

# Do growing pigs build sleeping nests? – A behavioural study in domestic pigs and European wild boar

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Master's thesis • 30 credits

Agronomprogrammet - husdjur

Uppsala 2020



# Do growing pigs build sleeping nests? – A behavioural study in domestic pigs and European wild boar

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**Credits:** 30 credits  
**Level:** Second cycle, A2E  
**Course title:** Självständigt arbete i husdjursvetenskap, A2E, Agronomprogrammet - husdjur  
**Course code:** EX0872  
**Programme/education:** Agronomprogrammet - husdjur  
**Course coordinating department:**

**Place of publication:** Uppsala  
**Year of publication:** 2020  
**Cover picture:** Wilhelmina Ehrenkrona  
**Online publication:** <https://stud.epsilon.slu.se>

**Keywords:** Domestic pig, wild boar, nest-building, Sus scrofa, behaviour, behavior, sleeping nest

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## Abstract

The domesticated pig, *Sus scrofa domesticus*, has long been used for meat production. Its wild relative, the wild boar, *Sus scrofa scrofa*, gives an important possibility to study some aspects of the domestication process. Thereby increasing our knowledge of important behaviours that may still exist in our domestic pigs.

The aim of this master thesis was to perform an observational field study in which the main focus was to study if growing slaughter pigs perform behaviours that could be seen as the building of sleeping nests. A comparative study with European wild boar (*Sus scrofa scrofa*) kept in a large, outdoor enclosure was performed to see if they build sleeping nests, and what behaviours they perform in relation to lying down.

A total of 158 domestic pigs in two age categories on a Swedish, KRAV-organic pig farm were included in the study, as well as four European wild boar. 84 domestic pigs aged 13 weeks were studied in their hut when kept on their summer pasture, and 74 domestic pigs aged 5 – 6 months were studied when kept indoors in large pens with deep straw bedding. The four European wild boars were approximately 1 year old and studied in their 4 ha large forest enclosure.

The animals were studied by camera recordings between June and September 2019. All animals were included to increase the likelihood of observing behaviours in relation to lying down and resting or sleeping. Behaviours considered relevant from a nest-building perspective were those that in some way manipulated the ground. In this study, these were rooting, pawing, plowing, arranging material and lastly, kneeling and rooting.

The results indicate that a majority of both domestic pigs and European wild boar perform at least one behaviour that manipulates the ground before lying down. No differences were found in mean number of relevant behaviours performed between the groups, nor were there any differences between most of the different relevant behaviours between the groups. Only plowing differed between the groups. Rooting was the most common behaviour performed in all three animal categories.

Further studies are needed to properly evaluate the possible nest-building in growing domestic pigs as well as European wild boar.

**Keywords:** Growing pigs, domestic pigs, *Sus scrofa*, European wild boar, sleeping nest, nest-building, behaviours,

## Sammanfattning/Abstract

Den domesticerade grisen, *Sus scrofa domesticus*, har länge använts för köttproduktion. Dess vilda släkting, vildsvinet, *Sus scrofa scrofa*, ger en viktig möjlighet att studera en del aspekter av domesticeringsprocessen. Därigenom kan vår kunskap om viktiga beteenden som fortfarande kan återfinnas hos våra tamgrisar.

Målet med den här masteruppsatsen var att utföra en observationsstudie i fält med huvudfokus att studera ifall växande slaktgrisar utför beteenden som skulle kunna ses som byggande av sovbon. En jämförande studie gjordes på europeiska vildsvin (*Sus scrofa scrofa*) i stora hägn utomhus för att se ifall de byggde sovbon, och vilka beteenden de i så fall utför i samband med att de lägger sig ner.

Totalt ingick 158 domesticerade grisar i studien, dessa var KRAV-ekologiska grisar i två olika ålderskategorier, samt fyra vildsvin hållna i hägn. 84 tamgrisar som var 13 veckor gamla studerades i deras hydda i deras sommarhage, och 74 tamgrisar i åldern 5 - 6 månader studerades i storbox inomhus med djupströbädd. De fyra vildsvinen var cirka ett år gamla och studerades i sitt hägn som bestod av 4 ha skog.

Djuren studerades via kamerainspelning mellan juni och september 2019. Samtliga djur inkluderades i studien för att öka sannolikheten att se de lägga sig ner. Beteenden som ansågs vara relevanta ur ett bobyggnadsperspektiv var i den här studien de beteenden som på något sätt manipulerade marken eller bädden. I den här studien var det följande beteenden; bökande, plogande, skrapande med framklövar, arrangerande av material samt när djuret stod på knä och bökade.

Resultatet indikerar att en majoritet av både tamgrisar och vildsvin utför minst ett beteende som manipulerar marken/bädden innan de lägger sig. Inga skillnader mellan grupperna fanns vad gällde genomsnittligt antal beteenden utförda, inte heller fanns det några skillnader mellan andelen utförda beteenden av de flesta av de relevanta beteendena. Endast plogning skiljde sig åt mellan grupperna, och sågs främst hos de yngre tamgrisarna utomhus. Bökande var det vanligaste beteendet att se i samband med att de la sig hos samtliga tre djurkategorier.

Fler studier behövs för att utvärdera möjliga bobyggnadsbeteenden av sovbon hos växande tamgrisar och yngre europeiska vildsvin.

*Nyckelord:* Växande grisar, tamgrisar, grisar, *Sus scrofa*, europeiska vildsvin, vildsvin, sovbo, bobyggnad, beteende

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# 1 Introduction

The domesticated pig, *Sus scrofa domesticus*, has long been used for meat production. Unlike cattle, a wild ancestor of domestic pigs still exists. The wild boar, *Sus scrofa scrofa*, gives an important possibility to study some aspects of the domestication process, thereby increasing our knowledge of important behaviours that may still apply to our domestic pigs. One such study looked at differences in maternal behaviour between domestic sows and wild boar crosses (Gustafsson *et al.*, 1999a). They found that there were only a few differences in number of nursing's and distance travelled from their young among other things, while nest-building behaviours showed no significant difference (Gustafsson *et al.*, 1999a). Other than that, it is also well known that foraging behaviours such as rooting are often well-preserved through the domestication process (Gustafsson *et al.*, 1999b). Another behaviour found in wild boars and domestic pigs alike is wallowing in mud, and it seems to be an important way for the animals to thermoregulate, according to a review on the subject by Bracke (2011). As seen in a study by Stolba (1988, see Stolba & Woodgush 1989) there were no differences in behaviour found between domestic pigs kept in semi-natural environments compared to wild boar (Gundlach 1965 among others, see Stolba & Woodgush 1989). Since the ability to perform natural behaviours, i.e. species-specific behaviours that animals would perform in natural conditions, is required in Sweden (SFS 2018:1192 chapter 2 §2), studying wild boars can tell us about what behaviours can be considered natural.

## 1.1 Nest-building and straw

In an introduced, i.e the animals did not emigrate there without the help of humans, population of feral pig/wild boar crosses in South Carolina it was

noted that not only do animals that are not pre-parturient sows build nests, but it is also possible to differentiate between farrowing nests and sleeping nests (Mayer *et al.*, 2002). In the study by Dardaillon (1986) in Camargue, France, it was noted that farrowing nests were generally more intricately built than sleeping nests, and farrowing nests were only found during the spring and closer to water. In a review by Wischner *et al.* (2009) it is summarised that the building of farrowing nests has changed little through the domestication process, showing it to be an important behaviour. They also describe the functions of the nest as providing protection from predators and weather, especially from a thermoregulatory point of view as piglets are very sensitive to cold. The thermoregulatory point is strengthened by a study by Algers & Jensen (1990) who found that the temperature inside farrowing nests built in straw changed very little regardless of the temperature outside the nest.

The question on hand is whether the building of sleeping and resting nests is another behaviour that has been preserved through domestication? Meaning that not only would sows have a need for bedding material to build farrowing nests prepartum but growing domestic pigs under commercial conditions might have a similar motivation to build sleeping nests, and thereby a need to be provided with bedding material.

Most scientific studies regarding nest-building in pigs have been done on pre-parturient sows or pseudo-pregnant gilts, i.e. gilts that show all signs of being pregnant but without having any foetuses, and legislation in Sweden reflects this. All gestating pigs must have access to bedding material in their farrowing boxes during the week before farrowing (SJVFS 2019:20). When it comes to slaughter pigs, some straw is required (SJVFS 2019:20) but the amount differs substantially between different production systems and farms.

There is a large number of scientific publications showing that straw is preferable as a substrate to fulfil explorative behaviours, thereby limiting abnormal behaviours (Bulens *et al.*, 2016; Scollo *et al.*, 2013; Tuytens 2005). However, only one study was found on whether growing pigs have an interest in building sleeping nests. Stolba & Woodgush (1984) looked at domestic pigs in a "Pig Park", a larger outdoor enclosure with both forest and grassland. They noted that the pigs built sleeping nests and that the pigs seemed to choose to establish sleeping nests at some distance from the feeding sites and either in the forest or at the forest border (Stolba & Woodgush, 1984). They also noted that pigs in pens given the possibility to

gather material and arrange it into a sleeping nest did do so (Stolba & Woodgush, 1984). As mentioned earlier, wild pigs in different age categories do build sleeping nests (Mayer *et al.*, 2002). Therefore, it seems likely that this behaviour still exists in our domestic pigs. Access to bedding material could therefore increase the welfare of slaughter pigs. However, it is possible that the box design and the amount of straw they are already given is enough to fulfil their motivation to build sleeping nests.

## 1.2 Aim of the study

The study was done during the summer of 2019 and the aim was to answer the following questions:

- Do growing domestic pigs perform any behaviours related to nest-building before lying down?
- If yes, what behaviours related to nest-building are performed and in what frequency?
- Do growing domestic pigs differ in nest-building behaviours performed when comparing different age categories?
- Do growing domestic pigs differ in nest-building behaviours performed compared to young European wild boar?
- Do the result from this study indicate that further studies are needed to properly evaluate the amount of bedding material needed for an improved welfare of growing pigs?

### 1.2.1 Definition of nest-building behaviours

The behaviours considered relevant for nest-building in this study were those that directly manipulated the ground or bedding material in some way. The definition was chosen to decrease the risk of including unrelated explorative behaviours, and as the focus was on building behaviours, behaviours such as walking or sitting that did not manipulate the ground were excluded.

Other behaviours that do not manipulate the ground may still be relevant for the welfare of the animals or connected to nest-building in other ways, however, they were not counted as relevant in this study.

## 2 Literature review

Since wild boars are a part of this study, and to show where our domestic pigs originate from, a short introduction to their wild relative will be given. The wild boar still exists around the world today, both in captivity and free roaming, meaning that differences and similarities between them and domestic pigs are possible to study. Afterwards, a description of the use of straw in the modern-day production systems in Sweden will be given, highlighting the differences between conventional, EU-organic and KRAV-organic production.

