Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

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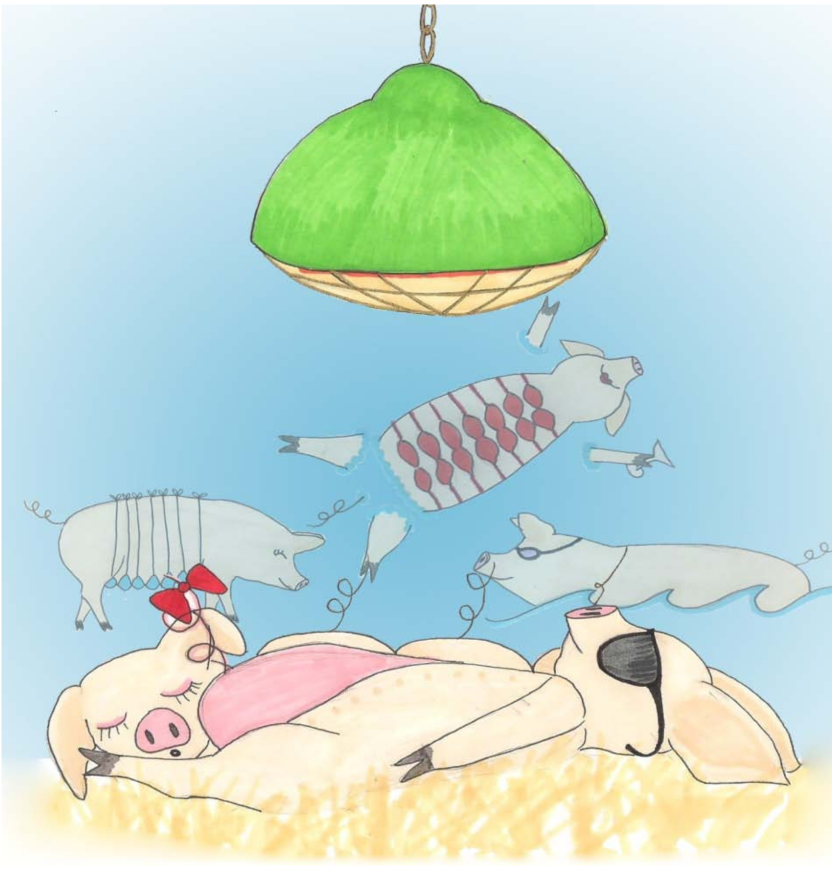

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Variation in piglet mortality between and within satellites in a sow pool

Variation i smågrisdödlighet mellan och inom satellitbesättningar i en suggring

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To Grandpa CM
Who despite what else he may had forgotten,
always remembered my dream to become an agronomist
I miss you

Thank you…

My supervisor *Nils Lundeheim* for all the help, especially with the statistics

Lotta Rydhmer, for being an excellent examiner

Sophia Isberg, for good collaboration and lots of enthusiasm

Mom and *dad*, for (among other things...) lending me your car and enabling stable visits

The very clever person who installed a GPS into my cell phone

And most of all, my sincerest thanks to all amazing producers, who made this possible!

CONTENTS

Abstract

The piglet mortality rates have become a major issue in today's pig production. While other production traits such as number of born piglets or produced piglets per sow have been improved, the mortality rate has escalated. High mortality rates before weaning does not only affect the economy but must also be looked at as both an animal welfare problem and an ethical issue. The background to this problem has been addressed many times, and its salvation has also been addressed by breeding. Breeding for increased piglet survival has been successful, but is time consuming and could not be seen as a quick fix. Through analyzes of production results, interviewing staff about management routines and herd visits has this study investigated the variation of piglet mortality within satellite herds of a sow pool, which share the same animal material but may differ in other aspects. The study focused on mortality from farrowing to weaning at approximately five weeks. It was found that there were great variation both between and within herds, even though the genetic material was the same, which indicate that the mortality rates were affected by management and housing. Furthermore, the mortality results within herds did also fluctuate heavily between batches, and could vary from 4-32%. Lower piglet mortality rates could be linked to certain management routines as many light hours during the lactation period and keeping the feed ratio of sows unchanged for the time around expected farrowing. Also, routines for identifying sow refusing to eat and the detection of the end of a farrowing was proved to be important for low mortality rates within the herd. The mortality rates were also dependent on season, party number and number of liveborn piglets in the litter.

Sammanfattning

Smågrisdödligheten har blivit en viktig fråga i dagens grisproduktion. Medan andra produktionsegenskaper, som antalet födda smågrisar eller producerade smågrisar per sugga, har förbättrats, har smågrisdödligheten eskalerat. Hög dödlighet före avvänjning påverkar inte bara ekonomin utan måste även ses som ett välfärdsproblem såväl som ett etiskt dilemma. Bakgrunden till den stigande smågrisdödligheten har undersökts många gånger, och har också angripits genom förändrad avel. Avel för ökad smågrisöverlevnad har varit framgångsrik, men är tidskrävande och kan inte ses som enda lösning. Genom analys av produktionsresultat, intervjuer av personal och stallbesök undersöktes i denna studie smågrisdödligheten satellitbesättningar inom samma suggpool, där man delar samma djurmaterial men andra yttre omständigheter kan skiljas åt. Studien har fokuserat på dödligheten under perioden från grisning till avvänjningen vid cirka fem veckors ålder. Det konstaterades att det fanns stora variationer i dödlighet både mellan och inom besättningar, även om det genetiska materialet var samma. Det tyder på att dödligheten påverkas av inhysning och skötsel. Smågrisdödligheten fluktuerade även kraftigt, mellan 4 till 32 %, mellan batcher, vilket ytterligare visar på att dödligheten påverkas av andra faktorer än genetiken. Lägre smågrisdödlighet kunde kopplas till vissa skötselrutiner så som fler ljustimmar under digivningsperioden och hålla suggans fodergiva oförändrad dagarna kring hennes förväntade grisning. Dessutom visade sig rutiner för att identifiera suggor som vägrar att äta, och identifiering av avslutade grisningar vara viktiga för låg smågrisdödlighet. Smågrisdödligheten visade sig också vara beroende av säsong, kullnummer samt antal levande födda smågrisar i kullen.

Introduction

Pig producers are paid for every produced pig for slaughter or sold piglet, depending on the type of production. To improve the profit, the pig producing industry has aimed to increase the number of produced piglets per sow through breeding, management and feeding, probably as long as there have been pigs in production. Even though as good as all of the afore mentioned parts of the production have been improved, still too many piglets are lost during the suckling period. This is reducing the number of weaned piglets per litter and also reducing the profits of farmers.

Preweaning mortality has become one of the major issues in piglet production. A Danish report on the issue found that preweaning mortality was high in whole Europe, and that Sweden had one of the highest piglet mortality rates (Pedersen et al., 2010). Piglet mortality during the lactation period is divided into two categories, see Table 1. Total piglet mortality, which contains the number of piglets lost from the litter, including both liveborn and stillborn piglets, and liveborn piglet mortality, which only considers those piglets that were alive after birth, but die before weaning. According to the results of the production follow up program PigWin Sugg, the average liveborn piglet mortality percent during the lactation period in the Swedish herds was 18.3 % in 2011, which is an increase by 0.9 percentage units compared to 2010 (Pig Win, 2012). According to Table 2, piglet mortality has increased every year from 2003-2011. In 2011, the best 25% of the herds had an average total piglet mortality of 14.9% while the 25% worst herds had an average total piglet mortality of 22.3%. The same trend was seen already in 2006 when the total mortality increased from 14.9% to 15.4% compared to the previous year, even though the number of liveborn piglets was the same (Svantesson & Mattsson, 2007).

Piglet mortality is not only an economical issue, but also an ethical and animal welfare problem due to suffering of the dying piglets (Pedersen et al., 2010). The pig industry has increasingly become an object of interest among media and the concerned public. This further underlines the importance of reducing piglet mortality rates, which otherwise may be interpreted as bad pig management and poor animal welfare. Furthermore, sick or weak piglets cost money, and piglets that die are often weak or sick prior to death. These piglets are in need of extra care and/or treatments and medications, such as antibiotics, which also add to the cost per produced pig.

