency to approach nor in frequency of behaviour response were found between the breed crosses in this study might be due to the similarities of genotypes for these breed crosses. The SY*H gilts had 50% SY in them and the ZY*H gilts had 25% SY in them. Therefore, the genetic difference between the breed crosses might have not been as big as if the ZY*H gilts would have 50% ZY in them instead of 25% and it lead to no differences between the breed crosses.

5.1.3. Novel Object test and Suddenness test (NO; SU)

In the present study, the latency to approach the novel object differed significantly between the breeds for the five months old gilts where the ZY*H gilts required more time to approach. This longer latency to approach the NO object might indicate that the ZY*H gilts had a higher level of fear towards the novel object. Marchetti and Drent (2000) and Zebunke *et al*. (2015) found that (pro) active pigs tend to rely on former experiences and need more time to adjust to an environmental change. The ZY*H gilts' longer latency to approach the novelties in this study might indicate that they, in addition to having higher levels of fear towards the novelty, had difficulties adjusting to the environmental change which occurred when the novelty were introduced. This might correspond to Marchetti and Drent (2000) and Zebunke *et al*. (2015) findings, where the ZY*H gilts in this study have a (pro) active coping style. However, Carreras *et al*. (2016) divided pigs into two genotypes depending on their Halothane gene, which is associated with greater stress sensitivity in pigs. Their results indicated that the latency to interact with novelties were not affected by the animals' genotypes. Instead, they argued that an animal's individual fear level due to e.g. learning or previous experiences affect its response to stimuli rather that other inherent factors such as gender and Halothane genotype. However, the gilts in this study had been brought up during similar conditions, being in the same stable and being handled by the same person, and should therefore have similar previous experiences. Therefore, for this study one can argue that the differences in response towards the stimuli is not influenced by learning nor previous experiences. However, this study did not include any Halothane genotyping and it is therefore unknown if the gilts' differences in behaviour response depends on their individual Halothane genotype.

In summary, a behaviour difference between the two breed crosses were found regarding their willingness to approach the novel object in the NO. In addition, the SY*H gilts were more prone to investigate their surroundings and adjust their behaviour towards changing stimuli. Thus, the SY*H seem to be less stressed when an environmental change occur, which could make them more adaptive to different pig production environments.

5.1.4. Intruder test (IN)

The frequency of escape behaviour differed for the five months old between the breed crosses during the IN, where the SY*H tried to escape more often. This might indicate that the gilts with a SY dam are more prone to escape from an unfamiliar pigs than attacking it. Price (2008) stated that agonistic behaviour includes different actions where the animal might express active or passive avoidance. The SY*H gilts in this study might, based on their elevated escape behaviour during the IN, engage in more active avoidance than the ZY*H gilts.

5.2. Change of behaviour response over time within test

The secondary aim of this MSc thesis was to investigate if the behavioural response alter over time within each test for growing finishing gilts. The analysis of the results from the NO and the SU will be discussed together due to the similarities between tests and results. The behaviour tests in this study were three minutes long and the data collection were divided into three one-minute intervals. In previous reports, these behaviour tests have been between one (Scheffler *et al*., 2014) and five minutes (Spoolder *et al*., 1999) long.

5.2.1. Human approach test (HA)

The ZY*H gilts, but not the SY*H gilts, showed significantly more escape behaviour during minute three than during minute one. This imply the ZY*H gilts had difficulties adjusting to the testing area and continued to perform escape attempts. This might indicate that the ZY*H gilts were more frightened of the human and tried to escape from the technician to a larger extent than the SY*H gilts. Other scientific reports have shown that fear of humans has genetic origin. The results from Forde *et al*. (2002), Janczak *et al*. (2002) and Grandinson (2003) indicates that pigs that are fearful of humans have good mother abilities, which could lead to a high piglet survival. One of the breeding goals for the ZY dams is high piglet survival (Brink, 2013). However, one of the breeding goals for the SY dams was maternal qualities (Hansson and Lundeheim, 2013) and for this example good maternal qualities means sows that does not trampling or lay down on their piglets. This would mean the SY dams with good maternity qualities would be expected to show high levels of fear of humans. To further speculate, Swedish farmers might have focused more on fear behaviour of humans than farmers in the Netherlands because of the different production and management system. The Swedish production and management systems include loose housing during farrowing and nursing in addition to group housing during gestations, which is not as commonly practiced in other EU countries. Therefore, an indirect selection on farm level might have occurred for the SY where the farmers decided not to select fearful sows as dams to the next generation of recruitment gilts because they did not function in group and loose housing systems.