### 2.1 The wild boar

The wild boar can be found throughout Europe and Asia and has been introduced to North America and New Zealand (Encyclopaedia Britannica, 2017). Wiepkema (n.d.) noted that wild boars living in an enclosure in the Netherlands have two different resting places, one where they rested during night and one for resting during the day. The latter were often found closer to food while the former did not have set locations. Important to notice is that in the study by Wiepkema (n.d.) the animals were used to human contact, which might have affected their choice of resting place as well as resting times. Wild boars are omnivores and live in family groups consisting of a few sows and their offspring, with males usually only present during mating periods (Spinka, 2002). In a study by Dardaillon (1986) on wild boar habitats in Camargue, France, it was noted that sleeping beds made by wild boar changed during the year. They noted that during summer most bedding places were on bare ground, but during wet seasons most bedding places had a vegetation layer (Dardaillon, 1986). Farrowing nests also had a vegetation layer but were more intricately built (Dardaillon, 1986). Sleeping beds were generally oval or kidney shaped with a strong correlation between

width and length and often found in places where other vegetation provided some sort of cover (Dardaillon, 1986). The sleeping nests could for example be beneath blackberry thickets or in patches of dry tall reeds (Dardaillon, 1986). The intricacy of the sleeping nests varied from depressions on bare ground, to depressions filled with litter from nearby plants (Dardaillon, 1986). Sleeping nests that were situated beneath low and thick vegetation could be only litter placed on flat ground (Dardaillon, 1986). Farrowing nests were only found during spring and were located much closer to water than bedding areas (Dardaillon, 1986). The animals in the study by Mayer *et al.* (2002) were categorized from earlier studies to be a mix between feral swine and European wild boar. They found nine sleeping or resting beds during their study, of which four were beds used by > 3 animals (Mayer *et al.*, 2002). The beds were found in various locations, beneath hawthorn crowns, next to fallen pine trees or at the base of slash pines (Mayer *et al.*, 2002). Six of the beds had constructed depressions, and one of those without an excavated depression was in a pile of pine straw, i.e. a pile of dried pine needles (Mayer *et al.*, 2002). A majority (six) of the beds had vegetation lining, but only one had vegetation that seemed to have been actively collected (Mayer *et al.*, 2002). Eight of the beds had a closed cover above, and four were situated in areas with dense understory vegetation (Mayer *et al.*, 2002).

The conclusion from this literature review was that European wild boar build nests for sleeping and resting, and that they generally choose to place these nests with some sort of vegetation cover. They seem to adjust the location and complexity of these nests depending on season, weather, time of day and number of animals.

## 2.2 The domestication process

The domestication of the wild boar into our domestic pig is considered to have taken place around 9 000 - 8 000 years BC (Giuffra *et al.*, 2000, see Spinka, 2002). The general idea is that domestication of pigs happened twice during history and in different locations (Giuffra *et al.*, 2000; reviewed by Ramos-Onsins *et al.*, 2014; Frantz *et al.*, 2015). The locations most supported by scientific evidence are the Mekong area in China and what is modern day Turkey (reviewed by Ramos-Onsins *et al.*, 2014; Frantz *et al.*, 2015). This is supported when looking at mitochondrial DNA where two European and one Asian clade, i.e taxonomic group including only descendants of a common ancestor, can be found (Giuffra *et al.*, 2000). The European clades

include the European wild boar (*Sus scrofa scrofa*), and the Asian clade includes Asian wild boars (in the cited study *Sus scrofa leucomystax*) (Giuffra *et al.*, 2000). The amount of time since the split between these two clades is uncertain. The European clades and the Asian clade should have separated from each other approximately 500 000 years ago to achieve the differences found today according to Giuffra *et al.* (2000). However, other studies have concluded that the split must have happened earlier than that, between 800 000 years ago and 1 600 000 years ago (reviewed by Ramos-Onsins *et al.*, 2014).

Mitochondrial DNA-analyses also point towards much more recent cross-breeding between these groups (Giuffra *et al.*, 2000). This fits with the cross-breeding between Asian domestic pigs and European domestic pigs during the 18<sup>th</sup> and early 19<sup>th</sup> century (Giuffra *et al.*, 2000; Frantz *et al.*, 2015). As a result, mitochondrial DNA from the Asian clade can be found in several European breeds, but not the other way around (Giuffra *et al.*, 2000).

During the time that has passed since their domestication, the breeding goals for pigs have varied (Spinka, 2002). As an example, the domestic pig used to be smaller than their wild counterparts until the Middle Ages, when breeding for bigger animals started (Spinka, 2002). Since then, other changes in selection choices have been made. As of now, animals that are efficient feed converters, gilts and sows that give large litters of uniform piglets and slaughter pigs with good carcass qualities are the goal (Topigs Norsvin, n.d.). The difference between a modern slaughter pig and a wild boar is striking and shows how far the domestication has come, even though there is evidence of some interbreeding between domestic pigs and wild boars during the entire time since domestication (Spinka, 2002; Frantz *et al.*, 2015). Although the differences in appearance are noticeable, many behaviours have been preserved through the domestication process (Spinka, 2002). Examples of preserved behaviours are different foraging behaviours such as rooting (Gustafsson *et al.*, 1999b) and wallowing (Bracke, 2011) as mentioned earlier. One difference is litter size, where a modern domestic pig hybrid can have litters of up to 14 - 15 weaned piglets (Topigs Norsvin, n.d.), while the average litter size of a wild boar in the study by Frauendorf *et al.* (2016) was 6.6 born piglets. However, those litters were unusually large compared to other studies on wild boar that they used as comparison.

## 2.3 Usage of straw in modern production systems

As mentioned earlier, straw is mandatory in all Swedish production systems (SJVFS 2019:20 chapter 4 4§). This does not mean that equal amounts of straw are used in different systems, only that the Swedish legislation describes that a minimum amount of straw should be provided to the animals. This is not described in terms of g/pig/day, but rather in terms of enrichment value, i.e. the function of the straw. The bedding material given should be given in quantities that gives the pigs a possibility to fulfil their “need of activity and comfort” (SJVFS 2019:20 chapter 4 4§), making it difficult to come to an agreement on how much straw is needed to comply with the legislation. Thereby leaving it up to each farmer to decide how much straw to use. It is unknown what constitutes as comfort for a pig, other than thermal comfort. The organic production in Sweden differs in that the EU-organic is not the highest standard, but rather a middle ground. The KRAV-organic production has the hardest rules and regulations as will be described later in the text.

Different studies have come to different conclusions on the amount of straw needed to fulfil pigs’ explorative behaviours. One such study has shown that there seems to be a maximum effect of adding straw and that until approximately 250 – 300 g straw/pig and day there is an increase in explorative behaviours directed at the straw, but bigger daily rations did not seem to increase these behaviours any further (Jensen *et al.*, 2015). Another study showed that manipulative behaviours directed at pen mates decreased with increasing daily allowances of straw until 387 g/pig and day (Pedersen *et al.*, 2014). Other than that, 265 – 279 g/pig and day seems to decrease the risk of oesophageal ulceration and scarring (Jensen *et al.*, 2017). That access to straw can decrease the risk of gastric ulcers is supported by other studies (Herskin *et al.*, 2016; Di Martino *et al.*, 2013).

According to a survey study by Wallgren *et al.* (2016) the average amount of straw provided on Swedish farms was 62 g/pig and day for finishing pigs, and 35 g/pig and day for pigs in nursery. The study included farms with deep litter, but these are excluded from the values mentioned. Another study by Wallgren *et al.* (2019) saw that pigs in the weight categories 10 – 30 kg live weight and 30 – 120 kg live weight that were allowed double the amount of straw provided to the control groups at the same farms had a significant increase in straw-directed behaviours. On the other hand, another study has found that giving pigs temporary access to straw during the last weeks before slaughter have no significant effect on cortisol levels in saliva or meat quality (Peeters *et al.*, 2006). They did see a significantly higher average

daily weight gain in two of the groups reared with straw during the last week, but at slaughter there were no significant differences between groups (Peeters *et al.*, 2006). They also found a significant effect of straw provision on the time spent manipulating the pen and pen mates, but as with weight gain, there were no significant differences in severity of skin lesions at slaughter between groups (Peeters *et al.*, 2006) and likely one week was too short time to see significant effects on e.g. healing wounds.

#### 2.3.1 Legislation covering all production

In conventional production the Swedish legislation requires that the animals have access to enough straw to fulfil their needs of explorative behaviours and their need of comfort (SJVFS 2019:20 chapter 4, 4§). There should be enough straw, or other material such as wood chippings, for the animals to have something to explore, perform rooting behaviour in and chew on (SJVFS 2019:20 chapter 4 4§). This means that there is room for different interpretations as to how much bedding material is needed. The material used should be of good hygienic quality (SJVFS 2019:20 chapter 4 3§)

#### 2.3.2 EU-organic production regulations

The legislation for EU-organic production differs from the above when considering bedding material. EU-legislation specifies that mammals in organic production should have access to a clean and dry resting place with bedding made of natural materials, such as straw (EG nr 889/2008). In EU-organic production the animals should have access to outdoor areas, but access to pasture during summer is not a requirement (KRAV chapter 5.4.3.3).

#### 2.3.3 KRAV-organic production rules

In organic production by the rules set by KRAV the production on the farms must be certified by an independent certification body to ascertain that the farm follows the KRAV rules. One rule that sets KRAV-production aside from EU-organic is that KRAV has a requirement that pigs should be on pasture for four months during summer (KRAV chapter 5.4.3.1). Another requirement is access to a deep straw bedding area for all animals (KRAV chapter 5.4.5.3). This rule is shared with the EU organic that further defines that this resting place should be spacious and covered with dry straw or other suitable natural bedding material (EG nr 889/2008, article 11, point 2).

### 3 Material and method

The study consisted of three different animal categories; domestic pigs housed indoors, domestic pigs housed outdoors and European wild boar in an enclosure. Each of the domestic pig studies included two groups of animals, while only one group of European wild boar was included. The study was done as a master thesis at The Swedish University of Agricultural Sciences (SLU).

#### 3.1 Animals

##### 3.1.1 European wild boar

The animals were young wild boars in a large enclosure that were mainly used for tourism and practice for hunting dogs. The enclosure held four animals and had a total area of 4 ha. All animals were approximately 1 year old (+/- 2 months) with an estimated live weight of 20 - 25 kg. All animals were included in the study. The animals in the enclosure were all intact males. They had been moved to the enclosure at two different dates, one had been there a couple of months while the other three were moved there sometime during the last four weeks before the start of the study.

##### 3.1.2 Domestic pigs outdoors

All animals in the two groups kept on pasture were included to catch as many relevant behaviours as possible. The animals belonged to a slaughter pig KRAV-organic production.

The pigs were growing pigs aged 13 weeks, weighing approximately 35 kg live weight. The animals were brought to the farm Wednesday June 19<sup>th</sup>

weighing approximately 30 kg live weight and aged 12 weeks. The recording was started on Tuesday June 25<sup>th</sup>. The groups consisted of both castrates and gilts. The animals were three-way crosses of landrace, Yorkshire and Hampshire. A total of 84 pigs were included in this part of the study. 39 pigs were kept in pasture 1 and the remaining 45 pigs were kept in pasture 2.