As the breeding program has focused on improving piglet production by improving the number of born piglets, the preweaning mortality has unfortunately raised as the litter sizes has increased, as seen in Table 2. This has been suggested to be caused by relationships between large litters and number of weak, small piglets in the litter (Grandinson et al., 2002; Pedersen et al., 2010). Changes in the breeding goal from total born to live piglets day five, was made in Denmark 2004 and just recently led to the expected decrease in piglet mortality (Pedersen et al., 2010; Vinther, 2012). Until this reduction, the piglet mortality had just stagnated, but was not reduced.

Even though the breeding material in Sweden is quite similar between herds, with Landrace*Yorkshire bred cross sows and Hampshire or Duroc boars the overall piglet mortality varies between herds. This variation could be influenced by several factors such as management, stable environment, or presence of disease within the herd. This report investigates the variation in preweaning piglet mortality between different satellite herds in a sow pool and possible causes of the variation. Also differences between different units in the same satellite herd are investigated, to further establish possible influences of the housing and other differences between the units, managed by the same staff.

Aim

The aim of this project was to reduce piglet mortality by obtaining new knowledge. Within the project the variation in piglet mortality between and within herds were investigated by analyzing production results, interviews and stable visits. The aim was to compile the factors affecting the piglet mortality and piglet mortality rate, by defining differences in how piglets were reared and managed. Furthermore the aim was to link these differences to the variation in preweaning mortality. Satellite herds that had several, differently shaped, farrowing units were investigated to see if there were any differences in piglet mortality between the units, managed by the same staff.

Questions:

Is there a difference in the piglet mortality rate between the satellites in a sow pool, even though they share the same animal material?

Does a specific satellite always have “good” or “bad” results when it comes to piglet mortality?

Is there a difference in piglet mortality between different units in the same satellite if the units diverge from each other? If mortality does diverge, could the differences be due to the differences between the units? If the mortality does not diverge, could the differences between the units be unimportant?

Could the variation in piglet mortality rate, both total and liveborn, be linked to a certain management routine or other specific stable conditions?

Literature survey

The importance of piglet mortality

The piglet mortality in Sweden is one of the highest in Europe, with an average liveborn piglet mortality of about 18 %, and total piglet mortality of 24% (Christiansen, 2010 cited by Pedersen et al., 2010; PigWin, 2012). The piglet mortality in Europe has been well studied and the live piglet mortality is reported to be all from 14 - 17% from birth to weaning, and is a major source of loss in the pig production (Marchant et al., 2000; Cecchinato et al., 2008; Pedersen et al., 2012; PigWin., 2012). This has a major impact on the economy of pig farming since number of produced piglets are what producers are paid for (Grandinson et al., 2002; Cecchinato et al., 2008; KilBride et al., 2012). It has also been found that if many piglets die, the rest of the litter has a slower growth rate, which further implies how piglet mortality affects the economy of the pig producer (Högberg & Rydhmer, 2000). As seen in Table 2, the reproduction results have been improved in Sweden, in terms of number of born and weaned piglets for example. In the meantime however, the number of stillborn piglets and the preweaning mortality has also increased. It has been proved that correlations between large litters and low birth weights exists (Grandinson et al., 2002). These correlations are furthermore suggested to lead to high mortality rates, and are mentioned as one of the reasons why the piglet mortality increases, when other production traits seem to improve.

Basics of piglet mortality

In Table 1 the main terminology used in this thesis is described. Some of the piglets that are stillborn are dead before the farrowing process, whilst some of them may have died during the farrowing process and could thereby possibly have been saved. It should however be noted that the rate of stillborn piglets has been suggested to be overrated, and thereby the mortality after birth is underestimated (Pedersen et al., 2010). The definition of stillborn is that the piglet is dead at birth, which could be hard to determine. Piglets that are dead by the time of the first inspection are often recorded as stillborn even though they might have been alive after birth (Pedersen et al., 2010). The only way to be absolutely sure that the piglets are actually stillborn is to do an autopsy of the lungs to make sure that the piglet has not had a breath. However this is not practiced on the typical pig farm (Lucia Jr et al., 2002; Pedersen et al., 2010). This should be taken into consideration when analyzing the piglet mortality from farm records and affects how the problem could be faced (Pedersen et al., 2010).

Table 1. Piglet mortality terminology

Terminology	**Explanation**
Stillborn	Piglets that are dead at birth
Total piglet mortality	(Liveborn piglets + stillborn piglets) – piglets dead before weaning
Liveborn mortality	Liveborn piglets – piglets dead before weaning

The piglet mortality has been reported to be highest the first week after farrowing, where up to 84% of the live piglet mortality occurs (Glastonbury 1976; Cecchinato et al., 2008; KilBride et al., 2012). Furthermore, major parts of the piglet mortality of the first week occur within the first 24 hours after farrowing. Glastonbury (1976) and Cecchinato et al. (2008) reported that up to 70 % of the liveborn mortality occurs within the first 24 hours of life while KilBride et al. (2012) found that the same proportion was 28%. According to KilBride et al. (2012) 62% of the live piglet mortality occurs within the first two days of life, while Miller et al. (2012) claims that the major part of the piglet mortality occurs within the first three days of life, which is supported by Rothe (2012). Spicer et al. (1986) and Marchant et al. (2000) found that 50-66 % of the liveborn mortality occur within four days after farrowing. Arango et al. (2006) found that 53% of the liveborn preweaning mortality occurred within five days after farrowing. The mortality rate does then progressively decrease until day 14 after birth (Cecchinato et al., 2008). This implies that it is within the first week that the piglet mortality is the highest, and this is where the effort to reduce the piglet mortality rate should be made (KilBride et al., 2012).

It is often claimed that the loose housing farrowing, which is the most common farrowing system in Sweden, has a negative impact on the piglet survival due to the sow being more likely to crush the piglets. This was supported by a study of Marchant et al. (2000) that found that sows housed in systems with conventional crates weaned more piglets than loose housed sows. Piglets in loose housed systems did though appear to grow faster. KilBride et al. (2012) though claims that the preweaning piglet survival in loose housing systems is similar to that in crated systems. The mortality did vary somewhat between systems, and the mortality rate was higher during the first 48 hours in the crated systems compared the loose house systems (KilBride et al., 2012). Furthermore 75% of the liveborn piglet mortality in the study was in both systems due to crushing. When combining all causes of piglet mortality (including stillbirth) into a single category, KilBride et al. (2012) found that the overall piglet mortality was higher in the crated system than in the loose house system suggesting that the crated systems provided a higher risk for piglet mortality.

Table 2. Production results in Swedish piglet production 2003-2011

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Produced piglets/ sow, and year	21.8	22.4	22.7	22.3	22.4	22.8	23.2	23.4	23.8
difference from previous year		*+0.6*	*+0.3*	*-0.4*	*+0.1*	*+0.4*	*+0.4*	*+0.2*	*+0.4*
Total born/litter	12.48	12.94	13.06	13.1	13.2	13.52	13.69	13.84	14.2
difference from previous year		*+0.46*	*+0.12*	*+0.04*	*+0.1*	*+0.32*	*+0.17*	*+0.15*	*+0.36*
Liveborn/litter	11.7	12.1	12.2	12.2	12.3	12.6	12.7	12.8	13.1
difference from previous year		*+0.4*	*+0.1*	*±0*	*+0.1*	*+0.3*	*+0.1*	*+0.1*	*+0.3*
Stillborn/litter	0.78	0.84	0.86	0.9	0.9	0.92	0.99	1.04	1.1
difference from previous year		*+0.06*	*+0.02*	*+0.04*	*±0*	*+0.02*	*+0.07*	*+0.05*	*+0.06*
Number of weaned/litter	10.0	10.3	10.3	10.3	10.3	10.5	10.5	10.6	10.7
difference from previous year		*+0.3*	*±0*	*±0*	*±0*	*+0.2*	*±0*	*+0.1*	*+0.1*
Liveborn mortality, %	14.3	14.8	14.9	15.6	16.2	16.7	17	17.2	18.3
difference from previous year		*+0.5*	*+0.1*	*+0.7*	*+0.5*	*+0.3*	*+0.3*	*+0.2*	*+1.1*
Total piglet mortality,%	19.9	20.4	21.1	21.4	20.5	22.3	23.3	23.4	24.6
difference from previous year		*+0.5*	*+0.7*	*+0.3*	*-0.9*	*+1.8*	*+1.0*	*+0.1*	*+1.2*

Modified from Quality Genetics (2009), PigWin (2010), PigWin (2011), PigWin (2012).