5.2.2. Novel Object test and Suddenness test (NO; SU)

Marchetti and Drent (2000) found that passive/reactive coping animals have a high tendency to observe and explore their surroundings more and then adjust their behaviour towards changing stimulus. The SY*H gilts altered their behaviour response over time and they showed a tendency to be more prone to investigate their surroundings over time and adjust their behaviour response towards changing stimulus. Thus, the SY*H gilts in this study might have a passive/reactive coping style and maybe be more adapted to today’s pig production due to their high level of adjustment, which might lead to less stress and better welfare for the animals. A high level of capacity to adapt is advantageous for today’s pig production in both Sweden and other countries because the pigs usually move from one home pen to another during different stages of life. In addition, they experience human presence during management routines, which is an advantage if they know how to react during those situations. Furthermore, recruitment gilts moves to group housed stables during gestations, which differs substantially from the pens they grow up in and it is therefore advantageous if they can adapt to those environmental changes.

5.2.3. Intruder test (IN)

The results regarding both breed crosses might imply that the younger gilts become more aggressive over time while the older switched their focus from the intruder towards the interior. Jones and Boissy (2011) results indicates that age is a factor affecting aggressive behaviour. In addition, D’Eath (2002) and Camerlink *et al.* (2013) results indicates that a pig’s weight and growth has an effect on its aggressive behaviour, which was why the intruder pig in the IN had a matching weight to the testing gilt. Thus, the results from this study might correspond to the previous scientific reports where the older pigs were not as aggressive as the younger ones. The older gilts might also have been able to improve their communication abilities, which might be a reason for why they fought and displayed less aggressive behaviour than the younger ones. Marchetti and Drents (2000) findings regarding passive/reactive coping animals shows these coping animals have a tendency to adjust their behaviour towards changing stimulus. Thus, the older SY*H gilts swap of interest from the intruder towards the interior might indicate that they adjusted their behaviour towards a changing stimuli when the intruder entered. After they rather quickly had finished their social establishment, they continued exploring their surroundings. Therefore, the results from the five months old SY*H gilts' IN indicates that they have a passive/reactive coping style.

Both breed crosses altered their behaviour response over time. However, the SY*H were more prone to alter their behaviour response towards changing stimuli and might therefore be more adaptive to today's pig production. A high level of adjustment is advantageous in both Sweden and other countries because the pigs usually moves from one home pen to another during different stages of life as discussed in "5.2.2. Novel object test and Suddenness test".

5.3. Differences in behaviour response to different kinds of novelty in terms of latency to approach

Different stimulus might elicit different levels of fear response from pigs depending on their previous experiences, age or genetics. A way to measure an animal's level of fear towards a certain stimuli is to measure their latency to interact with the stimuli. This analysis included the gilts latency to approach a human, a novelty introduced slowly, a novelty introduced in a sudden way and an unfamiliar pig.

Gilts of all age categories showed a significant difference in latency to the human compared to the latency to the objects in the NO and the SU. Spoolder *et al*. (1996) found a latency difference between their HA and NO test where the latency to approach the human were lower than the latency to approach their novel object. However, in this study the latency to approach the human was significantly longer than the latency to approach the novel objects in the NO and SU. The results from this study and Spoolder *et al*. (1996) study might differ due to different breeding material, but also how the different tests were executed. The longer latency to approach the human can be due to an elevated fear towards humans. More probably, the differences between the previous and the current study is due to differences in test procedures, e.g. testing time or the order of the tests or if one or multiple tests were performed each day.

In the present study, the behaviour tests were carried out in the same sequence for all the animals. The HA was the first test in the series due to gilts experience human presence every day during management routines and was therefore believed to have least impact on the animal. The second test was the NO. The order was so because the object in the SU would be scarier for the gilts than the object in the NO. Having the NO after the HA might have altered the results regarding the latency to approach the toy in the NO if they were fearful of humans and did not receive enough time to calm down between the tests. Furthermore, having the NO before the SU might have decreased the latency to approach the object in the SU due to the gilts then had it fresh in mind that a novel object close to them did not cause them any harm. It would have been of interest to change the order of the test to analyse the impact the order had on the results. However, due to the limited time and animals and the fact that this study was a pilot study, such testing did not occur.

An animal's reaction towards a certain stimulus depends on its current mind-set, e.g. if an animal is stressed or not (Forkman *et al.*, 2006; Price, 2008). The pigs in the present study were not used to being alone and they might have been stressed when they were left alone in the testing area. However, Hemsworth and Coleman (2011) suggested that in the same novel environment, there are systematic differences in approaching behaviour between animals depending on their individual levels of fear of humans. Nevertheless, the stress the animals might have experienced when being alone in the testing area might have altered the results and prolonged the latency to approach the human.