### 3.1.3 Domestic pigs indoors

A total of 74 animals divided into two groups were studied. They were kept in large indoor pens with access to an outdoor area with concrete floor, pen 1 and pen 2. These were finishing pigs at > 90 kg live weight at 5 - 6 months of age. The groups consisted of both castrates and gilts. The group in pen 1 consisted of 39 animals weighing between 90 to 120 kg and the group in pen 2 consisted of 35 animals weighing between 95 to 125 kg. The animals were three-way crosses of landrace, Yorkshire and Hampshire. The pigs were moved to the pens from their summer pasture on September 16, the same date that the cameras were placed in the pens. On Wednesday September 18 some pigs were sent to slaughter, the remaining pigs all weighed 90 kg or more. Recording started at 5.30 pm on September 18.

## 3.2 Facilities

### 3.2.1 European wild boar

The wild boars were kept in a large enclosure with natural forest, mainly conifer. The enclosure included both standing and naturally fallen trees, as well as places for wallowing and feeding stations. The dog training was continuous and on-going during the study period, and the number of people and dogs that visited the enclosure during the study period is unknown as it was not possible to gain access to the information.

### 3.2.2 Domestic pigs outdoors

The animals were kept on pasture with one hut per pasture. The huts measured 6x4 metres and were made mainly of sheet metal (picture 1). Pea straw was used as bedding inside the huts. The exact amounts of straw used is unknown. Pictured below (picture 2) is one of the two groups

while sleeping in their hut during the day, to give some indication on the amount of straw used. Similar amounts were used for the domestic pigs indoors.



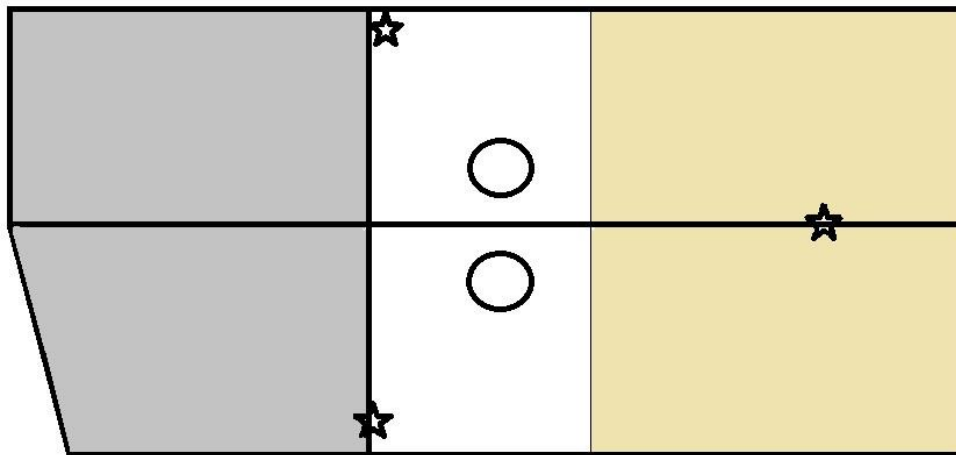
**Picture 1)** One of the huts used for growing pigs, it was made mainly of sheet metal on the KRAV-organic pig farm where the study was conducted.



**Picture 2)** Pigs in group 1 sleeping in their hut during the day. The picture is included to give some indication on the amount of straw used, as the farmer did not know the exact amount.

### 3.2.3 Domestic pigs indoors

The animals observed were KRAV-organic slaughter pigs kept in large group pens with access to straw and an outdoor area with concrete floor (picture 3). Pea straw was used as bedding. The pens measured 17x6 metres and the outdoor area was 10x6 metres.



**Picture 3)** The picture shows the two pens used in the study, the one on top is pen 2 and the one below is pen 1. The circles represent the feeding stations, the stars are the placement of the cameras. Deep straw bedding was found to the right of the thin line (beige), and the outdoor area was found on the left side of the thicker line (grey).

### 3.3 Observations

The studies were done by video recording with game cameras, which were activated by movement, and hence not filming continuously 24 h per day. The observations of the video recordings were done by continuous recording and behaviour sampling, as the behaviours were specific and presumably rare in occurrence. All behaviours related to nest-building that the domestic pigs and the wild boar performed during the recordings were noted. The occurrence of behaviours was counted, as well as the order of behaviours. The idea was to be able to see how often different behaviours were seen in relation to lying down.

#### 3.3.1 Technology

The cameras used were five Albecom BG529 cameras, which are game cameras and were thereby considered suitable for watching animals during different times of the day and night. They had a 1-minute delay from movement to the start of recording. They were equipped with 8 GB memory cards (SanDisk 8GB SDHC) that were exchanged for new, empty cards every 24h during the day when the camera was turned off when studying the domestic pigs outdoors. When studying the European wild boar, 32 GB memory cards were used (SanDisk Extreme Pro 32GB SDHC UHS-I Memo) and were exchanged for new, empty ones at the end of the first of two periods.

The same cameras were used when studying the domestic pigs indoors. The cameras were again equipped with 32 GB memory cards that were exchanged for new, empty ones each day.

The cameras were active from early evening until 6 or 7 am in the domestic pig observations. Different starting times were used to increase the likelihood of the cameras recording at the right time (table 1). During the indoor part of the study, the cameras were set to start recording at 5.30 pm since that part took place in September when the sun sets earlier. During the three evenings in the outdoor part of the study, the cameras started recording at 7 pm, 9 pm and 8 pm. This was done due to the smaller memory cards being used.

The wild boar were used for dog training during the day, and therefore, it was uncertain when they rested. To increase the likelihood of capturing their behaviours on camera the cameras were set to record 24h per day.

**Table 1) The different camera settings during the different studies**

<b>Animal category</b>	<b>Period/night</b>	<b>Camera set to record</b>	<b>Size of memory card</b>
Domestic pigs out-doors	1 <sup>st</sup> night	7 pm – 7 am	8 GB
Domestic pigs out-doors	2 <sup>nd</sup> night	9 pm – 7 am	8 GB
Domestic pigs out-doors	3 <sup>rd</sup> night	8 pm – 7 am	8 GB
Wild boar	Both periods	24 h/day until no memory left	32 GB
Domestic pigs indoors	All 3 nights	5.30 pm – 6 am	32 GB

### 3.3.2 Reviewing the footage

The chosen behaviours and definitions (table 2) mainly originated from the behaviours noted when studying nest-building in pre-parturient sows. This was due to the lack of studies done on nest-building in other pig categories. According to studies done on wild boars the difference between the two kinds of nests are noticeable, but mostly due to farrowing nests being larger in size and more intricate than resting nests. The behaviours performed during the building of farrowing nests in domestic pigs were therefore considered to be somewhat applicable in this study.

**Table 2) Ethogram**

The behaviours and their definitions have been gathered from Peeters *et al.*, 2006 and Gustafsson *et al.*, 1999 or added after discussion with the supervisor of this master thesis. The latter are marked with an asterisk. The animal lying down was used as an endpoint when it came to noting behaviours performed before lying down.

Behaviour	Definition
Lying	Body weight supported by sides/belly.
Sitting	Body weight supported by front legs and hindquarters.
Nosing	Nose has contact with the ground, straw or other material.
Rooting	Digging movement with nose, nose in direct contact with the ground or material on the ground.
Pawing	The animal uses its front leg(s) to perform scratching movements towards the ground/bedding.
Carrying material	Taking material, straw, twigs, leaves etc, in mouth and walking at least two steps with it.
Arranging material	Straw, twigs, leaves etc are manipulated by rooting, pawing, carrying material, or lifting and then dropping material. The behaviour is only counted as this if the behaviour is aimed at the material, and the material can be seen to be moved from its original position by the behaviour.
Plowing*	The animal keeps its nose close to the ground and moves forward creating a furrow in the bedding material.
Plowing beneath bedding*	The animal performs plowing behaviour that ends up covering parts of the animal with bedding material.
Arranging to lie on concrete*	The animal performs behaviours to remove straw from the floor before lying down.
Body contact*	Lying down with body in contact with other pigs.
Antagonistic behaviour*	An animal chases away another animal from their resting place.
Lying and rooting/pawing*	The animal is lying, pawing and kicking with their legs and/or doing rooting behaviour.
Kneeling and rooting*	Body weight supported by hind feet and front knees, performing rooting behaviour.

All relevant behaviours for all observed animals were counted. Order of behaviours were noted. A pause in the middle of the behaviour before continuing was regarded as a break from performing the behaviour. If, for example, an animal was seen rooting, then lifting its head and then continuing to root, this was counted as two separate occasions of rooting.

Behaviours that were immediately followed by the animal lying down was counted as being performed in relation to lying down. If an animal nosed, immediately followed by rooting and then lied down, nosing and rooting

were considered to be in relation to lying down. However, if the animal instead nosed, paused or walked a few steps, then rooted and lied down, only rooting was considered to be performed in relation to lying down.

When two cameras recorded the same location, the reviewing of recordings with matching time stamps was synchronised. Meaning that when one recording from one of the cameras had been studied and any relevant behaviours had been counted, the recordings from the other camera in the same hut were inspected. If a recording with a matching time stamp was found it was immediately studied to see if the different angle showed any other behaviours or the same behaviours. This was done to rule out the risk of counting the same behaviour twice and thus skewing the results. The number of recordings and number of minutes recorded for each animal category can be seen in table 3.

**Table 3)** Total number of recordings as well as total time recorded for each animal category.

Animal category	Total number of recordings	Total time recorded
European wild boar	1176	1116 minutes 58 seconds
Domestic pigs outdoors	384	313 minutes 37 seconds
Domestic pigs indoors	202	169 minutes 30 seconds

### 3.4 Weather

The study was conducted during summer, the outdoor domestic pigs were studied in late June, the wild boar during the entirety of July and the indoor domestic pigs in September. This was due to the schedule of the farmer as well as enabling the use of fewer cameras. The temperatures were noted by the cameras (table 4 and 5).