Risk factors of piglet mortality

Many studies have focused the risk factors of piglet mortality, and the subject has been studied in many different ways. The outcomes are often rather similar. A report of the Danish piglet mortality was conducted by Pedersen et al. (2010) on the behalf of the Danish government in order to investigate the mortality rates, and how they could be reduced. As Pedersen et al. (2010) reviewed; the main risk factors are large litters, low birth weight, hypothermia and a lack of colostrum uptake - factors that all are linked with each other.

The Danish report showed that the piglet mortality rates are highest the first week after farrowing and the causes of piglet mortality are the same in different herds and that there is mainly the frequency of deaths that varies, rather than the causes (Pedersen et al., 2010). The high mortality during the first week is often due to bad circumstances during the gestation period or due to problems during the farrowing and the first critical hours of the piglets life (Pedersen et al., 2010). According to Pedersen et al. (2011) causes of death are, besides stillborn and farrowing issues, dominated by crushing during the first three days, and along with death caused by starvation they dominate the causes of mortality the first week of life. After the first week however, the death cause is dominated by disease of the piglet. KilBride et al. (2012) found that crushing is the most common frequent death reason for healthy piglets. It accounts for 54.8% of the liveborn mortality. Low viability (13.8%), starvation (6.8%), crushed while sick (4.7%), diarrhea (3.5%) are the second most common causes for piglet mortality, and about 6.1% die of unknown causes (KilBride et al., 2012).

Littersize and birth weight

To increase the number of weaned piglets, selection to increase the total liveborn piglets has been an ongoing process in the pig production (Grandinson et al., 2002). Unfortunately, large litters have been associated with high piglet mortality, which has also been confirmed by several studies (Grandinson et al., 2002; Persdotter, 2010; Baxter et al., 2012). The average litter size in Sweden 2011 was 14.2 total born piglets, and 13.1 liveborn piglets, Table 2 (PigWin, 2011). This was an increase compared to 2010, when the total born was 13.8 and the total liveborn were 12.8 piglets, see Table 2. The liveborn preweaning mortality was also increased from 17.2 to 18.3 during the same period. Increased litter size lead to a decreased average birth weight of the piglet and increased proportion of stillborn piglets and mummified fetuses, even though the gestation length is not affected (Spicer et al., 1986).

A study by Baxter et al. (2012) found that litter size had an effect on the piglet mortality. Marchant et al. (2000) found that the total number of piglets dying per litter (including stillborn) was significantly associated with an increase in the total litter size. This is supported by Glastonbury (1976) who found that mortality increased significantly with increasing litter size at birth, and Högberg & Rydhmer (2000) who showed that the more piglets that are born in the litter, the more piglets die during and after farrowing. Weber et al. (2009) also suggested that the litter size is a major factor influencing all categories of piglet losses. According to Vasdal et al. (2011) large litters have an increased effect on piglet mortality both before and after milk intake, latency before first suckle and weight gain.

According to a study by Miller et al. (2012), piglet birth weight is a great determinant of subsequent weights and survival ($P<0.001$). Large litters give smaller piglets and an increased amount of underdeveloped and weak piglets, these piglets have an increased risk for dying during and after birth (Pedersen et al., 2010a). According to a study by Paredes et al. (2012) most piglets that did not reach weaning died mainly due to poor physical condition or low birth weight. Only 20 % of the pigs with a birth weight between 0.3-0.7kg reached weaning. This is supported by Rothe (2012) reporting that weaned were those who had a higher body weight. The birth weight is also correlated to weaning weight of piglets, piglets with a high birth weight reach a higher weight at weaning (Jones et al., 2012). A slightly negative, but favorable, correlation has been found between the piglet birth weight and mortality, suggesting that heavier piglets are less subjected to the risk of piglet mortality than smaller piglets (Grandinson et al., 2002). Grandinson et al. (2002) however found a positive, unfavorable, genetic correlation between birth weight and stillbirth, and birth weight and the total mortality.

Stillbirth

The high piglet mortality is not only due to piglets being lost during the suckling period, but the amount of stillborn piglets is a big part of the problem. In 2011 the average number of stillborn piglets in a litter was 1.10, with a range of 1.01-1.20 between the 25% best and 25% worst herds (PigWin, 2012). This was an increase from 2010 when the average number of stillborn piglets per litter was 1.04, as seen in Table 2. According to the report by Pedersen et al. (2010), the birth is the most critical part in a piglets life, and about 50 % of the total preweaning piglet mortality is due to stillborn piglets, which may have died during the farrowing.

Stillbirth is reported to occur in 48.3% of all litters (Vanderhaege et al., 2010a) and the stillborn rate is between 5.2% and -7.5% when calculated as percentage of total born (Vanderhaege et al., 2010a; Vanderhaege et al., 2010b; Pedersen et al., 2011). Stillborn piglets are born late in the litter and after a long inter pig interval (Spicer et al., 1986; Baxter et al., 2012). There is a significant difference between stillborn piglets and liveborn piglets in terms of the inter pig interval, were piglets that were liveborn had a mean inter pig interval of 18.8 minutes and the stillborn had a mean inter pig interval of 36.5 minutes ($P<0.017$) (Baxter et al., 2012). The inter pig interval is affected by stress, and a stressed sow is more likely to have longer inter pig intervals than a non-stressed sow. The inter pig interval is therefore suggested to be able to shorten if the stress levels of the sow is reduced (Pedersen et al., 2011). The number of stillborn piglets has also been shown to be significantly influenced by the farrowing system, where crated sows having a higher proportion of stillborn piglets than those kept in loose house systems outdoors (KilBride et al., 2012).

A high correlation between total born litter size and the number of stillborn piglets is reported by Vanderhaege et al. (2010a), larger litters increases the number of stillborn. Persdotter (2010) however, could not find any significant proof that the liveborn piglet mortality should be directly correlated with number of stillborn piglets in the litter. Pedersen et al. (2011) found that light piglets are more likely to be stillborn than heavier piglets. Light piglets are also more likely to suffer from a lack of nutrition due to a malfunctioning placenta during the gestation period. They are also subjected to a higher risk of premature rupture of the umbilical cord, which lead to death before farrowing. The risk of stillbirth has also been shown to increase if the back fat level of the sow is below 16mm compared to sows with a back fat level of 16-23mm (Vanderhaege et al., 2010a).

The parity of the sow has a significant influence on the amount of stillborn piglets in the litter (Vanderhaege et al., 2010a). If the sow in her previous farrowing had more than one stillborn the risk of stillborn piglets in the next litter is increased with 2.5 times compared to if there were no stillborn piglets in the previous litters. Vaginal palpation, during the farrowing is associated with the occurrence of stillborn in the litter (Vanderhaege et al., 2010a). Third parity sows or higher are more frequently subjected to vaginal palpation (7.9%) than lower parity sows (5.6%). Litters born during day time were more likely to have stillborn piglets than litters born during night time (Vanderhaege et al., 2010a).

Sex differences

Baxter et al. (2012) showed that female piglets were on average lighter than male piglets at birth. The males did also have a significantly higher body mass index than the females. But even so, there were more males dying preweaning than there were females and they supported the theory that male-biased mortality exists. The males are however favored by the sow prenatally, which together with the data that they more often died as a cause of disease was interpreted by Baxter et al. (2012) as males being more susceptible to casual mortality factors. The prenatal investments in the males was thought to produce more viable male piglets at birth, since they are more subjected to mortality, to provide an over-supply of the more vulnerable sex. Males tended to be crushed more often, while gilts tended more often to die of “other” causes (Baxter et al., 2012). Furthermore, males also suffered from a poorer thermoregulatory ability. It should however be noted that no significant differences between sexes could be seen at weaning.

Weak and/or underdeveloped piglets

Piglets that are small, weak or underweight have an increased risk of dying during or after the farrowing (Pedersen et al., 2010). A study by Spicer et al. (1986) found that most death (including stillbirth) were associated with a body weight that was below average. Grandinson et al. (2002) found that 62 % of all piglets born with a bodyweight below 800 grams died before weaning, or were stillborn. Larger litters have been proven to have an effect on the piglet development at birth, and may both lead to underdeveloped piglets and piglets that are weak at birth (Pedersen et al., 2010). The numbers of small, weak or underdeveloped piglets increase with an increased litter size, see section *litter size and birth weight*. Weak or underdeveloped piglets does also have a hard time keeping warm, and have an increased risk for becoming sick. Högberg & Rydhmer (2000) found several genetic correlations related to weak and underdeveloped piglets.