The 5 months old SY*H gilts had a shorter latency to approach the object in the SU compared to the object in the NO, which might imply that the recent previous (NO) introduction of a novel object effect the animals willingness to approach the current novel object. Suddenness, unexpectedness and strangeness, are from an ecological point of view, main signals of a predatory attack and lead to fear response from the animal (Shelton and Wade, 1979; Forkman *et al.*, 2006). This should mean that the gilts would interact more willingly with the object in the NO than the object in the SU. However, the latency to interact with the object in the SU was significantly shorter than the latency to interact with the object in the NO. The reason might be that the introduction of the object in the SU was more noticeable and therefore triggered curiosity in the gilts. Furthermore, the prolonged latency to approach the novel object in the NO might be due to the stress the animal might still have in the beginning of the NO after the HA if they were fearful of humans.

In summary, the latency to approach the human was overall longer than the latency to approach the other novelties. The longer latency to approach the human can be due to fear towards humans, which is believed to have a genetic origin and be connected to good mother abilities. The order of the tests can also have had an effect on the behaviour responses because an animal’s response depends on its mind-set at the time and react differently when it is stressed e.g. over being alone or around a human. However, the large difference seen for both breed crosses and both age categories suggests that pigs are more fearful of humans than of novel object and unfamiliar pigs. The older SY*H gilts had a latency difference between the novel object in the NO and SU, which might be due to the order of test or how the object was introduced to them.

5.5. Development of the different behaviour tests

Another purpose of this MSc thesis was to develop behaviour tests that can be performed routinely in the pig stables at SLU’s research herd and be used in future studies.

5.5.1. Testing area

The testing area was located in the growing finishing stable (Figure 2). A testing area in the same stable as the pigs’ home pens leads to similar olfactory and auditory clues, which lower the stress factors. Hemsworth and Coleman (2011) stated that while the degree of novelty in the testing area might be reduced when the area is similar to the animals’ home pen, animals introduced to a new environment will be motivated to explore it once the initial fear response of being moved has been reduced. Therefore, the animals were given time to familiarize themselves to the area before the testing begun and to readjust to the area after each test. In the SLUs pig stable, this choice of testing area is suggested.

5.5.2. Testing and developing

Jones and Boissy (2011) stated that the classical way to study fear involves three stages. 1) expose the animal to a frightening stimulus, 2) observe and measure the response from the animal and 3) the continued development and authentication of suitable, robust experimental test and measurements. This section will regard stage 3), thus how the behaviour tests involved in this MSc thesis might be developed to be more efficient or give more accurate results in future studies. In general, a larger number of animals in the sample would be required for a result that could be generalised for gilts in pig production environments.

5.5.2.1. Back test (BT)

The BT was only performed once on each piglet to try to improve the efficiency of the tests further from what e.g., Bolhuis *et al*. (2003; 2004; 2005) did. They performed the test twice on each piglet at two different ages (10 and 17 days old). To improve this test even further and to receive more accurate results, the parameters for the classifications might need adjustment for the categorization of the LR piglets. Earlier studies by Bolhuis *et al*. (2003; 2004; 2005) had the classification for LR a maximum of two escape attempts allowed for each testing occasion. Thus, the classification for LR for the BT might need to be less or equal to 2 for a more accurate result, instead of less or equal to 1 as it was in this current study.

5.5.2.2. Human approach test, Novel object test and Suddenness test (HA; NO; SU)

The gilts performed the test individually in order to reduce the littermates' impact on the test gilt. To improve these tests further, a littermate to the test gilt could be in the testing area at the same time. Previous scientific studies have performed the HA on pigs in group while they have been in their home pen (Forkman *et al*., 2007; Scheffler *et al*., 2014) or individually in a testing area (Thodberg *et al*., 1999; Forkman *et al*., 2007). Having a littermate in the testing area might reduce the gilt's stress because she is not used to being alone. Because an animal's reaction to a certain stimuli depends on the animals mind set, another result might occur if the animal's stress level is lower. Moreover, it might make the test more efficient by testing two animals at the same time. However, the limitation of having two gilts in the testing area is the influence that the individuals might have on each other, which might alter the results.

5.5.2.3. Intruder test (IN)

The gilts were tested individually to reduce the littermates' impact on the test results. Moreover, introducing the intruder pig to a stable group of individuals could be more dangerous for the intruder pig and practically difficult for the technician to separate them after the test. The growing finishing testing gilts displayed more aggressive behaviour towards the intruder than the intruder did towards the test gilts (more aggressive behaviour than escaping behaviour). This indicates that the test gilts had been in the testing area long enough to see the area more as her territory than the territory of the intruder. A main concern before this test was that the test gilt would not receive efficient amount of time to adapt to the test area before the IN, which might have led to lower reactions from the test gilt and the intruder gilt. However, that was not the case, which implies that the adaptation time was enough. To improve this test further, a variable for avoidance behaviour when the intruder is aggressive towards the testing gilts might be beneficial for results that are more accurate.