**Table 4) Temperatures registered during the domestic pig studies**

Period/night	Domestic pigs outdoors (°C)	Min/Max (°C)	Domestic pigs indoors (°C)	Min/Max (°C)
Night 1	20,9	17/30	10	2/12
Night 2	15,3	14/17	9,8	1/11
Night 3	19,6	15/23	11,6	9/13

**Table 5) Temperatures registered during the wild boar study**

Period	Mean temperature (°C)	Min/Max (°C)
Period 1	12,7	7/22
Period 2	17	6/33

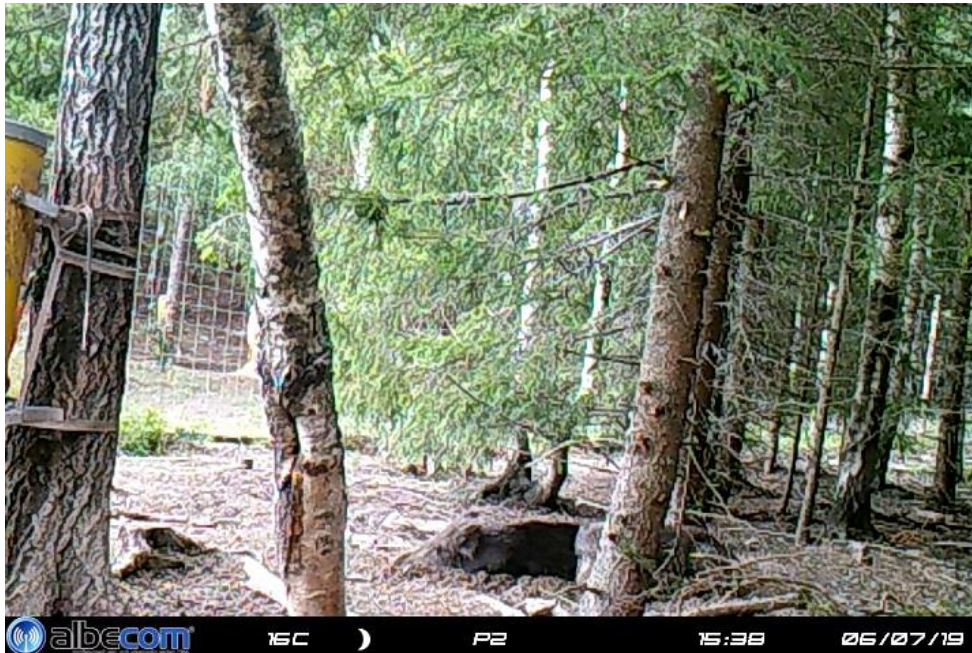
### 3.5 Study design

#### 3.5.1 European wild boar

All animals were included in this part of the study. To gain as much information as possible and increase the chance of catching relevant nest-building behaviours on camera recordings, the cameras were set to record 24h a day until they ran out of memory. Frequency and order of relevant behaviours was noted. The five sleeping/resting places (picture 4 – 8) used included one beside the bottom of an uprooted tree, and the other four were beneath standing trees with different amount of coverage. Out of these the first one offered protection on one side and it lacked in overhead cover. Of the other four three had only overhead cover, though the thickness and height above ground of that cover varied while the fourth offered some cover from the sides as well.



**Picture 4)** The resting place overlooked by camera 1 had a spruce creating cover from above.



**Picture 5)** The resting place overlooked by camera 1. The feeding station can be seen in the left side of the picture (yellow), and the resting place has some cover above from conifer branches, though not as thick as the other covers.



**Picture 6)** The resting place overlooked by camera 3. The resting place is situated beneath a spruce, with thick cover above and some cover to the sides.



**Picture 7)** The resting place overlooked by camera 4. This place was next to a fallen tree and close to the feeding station. There was only the cover given by the root system of the tree.



**Picture 8)** The resting place overlooked by camera 5 was situated beneath a spruce and offered cover from above.

The study was divided into periods. The first period spanned from July 6<sup>th</sup> from 10AM to July 17<sup>th</sup> 5PM. The cameras were placed at five different locations that were known to the staff to be used for sleeping and or resting. The cameras were left in their original positions and equipped with new memory cards for the next period that spanned July 17<sup>th</sup> from 5PM until August 5<sup>th</sup> at 5PM. During this second period the two cameras that had recorded the most were equipped with 64 GB memory cards. The cameras were in the training enclosure for a total of 31 days. Larger memory cards were used to account for these longer periods.

### 3.5.2 Domestic pigs outdoors

The cameras were placed in two different corners of the hut that the animals had access to. There was one hut per pasture with room for all the animals. The placement of the cameras (picture 9) was planned so that the footage would cover as much of the hut as possible, but some corners were out of view.

The first night, June 25<sup>th</sup> to June 26<sup>th</sup>, the cameras were set to start recording at 7 pm and film until 7 am. However, the memory cards were full after less than 2 hours. The second camera (P1.W) was placed at the back window of the hut and aimed towards the door of the hut, while the first (P1.D) was situated next to the door and aimed towards the back of the hut (picture 10), causing the different starting times as the cameras were motion activated.

The cameras were placed at the same places in pasture 2 (P2.D and P2.W) as in pasture 1.



**Picture 9)** The original placement of the cameras. The cameras were situated at the same places in both huts, in the pictures P2.D is shown to the left and P2.W to the right.

It was decided to move the starting time since the last films from the first night did not show animals sleeping and resting. Thus, during the second night the cameras were set to start filming at 9 pm. For unknown reasons, only one of the cameras filmed during the second night, and that was the camera in pasture 2 that was aimed towards the door opening. The cameras had correct and identical settings, and were turned off before removing the memory cards. However, due to the angle of the camera, the animals sleeping towards the back wall in the hut were not in the picture, and at the start of the first film animals were already lying down in the lower part of the picture.

To account for this, the cameras at the back of the hut were moved and placed at the other side of the door opening (picture 10) and renamed P1.D2 and P2.D2 respectively.



**Picture 10)** The placement of the cameras during the third and last night of the study as well as the interior of the huts. P2.D is shown to the right and P2.D2 to the left in the picture.

The cameras were set to start filming at 8 pm, and triple-checked that they were started and functional.

All cameras were recording during the third night.

### 3.5.3 Domestic pigs indoors

Both groups of animals were studied for 3 consecutive evenings with the use of game cameras that recorded from 5.30 pm – 6 am. Each pen was recorded by two cameras, one by the door overlooking most of the pen, and one on the side of the pen overlooking the innermost part of the pen. The cameras were set to record between 5.30 pm and 6 am. The cameras recorded every night from September 18<sup>th</sup> until September 21<sup>st</sup>. The cameras also recorded the night between September 16<sup>th</sup> to September 17<sup>th</sup>, but the recordings were only used to check if the camera angle was good.

### 3.6 Ethical approval

Since the study was conducted only through observations of the animals in their normal environment, no ethical approval was needed. To ascertain this the work plan of the study was sent to the board for ethical approval of studies involving animals, at SLU for reviewing. They agreed that no ethical approval was needed.

## 4 Results

### 4.1 Behavioural study – European wild boar

A total of 1 176 video recordings were gathered during this part of the study. The cameras recorded a total of 1116 minutes and 58 seconds of film during the study period, as most recordings were either 60 seconds or 30 seconds long. The last recording before the memory card was full often differed in time from the two mentioned. The placement of the cameras meant that different cameras recorded different amounts of movement, depending on how often the wild boar frequented the area. During this time, animals were seen to lie down on a total of 63 occasions. Out of these, 56 occasions of lying down are included in the study, as the other 7 times were occasions on which behaviours performed before lying down could not be seen. This included if, for example, an animal was seen to lie down with its front end out of picture or hidden behind another animal. In table 6 the total number of different behaviours are shown, as well as the number of times they were seen in relation to lying down. Nosing and rooting was by far the most common behaviours seen.

**Table 6) Total number of behaviours as well as number of behaviours performed in relation to lying down during the entire observation time and including all animals**

Behaviour	Total number of observations	Number of observations in relation to lying down
Sitting	7	5
Nosing	944	16
Rooting	289	45
Pawing	43	2
Carrying material	38	0
Arranging material	36	2
Body contact	11	11
Lying and rooting/pawing	6	0
Kneeling and rooting	9	8
Plowing	6	6

The number of relevant nest-building behaviours performed before lying down varied from zero to three. In table 7 the distribution of number of relevant behaviours in relation to lying down can be seen.

**Table 7) Number of observations with the different number of relevant nest-building behaviours performed before lying down**

Number of relevant behaviours performed	Number of observations
0	13
1	26
2	15
3	2
Total	56

## 4.2 Behavioural study – Domestic pigs outdoors

A total of 384 video recordings were gathered during this part of the study. A total of 313 minutes and 37 seconds of film were recorded during this part of the study, as most recordings were either 60 seconds or 30 seconds long. The last recording before the memory card was full often differed in time from the two mentioned. The total number of observations of the behaviours in the ethogram were calculated, and the proportion of these that were performed in relation to lying down can be seen in table 8.

Since there were two cameras filming in each hut, some of the films showed the same event of a behaviour. The recordings from the different cameras with same or similar timestamps were studied in succession to avoid counting the same behaviour twice. During this time, an animal was recorded to lie down a total of 162 times. Out of these, 151 occasions of lying down are included in the study, as the other 9 times were occasions on which behaviours performed before lying down could not be seen. This included if, for example, an animal was seen to lie down with its front end out of picture or hidden behind another animal.

**Table 8) Total number of behaviours as well as number of behaviours performed in relation to lying down during the entire observation time and including all animals**

Behaviour	Total number of observations	Number of observations in relation to lying down
Sitting	20	6
Nosing	329	68
Rooting	270	109
Pawing	51	5
Carrying material	8	1
Arranging material	3	1
Body contact	62	62
Lying and rooting/pawing	23	0
Kneeling and rooting	8	5
Plowing/plowing beneath bedding	22	20

Table 9 shows the distribution of number of nest-building behaviours performed before lying down.

**Table 9) Number of observations with the different number of relevant nest-building behaviours performed before lying down**

Number of relevant behaviours performed	Number of observations
0	41
1	86
2	19
3	5
Total	151

### 4.3 Behavioural study – Domestic pigs indoors

A total of 202 video recordings were gathered during this part of the study. A total of 169 minutes and 30 seconds of film was recorded during this part of the study, as most recordings were either 60 seconds or 30 seconds long. The last recording before the memory card was full often differed in time from the two mentioned. The total number of observations of the behaviours in the ethogram were calculated, and the proportion of these that were performed in relation to lying down can be seen in table 10. As can be seen, nosing and rooting were the most commonly performed behaviours, while rooting and sitting were the most common in relation to lying down. However, sitting in relation to lying down was mainly, in 20 out of 21 or 95.2 % of the cases, performed by an animal that was already lying down. In those cases, the animal sat up and shifted a bit before lying down again. This is counted as a new occasion of lying down in this study, making sitting a common behaviour performed in relation to lying down.

**Table 10) Total number of behaviours as well as number of behaviours performed in relation to lying down during the entire observation time and including all animals**

Behaviour	Total number of observations	Number of observations in relation to lying down
Sitting	25	21
Nosing	297	17
Rooting	177	61
Pawing	34	2
Carrying material	0	0
Arranging material	4	0
Arranging to lie on concrete	0	0
Body contact	10	10
Lying and rooting/pawing	20	0
Kneeling and rooting	14	13
Plowing/plowing beneath bedding	1	1

Since there were two cameras filming in each pen, some of the films showed the same event of a behaviour. The recordings from the different cameras with same or similar timestamps were studied in succession to avoid counting the same behaviour twice. During this study, an animal was recorded lying down on a total of 118 occasions. Out of these, 92 occasions of lying down are included in the study, as the other 26 times were occasions on which behaviours performed before lying down could not be seen. This included if, for example, an animal was seen to lie down with its front end out of picture or hidden behind another animal. Table 11 shows the distribution of number of relevant behaviours performed before lying down. Twice a pig was seen to perform four relevant behaviours before lying down, something not seen in the other two parts of the study.