Crushing

The crushing of piglets is one of the main causes of mortality during the suckling period (KilBride et al. 2012; Rothe, 2012). Crushing is highly dependent on the sow's attention on the piglets and the piglet vigilance on the sow (Pedersen et al., 2010). Pedersen et al. (2010) rewieved that piglets that suffer from heat loss short after the birth, such as weak or small piglets, will become less vital and less able to avoid the sow and increase the risk of crushing. Furthermore Pedersen et al. (2010) reviewed that pigs with a low birth weight have an increased nourishment need, and spending more time at the udder. This could increase the risk for being crushed under the sow. Crushing has been reported to account for all from 5.0 to 55 % of the liveborn piglet mortality during the lactation period (Pedersen et al., 2010; KilBride et al., 2012; Rothe, 2012). Furthermore, over 70% of the mortality due to crushing have been shown to occur to previously healthy piglets (Spicer et al., 1986). However 21% of the crushing has been associated with illness of the sow (18%) or illness of both the piglet and sow (3%) (Spicer et al., 1986). According to Pedersen et al. (2010) about one third of the piglets dying due to crushing, had no milk in their stomach when autopsied. This implies that the primary death cause might not have been crushing, but could have been starvation, or starvation at least being a co-cause of death.

Studies have shown that there are no significant differences between loose/crated sows in the crushing rate (KilBride et al., 2012). Instead, a trend of a reduced risk of crushing was found in the loose house farrowing system (KilBride et al., 2012; Pedersen et al., 2011). Glastonbury (1976) did support the theory that loose house farrowing systems had an negative impact on the mortality rate, compared to sows that are crated during farrowing and lactation. Pedersen et al. (2011) found that the micro climate in the pen was of more importance for the piglet mortality than if the sow was crated or not. Piglets that loose heat after birth become less viable and are less capable to avoid the movement of the sows, increasing likeliness of crushing (Pedersen et al., 2011). It should be noted that Swedish farmers are not allowed to crate the sows during the whole lactation period according to the Swedish animal welfare legislation (Djurskyddsförordning 1988:539, §15). At maximum the sows could be crated for a few days in a row, during the first days of the newborn piglets lives (Djurskyddsförordning 1988:539, §15; Lukkarinen & Lannhard Öberg., 2012). Furthermore, crating is only allowed through a "safety gate", and if the sow is aggressive towards humans or piglets.

Disease

The proportion of piglets that die of disease is of course very dependent on the health status and the infection pressure of the herd (Pedersen et al., 2010). Piglets that were anemic had a mortality rate of 36 % while non-anemic piglets had a mortality rate of 10% (Spicer et al., 1986). O'Reilly et al. (2006) did also underline the importance of supplementary iron to piglets. Only a small part of the piglets die directly out of anemia due to lack of iron, but the anemia will also lead to a reduced growth rate and the piglets being more susceptible to other diseases.

Colostrum intake and suckling

Large litters may lead to more piglets than teats, and this may decrease or inhibit the piglets colostrum intake. Vasdal et al. (2011) pointed out the importance of number of functional teats and latency before first suckling on the piglet mortality. They showed that the fewer teats there were per piglet, the longer the interval between farrowing to first suckle. The longer interval between farrowing and first suckle was correlated to reduced weight gain and a low rectal temperature (Vasdal et al., 2011). This does increase the risk for the piglets becoming victims of piglet mortality. Pedersen et al. (2011) however, could not see an effect ofthe latency to suckle and the odds of being crushed.

As Pedersen et al. (2010) pointed out, the larger the litter size, the less colostrum is available per piglet. This will give piglets from larger litter a less good immune defense due to their lower intake of colostrum compared to smaller litters. Colostrum is essential for the piglets, since they are born without antibodies (Xu, 1996). A study by Damm et al. (2005) found that 72% of the liveborn piglet mortality occurred to piglets that not had had an intake of colostrum, even though the death cause were reported as crushing, starvation or culled. Also, Rothe (2012) showed that the piglets that were born in the first quarter of the litter had a significantly higher immunoglobulin level than piglets born later in the litter (12.65-13.53 % compared to 13.87 %). It is not only the milk that changes character with time, but also the piglets intestine undergoes major changes (Weström et al., 1984; Xu, 1996). The gastrointestinal tract of the piglet undergoes major changes in morphology, it grows and the functionality of the intestine changes as the cells mature and proliferates (Xu, 1996). During this maturation, the intestine loses its ability to absorb macromolecules such as immunoglobulin. The transmission of macromolecules across the intestine are inhibited within 18-36 hours, and during the first 24 hours the ability is radically reduced (Weström et al., 1984). For piglets that are starved however or only drinks water, rather than milk, the intestine tract does not develop normally, but stay more or less unchanged (Xu, 1996).

Starvation

Part of the piglets dies due to starvation. The starvation could be due to a number of reasons, both piglet and sow related. Piglets with a low vitality and unsufficient uptake of colostrum after birth, will soon have to use the small glycogen depots of their own (Pedersen et al., 2010). This will then make it hard for the piglet to suckle enough to be able to compete with the siblings for an own teat the first day, when they establish their teat order. Therefore these piglets will become weaker and weaker, and have harder and harder to defend their teat and be able to suckle less and less.

As pointed out by Pedersen et al. (2011) it is hard to separate starvation from hyperthermia, and a failure in colostrum intake can often lead to hyperthermia. Piglets reported dead of other causes, such as crushing, are often found to have an empty stomach when autopsied which implies that the primary death cause could be starvation or at least influenced by starvation (Pedersen et al., 2011; Vasdal et al., 2011). Piglets with a low birth weight, low rectal temperature two hours after farrowing and an increased cordial plasma lactate in cord blood at birth are more likely to be subjected to die by starvation (Pedersen et al. 2011). They are also less viable at birth, which makes it harder to suckle. Pedersen et al. (2011) found that death due to starvation or disease were the most common cause of death after day eight and forward.

Parity

Sows in their sixth, eigth or ninth parity have a significantly higher risk for stillborn piglets than sows in their first parities (KilBride et al., 2012). Compared to the first parity, the risk of preweaning mortality was reduced in the second and third parity (KilBride et al., 2012). That could imply that piglet mortality is reduced when the sows have had several litters before. But it should also be taken into account that sows that are bad mothers are likely to be taken out of production, and that the preweaning mortality could be reduced because of that, and not because the sows are improving their mothering ability (KilBride et al., 2012).

Season

The year and month have a significant effect on the piglet mortality due to the climate, epidemiological and management differences, according to a study by Cecchinato et al. (2008). Weber et al. (2009) found that season had a significant effect on number of crushed piglets, and the highest piglet mortality rates were associated with the so called “hot” months (May-September) The lowest piglet mortality rates were present during the “cold” months (December –February). The study was conducted in Switzerland. According to Miller et al. (2012) season had no effect on the birth weight of the piglets, which otherwise could have a big impact on the piglet mortality.

Genetic relationships and heritability of piglet mortality

The preweaning mortality has been proven to be positively genetically correlated to the stillborn rate, and the more stillborn piglets, the higher the preweaning mortality (Friendship et al., 1986). The heritability of piglet mortality is low, and the direct heritability has only been calculated to be 0.03-0.05 while the maternal heritability is slightly higher 0.08-0.12 (Arango et al., 2006). Arango et al. (2006) suggested that direct components should be included in the preweaning mortality selection. The direct and maternal genetic correlations are large and negative for many traits such as; stillbirth, total preweaning mortality, birth weight, age at death, total number of piglets born, number of piglets born alive and dead (-0.50 - -0.84). The correlations were especially high for the piglet mortality during the suckling period (-0.82 - -0.84) (Arango et al., 2006).

Strategies for reducing the piglet mortality – piglet aspects

Management strategies

As concluded in the Danish report by Pedersen et al. (2010) there is a need for improved management strategies to be able to reduce the piglet mortality such as birth surveillance, birth assistance, since the breeding results for reduced mortality will not enable fast reductions in mortality. The piglet mortality is influenced by management factors (Glastonbury, 1976), and several studies have suggested different types of improved management strategies for reducing the piglet mortality, and there is a need to develop practical management solutions. According to a study by Friendship et al. (1986) a statistical significant relationship between the preweaning mortality and the total time the herdsmen claimed to spend in the farrowing stable could not be found. This study did however not specify how many minutes that were spent per sow. O’Reilly et al. (2006) suggested that dipping the navels of the piglets and giving iron injections lowered piglet mortality.