Conclusion

This study was too small for any major conclusions that would be representing the population as a whole to be made and further research regarding this area would be required. However, the conclusion of this study is that there are some behaviour differences between the two breed crosses studied (SY*H) and (ZY*SY)*H. The main behaviour differences between the breed crosses were that the (ZY*SY)*H gilts were more fearful of humans, which can lead to stress for the animals, lower the animal welfare quality and lead to injuries for both animals and farmers. In addition, the SY*H gilts had a tendency to be more adaptive to changing stimuli and explored their surroundings more than the gilts with a Dutch Yorkshire dam.

The Swedish Yorkshire breed does no longer exist. No Swedish Yorkshire sire is available and the Swedish Yorkshire sows are becoming old and are not fit for breading for many more generations. However, understanding that there might be differences between the breed we used to use in Sweden and those available on the breeding market today might lead to a change of breeding material in the future. Because Sweden in some ways is ahead of many other EU countries when it comes to housing and management systems, it might be adaptive to all if Sweden had more to say in what kind of breeding material should be used in the future production. Moreover, if the foreign breeding stations does not adapt their breeding towards animals suitable for the Swedish production systems and management routines, Sweden might need to consider to once again start an own breeding plan and try to make the Swedish Yorkshire come back.

The breeding should then focus on using a genotype of breed of pigs that has it easier to adapt to these environmental and stimulus changed. The ability to change the behaviour response towards a changing stimulus of environment might lead to less stressed animals, a better animal welfare, higher production and safer environment for the farmers, which might be advantages for future pig production.

Further research

This study was a pilot study and was therefore rather small. However, further research would be beneficial for a deeper understanding of breed impact on the behaviours performed during production. In addition, coming results could be the foundation for a change in breeding goal for dams leading to sows that are more adapted to production systems that involve loose-and group housing.

These further studies should include pure-bred Swedish Yorkshire (to the extent that is possible) and more pure-bred Dutch Yorkshire. These further studies should also include more animals so a results that might be representing the population as a whole would be possible. It would be beneficial if the behaviour tests that were used in this study would be used in the further studies and on the same gilts in different stages of life (both as a piglet, at weaning, at 2.5 months old, at 5 months old, as older gilts and as sows). It would also be beneficial to alter the order of the tests to further evaluate how the order of the tests might impact the results (e.g. have the suddenness test before the novel object test and have the human approach test second to last to minimize the human impact on the results.

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Appendix

Appendix 1. The protocol used for the registration of the behaviour response frequency and latency to approach the human during the human approach test. This protocol was used for one of the three minutes and two more (identical) protocols was used for the other two minutes. The protocol is based on information from Welfare Quality (2009).

Breed	ID	latency	Inactive behaviour	Manip-ulating fixture	Manip-ulating human	Escape behaviour

Appendix 2. The protocol used for the registration of the behaviour response frequency, latency to first escape attempt and the total duration of escape attempts. The protocol is based on information from previouse studies done by Forkman *et al*. (2006) and Bolhuis *et al*. (2003;2006).

Breed	ID	Number of escape attemps	Total duration of escape behavior	Latency to the first escape attempt	Number of grounts

Appendix 3. The protocol used for the registration of the behaviour response frequency and latency to approach the object during the novel object test. This protocol was used for one of the three minutes and two more (identical) protocols was used for the other two minutes. The protocol is based on information from Welfare Quality (2009).

Breed	ID	latency	Inactive behaviour	manipulating fixtures	Manipulating toy	Escape behaviour

Appendix 4. The protocol used for the registration of the behaviour response frequency and latency to approach the object during the suddenness test. This protocol was used for one of the three minutes and two more (identical) protocols was used for the other two minutes. The protocol is based on information from Welfare Quality (2009).

Breed	ID	latency	Inactive behaviour	manipulating fixtures	Manipulating object	Escape behaviour

Appendix 5 – The protocol used for the registration of the behaviour response frequency and latency to approach the intruder pig during the intruder test. This protocol was used for one of the three minutes and two more (identical) protocols was used for the other two minutes. The protocol is based on information from Welfare Quality (2009).

Breed	ID	Late-ncy	Inactive behaviour	Manipul-ating fixture	Manipul-ating intruder	Escape behaviour	Aggressive behaviour	fight	Belly nosing

Appendix 6. A picture on the objects used in the Novel object test (to the right) and the Suddenness test (to the left). An A4 paper is beside them for size comparison.