**Table 11) Number of observations with the different number of relevant nest-building behaviours performed before lying down**

Number of relevant behaviours performed	Number of observations
0	36
1	37
2	12
3	5
4	2
Total	92

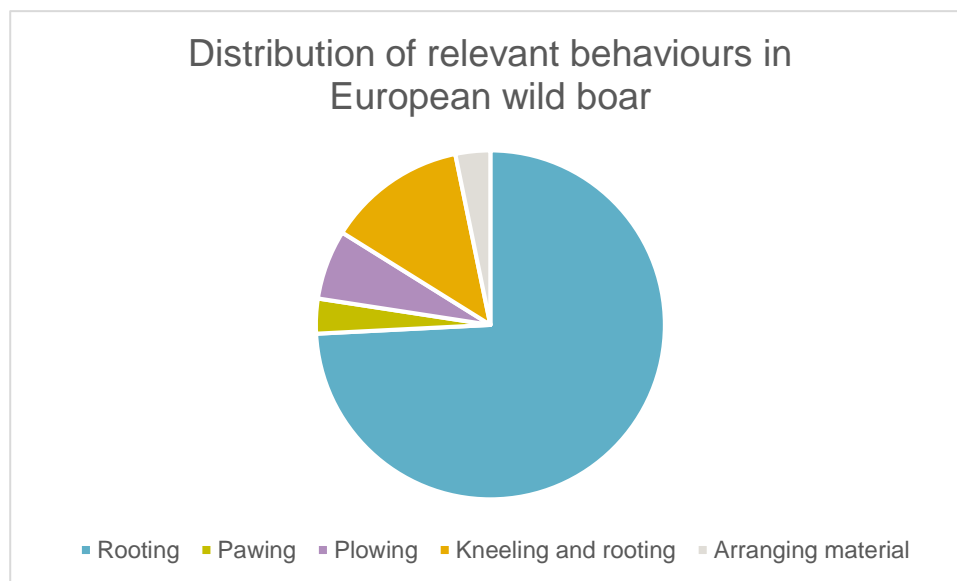
#### 4.4 Statistics

The statistical analysis was only descriptive and carried out in Microsoft Excel.

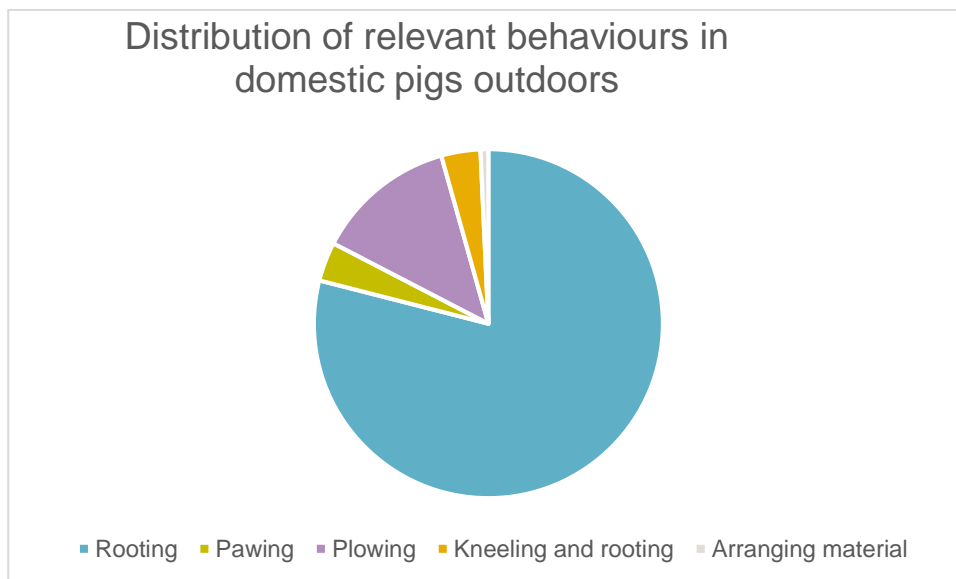
#### 4.4.1 Relevant behaviours

The percentages of observations of a pig lying down where relevant behaviours were performed beforehand was 76.8 % in the wild boar, 72.9 % in the domestic pigs outdoors and 60.9 % in the domestic pigs indoors. In the cases of no behaviour relevant for nest-building performed, 58 % of the irrelevant behaviours in domestic pigs indoors were pigs sitting up and then lying down again. Whether this can count as a new occurrence of lying down or if this should only be regarded as the animal shifting position is uncertain. However, if this chain of behaviours is excluded the percentages of animals performing relevant behaviours before lying down change to 81.1 % in the wild boar, to 74.8 % in the domestic pigs outdoors and to 78.9 % in the domestic pigs indoors.

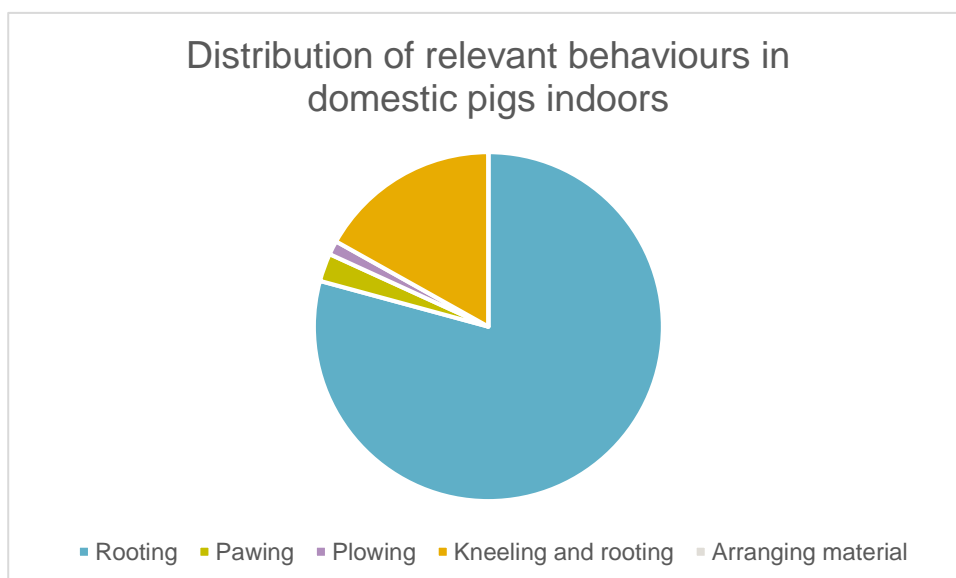
The behaviours considered relevant were rooting, kneeling and rooting, pawing, plowing and arranging material as all of these manipulated the ground/bedding. In figure 1, 2 and 3 the distribution of these behaviours performed in relation to lying down can be seen for the three study groups. Rooting is by far the most commonly performed behaviour across all three groups, at 74.2 % of behaviours in the wild boar, 79.0 % in the domestic pigs outdoors and 79.2 % in the domestic pigs indoors.



**Figure 1)** Distribution of relevant behaviours preceding lying down in European wild boar. Rooting is the most common behaviour followed by kneeling and rooting, with plowing in a third place.



**Figure 2)** Distribution of relevant behaviours preceding lying down in domestic pigs outdoors. Rooting is the most common behaviour, followed by plowing.

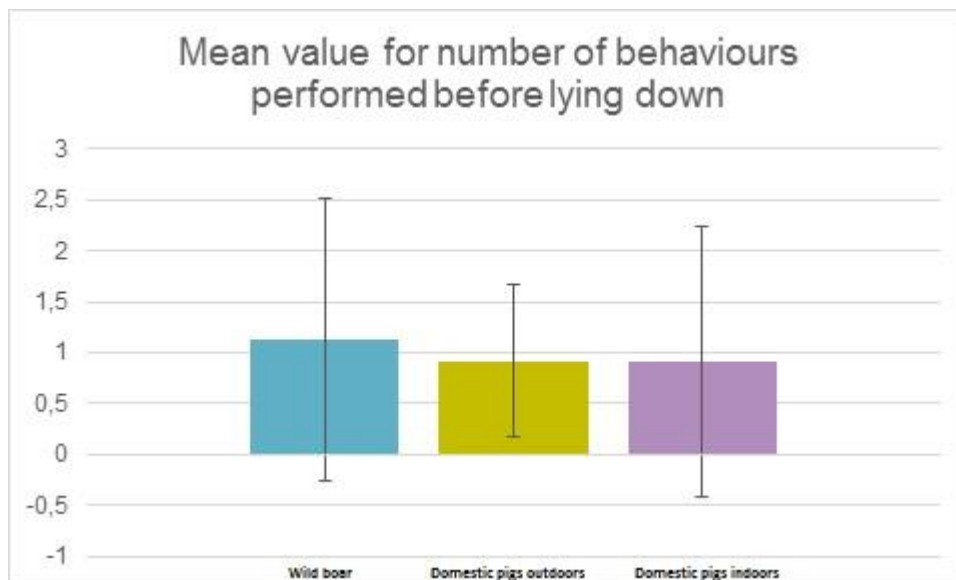


**Figure 3)** Distribution of relevant behaviours preceding lying down in domestic pigs indoors. Rooting is again the most common behaviour, with kneeling and rooting in second place, followed by pawing. Arranging material was not seen in relation to lying down.

#### 4.4.2 Number of behaviours before lying down

There was a variation in the number of relevant nest-building behaviours performed before lying down, in the range from zero up to four behaviours.

The mean values for the three groups were 1.13 relevant nest-building behaviours performed before lying down by the wild boar, 0.92 by the domestic pigs outdoors and 0.91 by the domestic pigs indoors. The mean values with the calculated standard deviations can be seen in figure 4. If the behaviour of a pig that was lying down sitting up and then lying down again is excluded, the mean values change to 1.17 by the wild boar, 0.95 by the domestic pigs outdoors and 1.18 by the domestic pigs indoors.



**Figure 4)** Mean number of relevant nest-building behaviours performed by the three categories of animals before lying down.

#### 4.4.3 The behaviours performed before lying down that were not considered relevant

The behaviours seen before lying down that were not considered relevant in this study were the following; nosing, sitting, scratching, eating, running/playing, lied down with no behaviours before but body contact, and lied down with no behaviours before and no body contact. These were considered irrelevant from a nest-building perspective as these were not related to manipulation the ground/bedding

## 4.5 Additional findings

### 4.5.1 Description of nest-building in European wild boar

The wild boar spent four recorded nights performing what can only be assumed to be nest-building behaviours at the location of one of the cameras. As most of the performed behaviours do not fall under the definition of behaviours performed in relation to lying down, a description of the seen behaviours will be given here. The descriptions are divided by night and 30 second recording.

#### Night 1

At 11.03 pm one of the wild boars arrived at the already existing depression in the ground and started nosing in the depression. The nosing was quickly followed by rooting. Then the boar continued to nose before pawing at the sides of the depression. A second boar arrived and nosed in the depression followed by rooting.