Colostrum

The piglet survival is highly dependent on the piglets ability to reach the udder for an early intake colostrum after birth (Pedersen et al., 2010). This put further importance of the vitality and birth weight on the piglet. The amount of colostrum and its quality, immunological quality and energy content, are limiting factors for the piglet mortality, and the piglets survival rate in big litters where the colostrum could be a limiting factor (Pedersen et al., 2010). Herds that helped piglet intake of colostrum had lower piglet mortality than herds that did not (Andersen et al., 2007). As studied by Damm et al. (2005), 72% of the liveborn piglets dying before weaning had not had a colostrum intake, even though their death cause was classified as other reasons.

Milk supplementation

Miller et al. (2012) found that milk supplementation had no effect on the mortality rate of piglets, and pointing out that it is highly unlikely that the supplementation of milk should decrease the piglet mortality due to the fact that most of the piglet mortality occurs within the first three days of life, when the voluntary intake of supplementary milk is low. Milk supplementation did however have a positive effect on the weaning weight. The weight gain, and weight gain benefits, is however totally dependent on how much milk the piglets consumed.

Littersize

Large litters have been suggested to be less affected by management routines since large litters have a negative impact on both piglets related factors and maternal motivation of caring for the piglets (Vasdal et al., 2011). The probability of the piglet survival decreased for piglets living in litters of less than six piglets, or twelve or more piglets compared to piglets living in litters of intermediate sizes (Cecchinato et al., 2008).

The sow does normally have at least 14 functional teats when farrowings for the first time, but the number of functional teats does normally decrease with increasing lactation number (Pedersen et al., 2010). According to the PigWin results of 2011 (PigWin, 2012) the average total born piglets in Sweden is 14.2, which is an increase with 0.36 piglets compared to 2010 (PigWin, 2011). A piglet must find a teat of its own and stimulate it in order to stimulate milk production within the first days of life (Pedersen et al., 2010). In litters were there are more piglets than functional teats, it is necessary to make sure that the “extra” piglets are getting fed by nursing sows or by shift nursing (letting half the litter nurse , when the other half is locked in the creep area). As long as the amount of liveborn piglets exceeds the amount of functional teats at the udder, the management should be expected increase in time due to the increased demands on both piglets and sows according to the report by Pedersen et al. (2010).

Crossfostering

To ensure that all piglets get fed, even when the litter sizes exceed the number of functional teats of the sow, it is common to use nursing sows and/or cross fostering**.** This could hinder the moved piglets from dying of starvation. It is however important not to move the piglets until they have had their share of colostrum (Pedersen, 2010). When they have had colostrum, they should though be moved as soon as possible, within 24 hours of life. The recommendations from the Swedish Animal Health Service is that piglets should only be cross-fostered if the litter exceeds the amount of teats on the sow, and they should further more not be moved later than 48 hours after birth. Sick piglets should never be moved from their biological mother, even if they will not survive in that litter (Karlsson Frish, 2012).

Every moved piglet become a risk for the piglets in the litter to which it is moved, cross fostering will also reduce the growth, and the piglets that are moved have an increased risk of dying, compared to those that are left with their birth mother (Pedersen et al., 2010). Other studies have shown that the extent of crossfostering do not have a significant effect on the piglet mortality when the piglets were mostly moved within 24 hours after farrowing to litters of 8-11 piglets (Andersen et al., 2007). Cecchinato et al. (2008) did however report that cross fostered piglets had a 40 % increased survival probability than the piglets raised by their biological mother when crossfostering was performed to reduce variation in size of nursed litters. In this study, crossfostering occurred for 46% of the piglets, and both males and females were crossfostered, regardless of size, only to even out the size differences in the litters. They suggested that crossfostering is an effective method to increase the postnatal survival of the piglets.

Disease

The immunity obtained from the colostrum will have a big impact on the future health, and minimizing the risk of disease, of the piglet, as will the health status of the sow (Pedersen et al., 2012). As an example, it is important to decrease the incidence of agalactia and increase the health status in the herd, to minimize the infection pressure. The herd health status should be maintained by batch system production, according to an all in- all out system, cleaning the units with high pressure washers, disinfection and enough empty time to let the stables dry out properly. Furthermore part of the pen should be slatted and the amount of crossfostering should be reduced to reduce the infection pressure for the piglets. The management routines should also be such that they will not lead to spreading if diseases or infections between different batches, and even washing of the sows with a mild soap is suggested, before introducing them to the farrowing stable (Pedersen et al., 2010).

Infections are common in the piglet production, and the risk of having an infection increases if the piglets have any soars or lesion (Pedersen et al., 2010). These could occur if there is a non-careful sow, from wearing against the concrete flooring, or be a result from piglets fighting at the udder for example. A study by Miller et al. (2012) shows that the medication rates were higher during the winter time than during the summer time for both litters of gilts and sows (7.2% resp. 1.9%, $P<0,05$). For instance, the gilt litters had more litters medicated for preweaning diarrhea in the summertime, than the sow litters. According to the Swedish Animal Health Service there are some essential rules to obey if there is a disease in the herd, to prevent further spreading (Karlsson Frish, 2012).

The creep area

According to Pedersen et al. (2010) many piglets die as a direct result of hypothermia. This could be reduced by ensuring a good piglet climate at the place of farrowing, by adding extra heating, isolated gantry or aplenty bedding. O'Reilly et al. (2006) showed that a higher preweaning mortality was found in a creep areas without bedding, and if extra heating was only provided through infra-red lights.

Vasdal et al. (2010) studied how the usage of the creep area could be improved, reducing the risk of piglets being crushed due to sleeping next to the sow improving the piglet survival. The study was carried out by comparing three different creep areas, with concrete floor, insulated and soft bedding and insulated soft bedding plus an additional wall to increase the heat conserving capacity in the creep area. The piglet behavior was recorded during 72 hours after farrowing. The attempts of making the creep area more attractive did not increase the usage of it or reduce the piglet mortality. The highest increase in usage was seen in the treatment with bedding and the creep area with the additional wall was used less than the other. They therefore suggested that the quality of the creep area have little impact on the piglet survival, which also was supported by a study of Andersen et al. (2007). Furthermore shutting in the piglets in the creep area after farrowing did not have a significant effect on the piglet survival rate (Andersen et al., 2007). The study by Andersen et al. (2007) also found that the piglet mortality differed between five and twenty-four percent between herds even though they all had similar farrowing environments and that drying piglets after birth and then placing them underneath the heating lamp not have a significant effect on the piglet mortality rate.

Light hours

O'Reilly et al. (2006) found that artificial lighting was associated to a lower piglet preweaning mortality. A study by Johnson et al. (2009) showed that piglets are less active during the dark hours. This could imply that the amount of light hours in the stable affects the piglet mortality since darkness may make the piglets less observing of the sows lying behavior, and may also decrease the suckling latency. As reported by Vanderhaege et al. (2010a) farrowings that occurred during day time were more likely to have stillborn piglets than sows farrowing in the night time.

A study conducted by Lessard et al. (2012) studied the impact of the light hours in the stable on the immune status of the piglets. Their results indicate that the number of light hours during lactation influences the establishment and function of the immune cells of both the innate and adaptive immune system of the piglet. Piglets that were raised with 8 light hours had a reduced polymorph nuclear neutrophils capacity, compared to piglets raised during more light hours (23 light hours/day from day in gestation 112 to day 4 after farrowing, followed by 16 hours of light hours/day the remaining part of the lactation period) (Lessard et al., 2012). The differences had though been even out at weaning, suggesting that the number of light hours only have an effect on the maturation of phagocytic cells. Exposing piglets to a low number of light hours during the lactation seemed to reduce the immune system to novel antigens, and thereby few light hours was considered unfavorable for piglet health, and may also have consequences on their abilities to cope with infections even after weaning (Lessard et al., 2012).

Strategies for reducing piglet mortality- sow aspects

As stated in a Master's thesis by Persdotter (2010) the piglet mortality caused by stillbirth, crushing and starving could be prevented by god management, stables and breeding. Maternal components that are associated with sow mothering ability are sow behavior and piglet traits such as birth weight (Arango et al., 2006). This could be claimed to determine sow productivity. Piglet losses were mainly caused by factors related to the sow, such as litter size and parity (Weber et al., 2009). Weber et al. (2009) found that the herd size, pen size, crating or protection bars had no significant effect on the piglet mortality and could be claimed to have a moderate influence on the piglet mortality. Andersen et al. (2007) did however find in a Norwegian study that the protection rails at the walls in the farrowing pens were reducing the piglet mortality.

Management routines

A Norwegian study by Vasdal et al. (2011) examined the effects of six different management routines at farrowing, and their effect on latency to first suckle, heat loss, weight gain and postnatal piglet mortality. The treatments were control (no treatment), piglets placed in the creep area without being dried, piglets dried and placed back were found, piglets dried and placed in creep area or piglets dried and placed at the udder after farrowing. No clear differences were found between the control and the treatments that included drying, but the highest mortality rate were found in the litters that were placed at the udder before being dried. They also pointed out that any positive effects of piglets being placed at the udder could be camouflaged by there being a large litter and competition at the udder.

According to Pedersen et al. (2010) stress is an important factor affecting piglet mortality. Reduced stress during the gestation has been suggested to have a positive effect on the piglet mortality rate, and the viability of the piglets (Pedersen et al., 2010). According to Vanderhaege et al. (2010) the amount of days that were spent in the farrowing stable before farrowing did not affect the number of stillborn piglets in the litter. In their study the days in the farrowing unit before farrowing ranged from 0-16 days with a mean of 6.9 days.

It has been proved that nesting is an important behavior for sows before farrowing. Damm et al. (2005) studied the effects of giving the sows in commercial pig farms long stemmed straw. They could not find a significant effect of the long stemmed straw on the piglet mortality within four days or three weeks of age. The lack of significance was though suggested to be due to the low ratio of added straw (2.5kg). Andersen et al. (2007) found that to hardly use litter as bedding material at all in the sow area at farrowing had a significant negative impact on the piglet survival.

Feeding of sows

Pedersen et al. (2010) suggested that optimized feeding of pregnant sows could reduce piglet mortality, but also that this would require further research in the subject to be able to provide such information. According to a study by Andersen et al. (2007), sows that were fed with a moderate amount of hay tended to have lower piglet mortality than sows that were not fed roughage. Also the sows that were not fed hay had a higher stillborn rate than the sows that were fed hay. The energy and immunological quality of the colostrum seem to be affected by the feeding of the sow (Pedersen et al., 2010).

High supplementations of folic acid to sows in heat or in early gestation are suggested to increase the amount of liveborn piglets (Pedersen, 2010). Also an addition of L-carnitine, which is also produced naturally in the body from the amino acid lysine, to the feed has been suggested to be a way of increasing the birth weight of the piglets (Pedersen et al., 2010). McDonald et al. (2002) did however not give carnitine any significant role on the nutrition of any farm animal.

Breed and parity

As reported by Vanderhage et al. (2010b) breed and breed combinations has a significant effect, and is considered a major factor, on the stillborn rate of the piglets. Breeds used in the study were CR Landrace, Topigs 20, Topigs 40, Hypor, Rattlerow Seghers, PIC, JSR, Dan Breed and French Hybrid. Topigs 40 and Dan Breed had the highest stillborn rates. Piglets that were nursed by sows in their 3-5 parity had a higher survival rate than piglets nursed by first or second parity sows (Cecchinato et al., 2008). This was supported by a study by Marchant et al. (2000). Glastonbury (1976) on the other hand found that that neither the breed nor the parity of the sow had a significant effect on the preweaning mortality. Vanderhaege et al. (2010a) suggested that the farrowing surveillance is of extra importance to sows with a history of stillborn piglets, large litters and within third parity sows or more. The number of weaned piglets per litter was however increasing up till their fifth farrowing. The weight gain of the litters was affected by the parity of the sow, and piglets of first party sows had less weight gain than piglets born by older parity sows (Damm et al., 2005). The within litter weight variation is tough found to be higher in sows than in gilts (Miller et al., 2012). Miller et al. (2012) showed that piglet mortality rate within the three first days of life was significantly higher in sows than in gilts.

Temperature

The temperature has been shown to influence both the sow behavior and performance. The temperatures in the farrowing stable during farrowing have a significant effect on the stillborn rate (Vanderhaege et al., 2010b). A temperature that of 22 degrees Celsius or more, did increase the stillborn rate significantly, compared to a stable temperature of below 22 degrees Celsius. Vanderhaege et al. (2010b) reported that sows that were showered with water before farrowing had a significantly lower rate of stillbirth, compared to those who were not showered before parturition. The rate of stillbirth was lowered from 7.7% to 5.8%, regardless whether the water was warm or cold.

A study by Malmkvist et al. (2012) examined the influence of thermal environment on the sows during farrowing and lactation. The study showed that the temperature of the housing does not have a significant effect on the duration of the parturition or inter-birth intervals. However, the parturition was prolonged if the floor heating had been preheating the unit, with an average farrowing time of 3.5 hours if the pen was only preheated for 12 hours, and 5.9 hours if the floor had been preheated for 48 hours. The effect of the floor heating was not affected by the overall temperature in the stable.

According to Malmkvist et al. (2012), sows kept in a temperature of 15ºC have been proven to nest more than sows kept at higher temperatures (20ºC and 25 ºC). Sows kept in a temperature of 25ºC during farrowing had reduced feed intake the first week after farrowing compared to sows kept at 15ºC or 20ºC (Malmkvist et al., 2012). Sows kept at a higher temperature (25ºC) did however have a higher daily feed intake and water consumption than the sows kept at a lower temperature, during the last part of the lactation. The temperature in the stables did not have any effect on the body weight, rectal temperature or the time spent lying down of the sow (Malmkvist et al., 2012). The ambient temperature did have an effect on the respiratory rate of the sow, surface temperatures, and usage of colder pen areas, which is interpreted as successful thermoregulation of the sow. Malmkvist et al. (2012) could not find any evidence that thermal effects were correlated to birth problems or long-term performance.

Sow health

It is of great importance that the sows are healthy at the time of farrowing. Being sick or injured does normally increase the stress level of the sow, which could have an impact on the number of stillborn piglets (Pedersen et al., 2010). It is however important to remember that the health status of the farm has a big impact on the sows health, and could thereby be claimed to be herd specific. As reported by Malmkvist et al. (2012) the risk of sow medication is influenced by both ambient room temperature and floor heating duration. The handling of the sickness is also of great importance. If the sows are unhealthy, it is still of great importance that the piglets are subjected to colostrum, even if it means that they need to be assisted, or get colostrum from another sow (Pedersen et al., 2010). Intensification of the advices about improvement of the sow health may also decrease piglet mortality (Pedersen et al., 2010). It is also essential that the sows are healthy during the whole lactation period, and are not subjected to farrowing fever, which affects the lactation and sow welfare negatively (Pedersen et al., 2010).

Farrowing fever/MMA (Mastitis, Metritis, hypo- or agalactia) (Pedersen et al., 2010) is a common problem in piglet producing herds, and causes problems for both sow and piglets, and could have a big influence on the mortality of the piglets. Farrowing fever has also been suggested to have a negative impact on the quality of the colostrum (Pedersen et al., 2010). The risk of farrowing fever could be reduced through stabilization of the sows intestinal flora and minimizing the risk for constipation (Pedersen et al., 2010). This is due to the importance of a normal intestinal flora to the function of the immune system.

Farrowing supervision

Pedersen et al. (2010) suggested that surveillance during farrowing could reduce both the amount of stillborn piglets and mortality after birth. Supposedly the total piglet mortality could be reduced by 50 % with increased farrowing surveillance and counseling with focus on improving the sow health. The farrowing surveillance should focus on helping sows with the actual farrowing, by for example palpation if needed. Farrowing surveillance should also include making sure that all liveborn piglets get colostrum and a good, piglet, environment. In some cases it might be needed to use clothing for the piglets in order to help them to keep warm. Vanderhaege et al. (2010a) suggests that the farrowing surveillance is of extra importance to sows with a history of stillborn piglets, large litters and third parity sows and older. Vanderhaege et al. (2010b) did however find that occasionally supervision of farrowing had a significantly negative impact on the stillborn rate (8.1%) compared to no supervision (6.5%) and frequent supervision of the farrowing (6.9%). This could be due to the type of the supervision, and it was suggested that caretakers that supervise the farrowing frequently were better at knowing how and when to interfere and help the sow. Vanderhaege et al. (2010a) underlines that all practical management should be carried out precautious and without disturbing the sow during the parturition, in order not to stress the sows, and affect the farrowing in a negative way.