At 11.05 pm the first two boars were pawing at opposite sides of the depression, approx. 0,5-1 metre away from the depression. A third boar arrived and started nosing in the depression. The first two immediately joined him in the depression, the one closest to the camera started rooting. The other two were in the depression but any behaviours were at first hidden by the one in front. Soon two of the boars could be seen rooting at the edges of the depression (making it larger?) when the fourth and last boar arrived. The others continued to root while the newcomer paused next to the depression. One of the first three boars lied down in the depression.

At 4.22 three boars could be seen lying in the depression, while the fourth one walked around a couple of metres away.

#### Night 2

At 11.23 pm the boars all arrived at the depression. Two of them immediately started rooting in the depression while the third started to nose, the fourth was hidden behind the others. The fourth soon left while the others continued to root.

At 11.24 pm the fourth pig returned and started to root in the depression with two of the others. The third pig was nosing approximately 0,5-1 metre away from the depression but soon returned to the depression. Two of the

boars rooted while the fourth was pawing at the edges of the depression, the third pig was hidden behind the others. Soon all three visible pigs were pawing.

At 11.25 pm two pigs were pawing at the edges of the nest and one was nosing and rooting at the bottom of the depression. Soon all three were pawing, one in the depression and the other two approximately 1-1,5 metres away from the depression (both on the left side). One of them returned to the depression and started to root.

At 11.26 pm only two pigs were visible, and they were pawing to the about 1 metre to the left of the depression. They both returned to the depression and one started to root, the other was hidden behind the first. The first seemed to arrange material by rooting at some pine tree twigs at the edge of the depression.

At 11.27 pm all four boars could be seen to arrive at the depression. Two of them immediately started to root at the bottom of the depression, the third boar seemed to be chased away by one of the two. The two continued to root in the depression, then one of them started to paw at the edge of the depression instead. The fourth boar started to root in the depression while the one that was pawing moved away to the left of the depression while continuously pawing at the ground. The remaining of the two first started to paw at the edges of the depression.

At 11.33 pm one boar arrived, at least two other boars were lying down in the depression. The arriving boar disturbed one of them who sits up. The newcomer went to stand behind the two and could not be seen properly.

At 7.52 am three boars could be seen lying in the depression, while a fourth walked around a couple of metres away.

### Night 3

At 9.48 pm all four wild boars could be seen gathering at the depression, two pawing at the ground about a metre away, one nosing in front of it and the fourth unseen. The fourth was later seen rooting at the edge of the depression.

At 9.53 pm one pig could be seen pawing behind the depression, while another one was rooting. The one that was rooting could then be seen first pushing a longer twig, approx. 40 cm long in the depression, then using its

mouth to lift it and move it to the side before continuing to root. The other two boars were seen to arrive at the same time, one of them carrying a twig in its mouth.

At 9.55 pm one wild boar was seen pawing in the depression, another was pawing and rooting a couple of metres away from the depression and a third one seemed to be pawing about 0.5 metres away from the depression. The second wild boar walked back to the depression, lifting a smaller branch found on the way and carrying it to the depression where it seemed to be moving it around with its mouth. The pawing wild boar started to root.

At 10.03 pm two boars were pawing the ground on different sides of the nest, one was rooting at the bottom of the nest and the fourth was standing behind the rooting pig, any behaviours unseen. One of the pawing boars grabbed a small twig in its mouth and carried it to the depression. The pig seemed to drop the twig and then nipped at one of the original boars. The other pawing boar started to root.

At 10.10 pm only two boars could be seen. One walked away while the other started to pull on a tree branch that was still attached to a tree. The one that walked away could be seen rooting farther away, while the pulling boar continued to do so for the rest of the recording, only taking breaks to change the grip.

At 10.24 one of the wild boars could be seen to arrive at the depression, it started to root. Followed by arranging material by rooting at and lifting twigs with its mouth.

At 10.26 pm three of the wild boars could be seen at the depression, one seemed to be rooting while another one stood beside it. The third boar tried to walk closer but was chased away by nipping by the rooting boar. It walked away while the other two started to root in the depression.

At 10.27 pm two wild boars could be seen at the depression, one may have been lying down in it but only part of its head could be seen. The second boar nosed at the ground next to the depression. A third boar arrived.

At 10.29 pm one wild boar was rooting and arranging material in the depression, while a second one was nosing a couple of metres away. The

rooting boar may have lied down, but only its head was seen; the second boar walked back to the depression.

At 10.32 pm one wild boar was seen rooting at the depression before lying down, while a second wild boar was nosing some metres away.

#### Night 4

At 9.54 pm two wild boar arrived at the depression, at first, they nosed in it, followed by pawing.

At 9.57 pm one wild boar was nosing in the depression while another one was pawing a couple of metres away. A third boar arrived, and they all start to nose and root in the depression.

At 10.04 pm at least two wild boar can be seen lying in the depression. A third boar walked into the picture, stopped in front of the depression and then walked away.

#### 4.5.2 The avoidance of a hole in the wall in one of the huts

During the third night in pasture 2 the domestic pigs outdoors was seen to seemingly avoid sleeping right in front of a hole in the back wall. This was seen from 10.32 pm until 00.32 am when a pig lied in front of the hole. The camera measured a temperature at the other side of the hut as 18 °C at the start and 15 °C when they again chose to sleep in front of the hole.

## 5 Discussion

### 5.1 Brief summary of results

The results showed no differences between the three animal categories (European wild boar, domestic pigs outdoors and domestic pigs indoors) regarding average number of behaviours performed before lying down. No differences were found in the number of times four of the five relevant behaviours were performed by the three animal categories. Plowing was the only behaviour that differed in the proportion of times performed by the three animal categories and was almost never performed by domestic pigs indoors.

### 5.2 Statistics

The group sizes, ages, sexes, materials provided and environments as well as time observed is unbalanced in this study and therefore any comparisons had to be descriptive. The small group of European wild boar used in this study means that the result from that animal category may not be as reliable as from the domestic pigs. Further studies with more balanced groups are needed, but as this was only an early attempt to study the behaviour of nest-building for sleeping, a small group of wild boar was considered better than none. Nonetheless, all three categories of animals seemed to perform similar amounts of nest-building behaviours.

### 5.3 European wild boar

The cameras were strategically placed at five different locations known by the staff at the enclosure to be used for sleeping and/or resting by the European wild boar. However, some regularly used sleeping places underneath fallen trees had to be excluded due to difficulties in placing the cameras so that a view could be obtained. I.e. some resting places were too secluded to be studied. The wild boar had access to several different resting places, the total number is unknown as they sometimes choose new places and abandoned old resting places. This means that the resting places used in the study were mainly open spots beneath standing trees that offered less protection in comparison to the fallen trees. This may affect the behaviours performed by the animals, since it is possible that different behaviours or a different number of behaviours are performed depending on how protected or hidden the resting place is by surrounding nature. Thus, the resting places included in this study were generally very open to their surroundings, as opposed to the resting places found in the studies by Dardaillon (1986) and (Mayer *et al.* (2002) were they were often surrounded by dense vegetation. Meaning that this study can only account for nest-building behaviours performed by European wild boar when they choose more open resting places. It should also be noted that the European wild boar in this study were recorded during summer, which is very likely to have affected the intricacy of the sleeping nests as noted by Dardaillon (1986).

During the study period the wild boars were occasionally used for dog training, meaning that one dog at a time would be tasked with finding the wild boars and bark at them. The dog could either bark at them to make them move or try to make the wild boars stand still. No studies on stress reactions in wild boars used for dog training has been found, and any conclusions about stress in the animals is therefore difficult to discuss scientifically. The animals were observed to continue rooting and even lie down regardless of dogs barking at them from approximately 3 - 5 metres. This could indicate that this group of wild boars was not noticeably affected or stressed by the dogs. On the other hand, it could be that they were used to the dogs keeping their distance and therefore not as affected by them as other wild boars would be.

There was a problem in the definition used for relevant behaviours in relation to lying down that was especially noticeable in the wild boar study. Since only behaviours immediately preceding the act of lying down was

counted as being in relation, some potential nest-building behaviours in the wild boar were not counted. These were behaviours during four nights where the animals could be seen performing several relevant behaviours mostly together at a depression in the ground that they later lied down in. These behaviours could be nest-building behaviours performed in group by the animals, but most of these behaviours were not counted as such due to the definition used. This was caused by the animals working on the depression in the ground over the course of several recordings and moving around a bit in the area during. Since the definition of behaviours performed in relation to lying down made it clear that the behaviours must be immediately followed by the act of lying down, most of these behaviours were not counted as related. Thus, the result of this part of the study may not show the true amount of effort that the European wild boar puts toward the building of sleeping/resting nests. However, the effort put towards building nests during late evening was much higher than the number of behaviours performed before lying down during daytime. On two of these occasions the animals could be seen to have stayed in the nest during most of the night. This might indicate that there are differences not only between farrowing nests and sleeping/resting nests as discussed by Mayer *et al.* (2002), but also differences in complexity between sleeping nests and resting nests.

Only four wild boar, under special conditions in a training enclosure for dogs, were included in the study. This means that the results must be interpreted carefully. The behaviours are examples of what can be seen in European wild boar kept in enclosures. Thus, the results from the study on European wild boar will mainly be discussed as a simple comparison to the domestic pigs in the study and should not be seen as representative for all wild boar in enclosures until further studies have been made. It can also be viewed as a very basic first description of some of the possible nest-building behaviours performed by these animals.

## 5.4 Domestic pigs outdoors

The cameras were placed inside the huts, meaning that anything happening outside is unseen. They were placed to capture as much of the inside of the hut as possible but there were corners that were out of view. The cameras were set to start recording at different times every night due to the small memory cards. Due to this, different starting times were used during

the three evenings. During the first night it was noticed that only a few animals seemed to be resting/sleeping when the memory cards were full at around 8 and 9 pm in the different huts. Therefore, the starting time was adjusted until 9 pm. However, during night 2 it seemed as if most animals had already lied down when the only camera recording started to record at 9 pm. Thus, during night 3 the cameras were set to start recording at 8 pm. It would seem as if most of the animals in this part of the study started to lie down for the night sometime between 8 pm and 10 pm.

The entirety of the ground inside the hut was covered in straw, causing all behaviours directed at the ground in this study to be directed at the straw. This means that it is impossible to know any preferences for ground to lie down on for this category of pigs, as the other available choice, the ground outside the hut, was not overlooked by cameras. Most studies done on different materials have been done from more of an explorative perspective, but sows may prefer straw over peat and wood shavings as nest-building material for farrowing nests (Rosvold *et al.*, 2018). Another study on the building of farrowing nests in gilts noted that if the gilts were given access to both straw and branches, they chose to use both to build their nests (Damm *et al.*, 2000). As the wild boar in this master thesis were seen to use branches in the building of sleeping nests, it would be interesting to see if domestic pigs would do the same.

As opposed to the study on the European wild boar, no known disturbances could be found in this part of the study. The animals were only recorded during the evening and night when no work was conducted near them. It is however impossible to know if any wild animals or people walking passed by the pasture during the evening/night, and it is also unknown whether this may have had an effect on the choice of resting place for the pigs.