Mothering ability and crushing

The risk of being crushed is partly due to the sows awareness of the piglets, as well as the piglets awareness of the sows movement (Pedersen et al., 2010). It has been proven that part of the sows' mothering ability is inherited, which enables breeding and will be further discussed in the following chapter. But the mothering ability is also due to the previous experiences of the sow, and of course due to her health status. The sows own awareness of the piglets increase and the rate of crushing the piglets decrease, if the sows are given the opportunity of building a nest before farrowing (Pedersen et al., 2010).

It is often claimed that systems where the sow is crated during the farrowing and/or the lactation period should have lower piglet mortality than systems were the sows are kept loose. As reviewed by Pedersen et al. (2010) there is a higher risk for sows in loose house systems to lie down on weak piglets than in crated systems. The risk for sows in loose house systems to lie down on an already dead pig is also higher than in crated systems, which easily could mix up the death cause in the documentation (KilBride et al., 2012).

Breeding strategies for reducing piglet mortality

Piglet mortality has a low heritability and is affected by many factors (Högberg & Rydhmer, 2000). The number of weaned piglets is affected by litter size at birth, total piglet mortality including farrowing and preweaning loss (Arango et al., 2005). As reported by Pedersen et al. (2010) the Danish breeding for larger litter sizes (total born) between 1992 until 2004 have been suggested to be part of the reason why the rates of piglet mortality has increased drastically during the same time period, both due to increased preweaning mortality and piglets that are born dead. As Högberg & Rydhmer (2000) suggested, breeding for larger litter sizes most likely lead to higher mortality, due to genetic correlations between number of born piglets, birth weight, and piglet mortality. They did point out that an increase in the litter size does not necessarily lead to an increase in the number of weaned piglets. Grandinson et al. (2002) suggested that to benefit from selection for litter size, the breeders must ensure that the sow can care for all piglets.

To reduce the negative trend in piglet mortality, the breeding goal in Denmark was changed from total number of born piglets to number of live piglets day five (Pedersen et al., 2010). The mortality rates first stagnated, and the expected decrease in piglet mortality was first seen in 2011 (Vinther, 2012). Even though Pedersen et al. (2010) claimed that there is enough documentation supporting the hypothesis that the piglet mortality could be reduced by including an economical weight of mortality in to the breeding index, and possibly connect it to the birth weight of the piglets. The breeding strategies for piglet survival could be increased through economical weight on piglet mortality, possibly also on weakness at birth, in the breeding goal (Pedersen et al., 2010).

Grandinson et al. (2002) claimed that the selection potential for piglet mortality traits is quite low due to the low heritabilities for these traits, except for the heritability of stillbirth. The heritabilities, measured with a threshold model were estimated to be 0.05 for total mortality, 0.15 for number of stillborn piglets and 0.06 for number of crushed piglets. Grandinson et al. (2002) suggested that stillbirth and crushing have different genetic backgrounds. The direct heritability of preweaning piglet mortality has been estimated to be less than 0.0005 (Grandinson et al., 2002). Since preweaning mortality is not recorded individually per sow in the production but rather per batch, the possibility of selecting against preweaning mortality is limited (Arango et al., 2006). The low heritability and the categorical nature of piglet mortality further complicate the modeling to estimate breeding values. Högberg & Rydhmer (2000) also found that number of total born was negatively correlated to mean piglet weight at three weeks. They did though point out that this did not necessarily have anything to do with low milk production or poor mothering ability, but may be due to the genetic growth capacity of the piglets. They also found that the effect of father was less than 2 % of the phenotypic variation in the mean piglet in weight of week three. The heritability of mean piglet weight at three weeks was calculated to 0.3, and the heritability of number of dead piglets up to three weeks were 0.09 according to Högberg & Rydhmer (2000).

The low heritability of piglet mortality make selection against preweaning mortality more difficult. The higher direct heritability of piglet body weight and its negative correlation between direct and maternal effect on pre weaning mortality selection for piglet body weight could be a way of breed indirectly for improved piglet mortality rates (Arango et al., 2006). Selection for an increase in piglet weight at birth could though have a negative impact on the piglet mortality rate, due to disadvantageous positive correlation between direct genetic effect of birth weight and maternal component of stillbirth (Arango et al., 2006). Sows that have a high ability of producing heavy piglets also crushed fewer piglets (Grandinson et al., 2002). Selection for sows with heavier piglets at birth might lead to a decrease in number of crushed piglets but cannot be expected to lead to fewer stillborn piglets and may not improve the overall survival rate. Strong unfavorable correlations between direct and maternal effects for body weight and stillbirth have been found (Grandinson et al., 2002). That implies that selection for body weight may not be a good strategy for improving survival of the piglets. Selecting heavier piglets as a direct effect would have a larger impact on the survival of the piglets than if selection is based on the maternal trait. The negative correlations between direct and maternal effects for total piglet mortality, piglet mortality within five days, piglet mortality after five days, liveborn piglet mortality, number born alive, number stillborn would enable direct selection for body weight of the piglets can have a positive impact on the piglet mortality (Arango et al., 2006).

Arango et al. (2006) pointed out the importance of piglet body weight and its correlation to piglet survival. Selections for larger litter size has been proven to both decrease the body weight of the born piglets, but also increase the variation in body weight within the litters, selection for increased birth weight however does increase the number of stillborn piglets and preweaning mortality (Wolf et al., 2008). Wolf et al. (2008) therefore suggest that selection for litter size should be combined with selection for reduced mortality and/or traits for minimum piglet body weight.

Materials and methods

Animals and data record

Data used in this study were collected from a sow pool in the south-central of Sweden. Data originated from records in the herd monitoring software PigWin, containing observations from 12 127 farrowings from January 2010 to May 2012. PigWin is a computer program used mainly for collecting production results and to monitor the production on herd level. The PigWin information used included sow id, parity number, farrowing date, satellite, total number of born piglets, liveborn piglets, weaning date, and number of weaned piglets. The PigWin results consisted in total of 12 127 individual litter records and from these 11 501 observations could after editing be used for stats analyses. Information on 626 litters were not included in the analyses due to not fitting in to a batch or belonging to the satellite that was closed and thereby excluded from the study.

A sow pool consists of a central unit and a number of independent satellite herds, eleven in this case. One of the satellites was deleted from further investigation due to significantly different production conditions and no true batch production. Therefore only ten satellites were further investigated in this study. The central unit keeps sows from the time of weaning and most of the gestation period. Three weeks before expected farrowing, the sows are transported to a satellite herd in groups of 28-50 sows. The sows are staying in the satellite herd during the whole farrowing and nursing period. After weaning, the sows are transported back to the sow pool and are inseminated again. The sows are leased by the satellite herds in groups, in order to keep batchwise production in the herd. The piglets that are born belong to the satellite. The satellite can sell the piglets at approximately 30 kg, or raise the piglets to slaughter. All satellite herds do thus share the same animal material, which enables the study to focus on differences in housing and management apart from the animal material.

The satellite herds were a mix of piglet producing herds (3), fully integrated (farrowing to finish) herds (5) and some partly integrated herds (2). The different satellites had different batch intervals, differing from farrowing every week up to farrowing every eight week. There were one to three farrowing units per satellite, and the production ranged from 975 sold piglets to 8000 sold slaughtering pigs per year. The farrowing units had different constructions and consisted both of confinements with possibility to crate sows(1) and loose housing systems (8) and one herd which had both systems within the same unit. There were several different types of loose house systems present in the herds.

The sows in the production are mainly crosses between Landrace and Yorkshire (commercial sows). The central unit also manages the production of replacement gilts. During larger expansion of the production however, pregnant gilts have been bought in to fulfill the needs. Occasionally, there are purebred sows from the multiplying herd also in the satellite units. These are purebred sows that do not fulfill the requirements of a hybrid mother, but are good enough to produce pigs for slaughter. The commercial sows are inseminated with Hampshire semen, and the piglets in the satellites are thereby three breed crosses.

Interviews

The production data was complemented with interviews regarding the current production, and management routines in the satellite herds. The interviews were made with staff and/or owners of the individual satellites. This information was complemented with a stable visit during a farrowing week, were the stables, routines and management were observed. Herds with several farrowing units with different designs were reported separately as different satellites, therefore there were 10 herds investigated, but 13 environments. The interviews and stable visits were done in July to September in 2012. The interview and stable data are attached as Appendix I and Appendix II.