A majority of pigs were seen to sleep inside the hut during the one night that the camera recorded until morning. Unfortunately, it is impossible to know if all pigs chose to do so, as only one camera was recording thereby limiting the view of the hut to approximately half of it.

## 5.5 Domestic pigs indoors

The cameras were placed at two different parts of the large pens, but almost all recordings came from the two of the cameras placed at the entrance. Again, the cameras were set to record only during hours where no work was being done on the farm to limit any disturbances. The cameras were recording for one night earlier than the three studied nights, but these recordings were excluded from the study due to work being done around and with the pigs studied.

These pigs had spent the shortest amount of time in their environment before the start of observations, as they had been moved to the pens from pasture only two days earlier. This is opposed to the domestic pig's outdoors who had been in their pasture for one week before start of recordings, and the wild boar who had spent between one week and a couple of months in their enclosure before start of the study period. Whether this may have influenced the results is unknown, the pigs indoors did not show a lot of explorative behaviours in the new environment, which could indicate that they had had time to get used to their new environment.

Approximately two thirds of the inside area were covered in deep straw bedding and seemed to be the chosen area for resting. The pigs observed in this part of the study were much less active than the younger ones, and several animals can be seen to lie down in the bedding on all recordings. If this is connected to them being older or heavier is unknown, but possible.

## 5.6 Behaviours

Only behaviours that in some way manipulated the ground/bedding material were considered as relevant in this study. This may have changed the results, since nosing was a common behaviour that was considered irrelevant. Nosing does not manipulate the ground in any way and was therefore not considered a nest-building behaviour. However, nosing was often seen before relevant behaviours. Thus, nosing may be a part of nest-building, either to spot the best place for a nest or as a way to investigate the ground.

When looking at the distribution of the behaviours that were considered relevant in this study, rooting was the most common behaviour performed in relation to lying down. This was seen in all three groups of animals, and in the two groups of domestic pigs, outdoors and indoors, rooting accounted

for 79.0 % and 79.2 % of the seen behaviours respectively. In the European wild boar rooting accounted for 74.2 % of the relevant behaviours. This would indicate that growing domestic pigs of different ages generally perform the same amount of rooting as a nest-building behaviour before lying down. Why the domestic pigs were seen to root to a higher degree before lying down might have been due to several reasons. A theory could be that the wild boar could perform a wider range of behaviours, such as carrying and arranging material, as they have access to twigs and branches. Furthermore, as the domestic pigs only had access to straw it was impossible to differentiate between rooting and arranging material, while rooting directed at twigs and branches by the wild boar were counted as arranging material instead of rooting. This is something that may very well have affected the proportions of relevant behaviours performed by the different animal categories. Rooting has also been seen to be the most common nest-building behaviour performed when sows and gilts build farrowing nests (Rosvold *et al.*, 2018).

As only the behaviours performed immediately before lying down were counted as being in relation to lying down, some nest-building behaviours may have been excluded. This was certainly true for some behaviours performed by the wild boar as mentioned earlier. However, this may be the case for some behaviours performed by the domestic pigs as well, though it is less clear since they used an area with less defined edges for sleeping and resting than the wild boar. Thus, a domestic pig could move much further and still be on the general resting area, i.e. the area covered in straw, and behaviours performed in different parts of the hut or pen may have both been connected to nest-building, or it may be completely unrelated. A wild boar rooting and pawing in an area that is less than approximately two square metres large and then lying down in the same area is easier to claim that the earlier behaviours performed may have been part of a nest-building repertoire. When comparing the number of observations of the relevant behaviours immediately before lying down, no differences were found for any behaviour except plowing. Plowing was mainly seen performed by the domestic pigs outdoors and the European wild boar but only seen once in the domestic pigs indoors. A possibility is that the behaviour is affected both by the size of the animal as well as the bedding material available. This would explain that it was mainly seen in the smaller animals, as the wild boar weighed about 20 kg and the domestic pigs outdoors weighed about 35 kg. A study on the building of farrowing nests in domestic gilts and sows found that the act of pushing the straw, which

would be a similar behaviour to plowing in this master thesis, was performed in a higher frequency by the gilts than by the older sows (Rosvold *et al.*, 2018). Furthermore, if the behaviour is connected to the available bedding material, it would explain that it was seen more often in the domestic pigs that had access to straw, but more unusual in the wild boar that did not have access to other bedding material than dirt and possibly twigs. The same study as earlier found that the total number of nest-building behaviours performed differed significantly between animals given straw and animals given peat as bedding material (Rosvold *et al.*, 2018). This could indicate that similar preferences may be found in other animal categories than pre-parturient sows and gilts.

One of the most commonly performed behaviours in relation to lying down that was not considered to be relevant for nest-building was nosing. Nosing was not considered relevant in this study as it does not manipulate the ground/bedding. However, it was commonly performed by all animal categories. Studies on pre-parturient sows building farrowing nests do sometimes include nosing as a relevant behaviour (Peeters *et al.*, 2006), while excluding it in other cases (Burne *et al.*, 2000).

Sitting was also one of the most common behaviours in the wild boar and the most common behaviour in domestic pigs indoors. Running/playing was the second most common in domestic pigs outdoors. These differences may be related to the age and weight of the animals, especially when comparing the two different groups of domestic pigs. Running/playing in relation to lying down was often seen in the younger and lighter animals, while rarely seen in the older and heavier pigs. The opposite held true when considering the number of animals that sat up, shifted a bit and then lied down again. This behaviour was mainly seen in the older and heavier animals. When it comes to sows and gilts building farrowing nests, a study found that older sows, when given access to straw, performed a higher total number of nest-building behaviours and spent more time on nest-building behaviours than younger sows (Rosvold *et al.*, 2018). Additionally, Stolba & Woodgush (1984) did note that the older pigs were generally more involved in the building of the communal nests than the younger animals.

## 5.7 Nest-building behaviour and straw usage

It is possible that a higher mean number of nest-building behaviours would be seen if the pigs were not in a pen or a hut, were they have access to protection both from the sides and above. This could make nesting before sleeping less of a priority than if they would have been in a less protected environment. Furthermore, it is important to remember that all animals were studied during the warmer part of the year, and higher temperatures has been noted to decrease nest-building behaviour in pre-parturient sows (Malmkvist *et al.*, 2012 se Aagaard Schild 2018). European wild boar in earlier studies have been shown to prefer nesting sites with some sort of cover, as well as varying a lot in complexity of their nests (Dardaillon 1986; Mayer *et al.*, 2002). As seen by Stolba & Woodgush (1984), domestic pigs in semi-natural environments chose sites for nests that were rarely fully enclosed but rather preferred sites that were moderately sheltered. Thus, it is possible that the cover given by the huts and indoor pens in this study was enough for the animals to choose to only create very simple resting places.

The reason for why sitting up and lying down again was more common in the domestic pigs kept indoors than the other two groups may be due to them being much larger and heavier, and that the amount of bedding may not be enough to keep them comfortable. It may also be that the smaller animals have an easier time moving around, thereby not resting and shifting resting position as much as the larger animals. A majority of the pigs indoors were seen lying down on most recordings, which could be seen as support of the latter theory. It could also be related to the environment, as both the wild boar and the domestic pigs outdoors had larger areas to move around and explore in, limiting the time spent resting.

Both groups of domestic pigs used in this study can be considered to have access to large amount of straw, especially compared to most conventional pigs. The pigs did perform a lot of rooting and nosing behaviours, and no pig was seen to lie down on concrete during the study. This would indicate a preference to lie on softer material, at least when the temperatures are below 14 °C as in this study. As the outdoor pigs and wild boar had no concrete ground to lie on, any possible preferences they may have had cannot be discussed. A study by Algers & Jensen (1990) showed that farrowing nests built by sows did not change temperature when the temperature outside of the nest changed, meaning that straw as a nest material seem to be a very good insulator. Additionally, it has been seen that even

in higher temperatures finishing pigs prefer to spend time on bedding material compared to concrete floor (Hötzel *et al.*, 2009).

The amount of straw used for both domestic pigs indoors and outdoors was an unknown variable, making it difficult to replicate this study exactly. The farmer did not know how much straw that was used, they added as much as they felt was needed and then added more when they felt it was necessary.

## 5.8 Usage of game cameras

The usage of game cameras saved a lot of time as the recording was not continuous during the entire time period. The cameras started recording when triggered by movement, which was especially useful when recording the European wild boar in a large enclosure. However, when recording the cameras were not able to start the recording as fast as when photographing. The only choices were a delay of 1 minute, 5 minutes or 10 minutes. Meaning that even though the cameras were set to start recording with the shortest possible delay, it was still possible to miss relevant behaviours. Another problem that was not properly described in the manual was that when the cameras recorded in colour it was possible to choose if they should record for 60 or 30 seconds, but when the cameras switched to night mode and recorded in black-and-white, they only recorded for 30 seconds. Another thing noticed by accident was that even though the manual claimed that the cameras could not support memory cards bigger than 32 GB, they worked perfectly fine with 64 GB memory cards as well. Had this been known from the start it would have been possible to get a lot more footage from the cameras. The memory cards used in the domestic pig's outdoors part of the study were only 8 GB, which was far too small. It was not possible to move the study period to a later date when the larger memory cards had arrived. This was due to the farmers schedule as well as the planned wild boar study using the same cameras.

The cameras handled dust, rain and wild boars scratching against them without showing any signs of wear, and it was possible to have them only record during predetermined hours of the day.

The study would have been improved if there would have been time to do a pilot study to try out the cameras beforehand, as well as if the larger memory cards could have been used from the start.

## 5.9 Legislation

The result from this study alone cannot be used as basis for any changes in the legislation. Further studies on the importance of the behaviour as well as studies on minimum amount of bedding material needed to fulfil their motivation for nest-building are necessary. This master thesis can only be considered as a very basic, first step towards studying nest-building for resting and sleeping in pigs.

## 5.10 Future studies

To further study the subject of the building of sleeping/resting nests in growing pigs, more controlled studies will be needed. Groups of similar size, age and live weight, with predetermined amounts and types of bedding material and control groups. These studies should include a wide range of amounts of bedding material, from as little as is allowed by laws and regulations to larger amounts, to see where the minimum amount of bedding material needed for the animals to perform these behaviours.

It would be interesting to study growing domestic pigs in larger enclosures to see if that may influence the behaviours performed by the animals. Preference tests on bedding material to study what materials produce the most behaviours performed by the animals would give an indication on what might increase the welfare through increased performance of natural behaviours.

Moreover, studies designed to specifically study how strong the motivation is to perform the relevant behaviours would be needed to assess the importance of these behaviours on the pigs' welfare. Studies designed to test the effort that growing pigs are willing to put into gaining access to different kinds of bedding material would be one example, but it is important to be able to differentiate between motivation to gain access to bedding material as nest-building material and other motivations, as bedding material can serve several functions. Time spent on nest-building behaviours when given access to different kinds of bedding material could also be studied.

It would be interesting to see if any future studies with more controlled and larger study populations of these or similar categories of animals come to the same conclusion as this study.

## 6 Conclusion

In summary, the results from this master thesis indicate that sleeping/resting nest-building behaviours may exist to some degree in growing pigs. The results from the studies performed in this master thesis shows that:

- In a majority of observations growing domestic pigs perform behaviours relevant for nest-building before lying down
- Out of the behaviours performed, rooting was by far the most common. No differences were found between groups regarding average number of behaviours performed nor proportion of relevant behaviours, with plowing being the only exception and was rarely performed by domestic pigs indoors.
- No differences were found between the different age categories of domestic pigs, plowing being the only exception and was rarely performed by the older domestic pigs indoors..
- No significant differences were found between domestic pigs and European wild boar, plowing was seen in both domestic pigs outdoors and wild boars but rarely in domestic pigs indoors.
- The results provide basis for further studies in more controlled environments to properly evaluate the motivation to perform these nest-building behaviours.

Furthermore, there are several other unknown variables in this study that needs to be noted. As this is meant to be a first study on the subject, the main idea was only to see whether the behaviour of nest-building seem to exist in these animal categories. Further studies will be needed to properly decide the importance of the behaviour.

## Acknowledgements

I want to thank both my supervisors, Jenny Yngvesson and Maria Vilain Rørvang for all their help and support during this project. I would also like to thank the owner of the KRAV-organic pigs that I studied during the domestic pig part of the study, as well as the owner of the dog training facility where I studied the European wild boar. Further thanks to the staff at both the farm and the training facility for answering all of my questions and helping me find good places for the cameras, and in the case of the wild boar enclosure, helping me find the cameras again once they were placed.

## References

- Aagaard Schild S.-L.** (2018). *Giving birth outdoors: impact of thermal environment on sows' parturition and piglet survival*. Diss. Aarhus University Foulum.
- Algers B. & Jensen P.** (1990). Thermal microclimate in winter farrowing nests of free-ranging domestic pigs. *Livestock Production Science*, vol. 25, pp. 177 – 181.
- Bracke M.B.M.** (2011). Review of wallowing in pigs: Description of the behaviour and its motivational basis. *Applied Animal Behaviour Science*, vol. 132, pp. 1 – 13.
- Bulens A., Van Beirendonck S., Van Thielen J., Buys N. & Driessen B.** (2016). Long-term effects of straw blocks in pens with finishing pigs and the interaction with boar type. *Applied Animal Behaviour Science*, vol. 176, pp. 6 – 11.
- Burne T.H.J., Murfitt P.J.E. & Gilbert C.L.** (2000). Deprivation of straw bedding alters PGF<sub>2α</sub>-induced nesting behaviour in female pigs. *Applied Animal Behaviour Science*, vol. 69, pp. 215 – 225.
- Damm B.I., Vestergaard K.S., Schröder-Petersen D.L. & Ladewig J.** (2000). The effects of branches on prepartum nest building in gilts with access to straw. *Applied Animal Behaviour Science*, vol. 69, pp. 113 – 124. DOI: [https://doi.org/10.1016/S0168-1591\(00\)00122-2](https://doi.org/10.1016/S0168-1591(00)00122-2)
- Dardaillon M.** (1986). Seasonal variations in habitat selection and spatial distribution of wild boar (*Sus scrofa*) in the Camargue, Southern France. *Behavioural Processes*, vol. 13, pp. 251 – 268.
- Di Martino G., Capello K., Scollo A., Gottardo F., Stefani A.L., Rampin F., Schiavon E., Marangon S. & Bonfanti L.** (2013). Continuous straw provision reduces prevalence of oesophago-gastric ulcer in pigs slaughtered at 170 kg (heavy pigs). *Research in Veterinary Science*, vol. 95, pp. 1271 – 1273. DOI: <http://dx.doi.org/10.1016/j.rvsc.2013.08.012>
- Encyclopaedia Britannica.** (2017). *Boar*. Available: <https://www.britannica.com/animal/boar-mammal> [2019-02-11].
- EU-kommissionens förordning (EG) nr 889/2008.** Kapitel 2 Animalieproduktion, Avsnitt 2, Artikel 11).
- Frantz L.A.F., Schraiber J.G., Madsen O., Megens H.-J., Cagan A., Bosse M., Paudel Y., Crooijmans R.P.M.A., Larson G. & Groenen M.A.M.** (2015). Evidence of long-term gene flow and selection during domestication from analyses of Eurasian wild and domestic pig genomes. *Nature Genetics*, vol. 47, pp. 1141 – 1149.
- Frauendorf M., Gethöffer F., Siebert U. & Keuling O.** (2016). The influence of environmental and physiological factors on the litter size of wild boar (*Sus scrofa*) in an agriculture dominated area in Germany. *Science of The Total Environment*, vol. 541, pp. 877 – 882. DOI: <https://doi.org/10.1016/j.scitotenv.2015.09.128>
- Giuffra E., Kijas J.M.H., Amarger V., Carlborg Ö., Jeon J.-T. & Andersson L.** (2000). The origin of the domestic pig: independent domestication and subsequent introgression. *Genetics*, vol. 154, pp. 1785 – 1791.

- Gustafsson M., Jensen P., de Jonge F.H., Illman G. & Spinka M.** (1999a). Maternal behaviour of domestic sows and crosses between domestic sows and wild boar. *Applied Animal Behaviour Science*, vol. 65, pp. 29 – 42.
- Gustafsson M., Jensen P., de Jonge F.H. & Schuurman T.** (1999b). Domestication effects on foraging strategies in pigs (*Sus scrofa*). *Applied Animal Behaviour Science*, vol. 62, pp. 305 – 317.
- Herskin M.S., Jensen H.E., Jespersen A., Forkman B., Jensen M.B., Canibe N. & Pedersen L.J.** (2016). Impact of the amount of straw provided to pigs kept in intensive production conditions on the occurrence and severity of gastric ulceration at slaughter. *Research in Veterinary Science*, vol. 104, pp. 200 – 206. DOI: <http://dx.doi.org/10.1016/j.rvsc.2015.12.017>
- Hötzel M.J., Lopes E.J.C., de Oliveira P.A.V. & Guidoni A.L.** (2009). Behaviour and performance of pigs finished on deep bedding with wood shavings or rice husks in summer. *Animal Welfare*, vol.18, pp. 65 – 71.
- Jensen K.H., Jørgensen L., Haugegaard S., Herskin M.S., Jensen M.B., Pedersen L.J. & Canibe N.** (2017). The dose-response relationship between the amount of straw provided on the floor and gastric ulceration of pars oesophagea in growing pigs. *Research in Veterinary Science*, vol. 112, pp. 66 – 74. DOI: <http://dx.doi.org/10.1016/j.rvsc.2017.01.005>
- Jensen M.B., Herskin M.S., Forkman B. & Pedersen L.J.** (2015). Effect of increasing amounts of straw on pigs' explorative behaviour. *Applied Animal Behaviour Science*, vol.171, pp. 58 – 63. DOI: [dx.doi.org/10.1016/j.applanim.2015.08.035](http://dx.doi.org/10.1016/j.applanim.2015.08.035)
- Mayer J.J., Martin F.D. & Lehr Brisbin Jr I.** (2002). Characteristics of wild pig farrowing nests and beds in the upper Coastal Plains of South Carolina. *Applied Animal Behaviour Science*, vol. 78, pp. 1 – 17.
- Pedersen L.J., Herskin M.S., Forkman B., Halekoh U., Kristensen K.M. & Jensen M.B.** (2014). How much is enough? The amount of straw necessary to satisfy pigs' need to perform exploratory behaviour. *Applied Animal Behaviour Science*, vol. 160, pp. 46 – 55.
- Peeters E., Driessen B., Moons C.P.H., Ödberg F.O. & Geers R.** (2006). Effect of temporary straw bedding on pigs' behaviour, performance, cortisol and meat quality. *Applied Animal Behaviour Science*, vol. 98, pp. 234 – 248.
- Ramos-Onsins S.E., Burgoz-Paz W., Manunza A. & Amills M.** (2014). Review: Mining the pig genome to investigate the domestication process. *Heredity*, vol. 113, pp. 471 – 484.
- Rosvold E.M., Newberry R.C., Framstad T. & Andersen I-L.** (2018). Nest-building behaviour and activity budgets of sows provided with different materials. *Applied Animal Behaviour Science*, vol. 200, pp. 36 – 44. DOI: <https://doi.org/10.1016/j.applanim.2017.12.003>
- Scollo A., Di Martino G., Bonfanti L., Stefani A.L., Schiavon E., Marangon S. & Gottardo F.** (2013). Tail docking and the rearing of heavy pigs: The role played by gender and presence of straw in the control of tail biting. Blood parameters, behaviour and skin lesions. *Research in Veterinary Science*, vol. 95, pp. 825 – 830.
- SFS 2018:1192.** *Djurskyddslag*. Stockholm: Näringsdepartementet.
- SJVFS 2019:20.** *Statens jordbruksverks föreskrifter och allmänna råd om grishållning inom lantbruket m.m.* Jönköping: Statens jordbruksverk.
- Spinka M.** (2002). Behaviour of pigs IN. Jensen P. *The ethology of domestic animals*. 2<sup>nd</sup> edition. Linköping: CABI, pp. 177 – 180.
- Stolba A. & Woodgush D.G.M.** (1984). The identification of behavioural key features and their incorporation into a housing design for pigs. *Annales de recherches Vétérinaires*, INRA editions, vol. 15, pp. 287 – 302.
- Stolba A. & Woodgush D.G.M.** (1989). The behaviour of pigs in a semi-natural environment. *Animal Production*, vol. 48, pp. 419 – 425.
- Topigs Norsvin.** (n.d.). *TN70*. Available: <https://topignorsvin.com/products/tn70-2/>

[2019-02-12].

**Tuytens F.A.M.** (2005). The importance of straw for pig and cattle welfare: A review. *Applied Animal Behaviour Science*, vol. 92, pp. 261 – 282.

**Wallgren T., Larsen A., Lundeheim N., Westin R. & Gunnarsson S.** (2019). Implication and impact of straw provision on behaviour, lesions and pen hygiene on commercial farms rearing undocked pigs. *Applied Animal Behaviour Science*, vol. 210, pp. 26 – 37.

DOI: <https://doi.org/10.1016/j.applanim.2018.10.013>

**Wallgren T., Westin R. & Gunnarsson S.** (2016). A survey of straw use and tail biting in Swedish pig farms rearing undocked pigs. *Acta Veterinaria Scandinavica*, vol. ????. DOI: DOI 10.1186/s13028-016-0266-8

**Wiepkema P.R.** (n.d). Remarks on the behaviour of wild boar.

**Wischner D., Kemper N. & Krieter J.** (2009). Nest-building behaviour in sows and consequences for pig husbandry. *Livestock Science*, vol. 124, pp. 1 – 8. DOI:

<https://doi.org/10.1016/j.livsci.2009.01.015>