The questions in the interview (Appendix I) were divided in to nine parts;

- *Basics*, concerning the basics of the production, how the stables were constructed and how the pig production is functioning.
- *Stable*, concerning climate, functioning and washing of the stable between batches. How the interviewed thought that this functioned.
- *Feed*, concerning the feed and feeding of piglets and sows during the lactation.

- *Supervision*, concerning how much and how the pigs are supervised during farrowing and lactation period.
- *Sows*, concerning how the sows are handled and the sows health status during farrowing and lactation period.
- *Piglets*, concerning how the piglets are handled and the piglet health status during farrowing and lactation period.
- *At farrowing*, concerning the management during the farrowing and the status of the litters at birth.
- *At castration*, concerning the management during the castration and the status of the piglets at castration.
- *Health*, concerning if there had been any health issues during the last farrowing period among sows and piglets.

The stable observations (Appendix II) were divided in to six parts;

- *Basics*, concerning the stable, pen construction, amount of straw, draught etc.
- *Biosecurity*, such as presence of basin at entrance, foot bath, boot and clothes changing etc.
- *Sows*, concerning the appearance of the sows, body fat, injuries and how they acted against humans and their piglets etc.
- *Piglets*, concerning the appearance of the piglets, growth, illness, climate in the creep area etc.
- *Staff*, concerning the staffs handling of the pigs and working routines.
- *Temperature* in the stable, surface temperature of the creep area and pen floor was measured with a Black & Decker TLD100 Thermal Leak Detector.

Statistical analyses

Data from PigWin was transferred to, and all statistical analyses were performed by using the SAS software (SAS Inst. Inc, Cary, NC). From the collected data, descriptive statistics such as frequencies and means were calculated. The variation in the traits was analyzed using analysis of variance. Due to crossfostering applied in all herds, and nursing sows being used to some extent in five of the herds, the mortality analyses could not be made on litter level, but were instead performed on batch level. Parity ranged from 1 to 11, but in the analyses on litter level sows with the parity 6 or higher were grouped together. Nursing sows were identified as sows having two recorded weaning days within two weeks. Piglets recorded weaned when less than 20 days of age were set as crossfostered to another sow. Litter size and mortality on batch level (see Figures 1&3) had close to normal distribution. Also the number of weaned piglets per batch was close to normally distributed (Figure 4). All analyzes were made by using a linear model, even though the stillborn trait was skewed (Figure 2). The linear model was yet chosen since another model would be too complicated for this kind of project.

Analyses on litter level

The total number of born, liveborn and stillborn piglets were analyzed on litter level, using PROC MIXED. The statistical model included the random effect sow, and the fixed effect of parity number (1-6), satellite (10), farrowing year (3) and farrowing month (12). Pair wise t-tests were used to compare LS-means (corrected means) and detect if there were significant differences between classes.

Table 3. Variables analyzed on litter level

Variables	Calculation
Number of total born piglets/litter	
Number of liveborn piglets/litter	
Number of stillborn piglets/litter	Number of total born piglets- Number of liveborn piglets

Table 4. Variables analyzed on batch level

Variables	Calculation
Number of weaned piglets/sow	Number of total weaned in the batch/Number of weaned sows
Total piglet mortality/batch	(Total number of born piglets –(Number of weaned piglets)/Total number of born piglets
Liveborn piglet mortality/batch	(Number of live born piglets –(Number of weaned piglets)/Number of liveborn piglets

Analyses on batch level

Piglet mortality during the lactation period, as well as number of weaned piglet per sow, was analyzed on batch level. Also the number of weaned piglets per sow was analyzed on batch level. This approach was used since analysis on litter level was not applicable due to crossfostering, which occurred in all herds, and usage of nursing sows which too some extent occurred in some herds. Batches were created retrospectively when there were at least 20 sows weaned from the satellite within 14 days. Batch information was not included in the collected data. Piglets recorded as weaned when less than 20 days of age, were set as moved to another sow. In total, 270 batches were created from data including 11 501 litters. 626 of the original 12 127 litter litters did not fit into any batch (due to have being weaned inbetween batches or weaned within two weeks before farrowing) and were not included in the batch analysis. In the statistical model used for the analysis on batch level satellite was set as a fixed effect, average parity number as a regression and weaning year and weaning month as independent fixed effects variables. The satellite herds were grouped according to liveborn piglet mortality rate into three categories, the lower quartile, the upper quartile and a middle category consisting of approximately 50% of the piglet satellites results. The groups were then used in order to investigate the impact of the mortality rate on litter size, number of weaned and stillborn piglets.

Analyses of interview

The results from the interviews and stable visits were categorized and compiled into most common answer, mean and/or median values, depending on which type of answer would be most useful. The number of observations on each category was also noted to show the distribution of answers.

Analyses of production and interview results

The interview results were merged together with the PigWin results on batch level, to combine the mortality rates with the management routines and conditions conducted from the interviews. In order to identify interview questions that may have had an effect on the mortality rate, the 10 satellite herds were divided in to three groups; low, medium and high liveborn mortality rate (containing 25%, 50% and 25% of the population results). By comparing the answers from the high mortality herds with the low mortality herds, question answers that differed between groups were identified. These questions were further analyzed to identify if the different management routines etc. had any relevance for the mortality rate. The statistical model used was the same used when analyzing mortality on batch level, expanded with satellite group and satellite as a random effect.

Analysis of impact of interview answers on liveborn mortality

The interview questions identified as having possible impact on the mortality rate were included in the statistical model. The analyses were performed on batch level, one record per batch. For this PROC MIXED was used; the statistical model included the fixed effect of "question", month and random effect of satellite regression on average parity number.

Levels of significance are set as * when significant at 0.05% level, ** when significant at 0.01% level, *** when significant at 0.001% level. Not significant differences are marked as n.s. (not significant).

Results

Descriptive statistics of production results

Litter level

Littersize (both liveborn and total born) were normally distributed even though it was a bit skewed downwards, as seen in Figure 1. There was a peak at 15 liveborn piglets per litter, and the total number of born piglets peaked at 16 piglets per litter. The number of stillborn piglets per litter (Figure 2), was not normally distributed, but had an extreme skewed distribution.

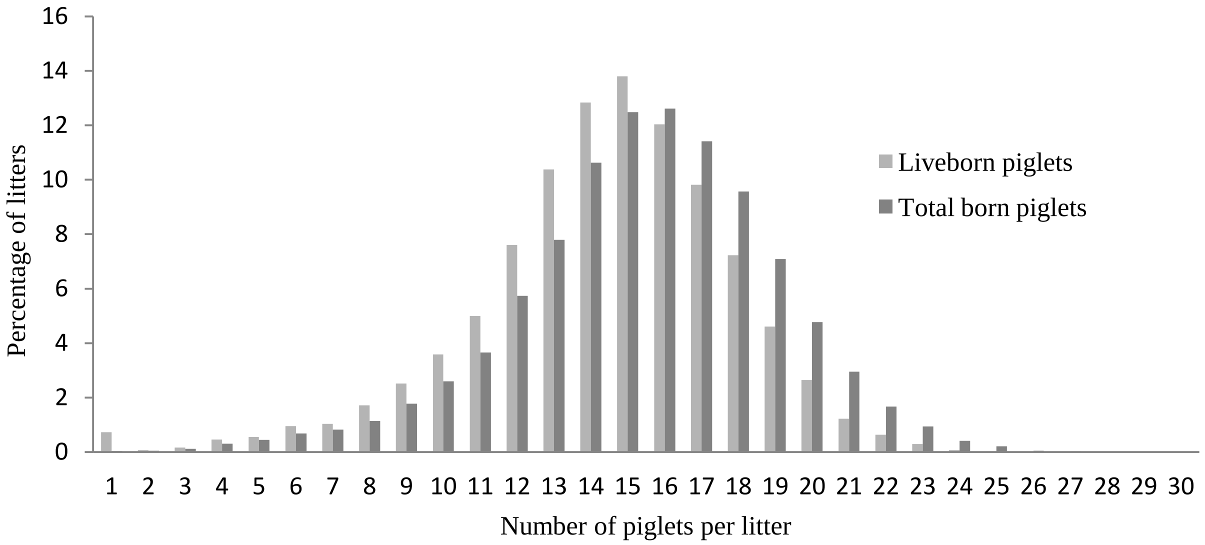


Figure 1. Percentage distribution of number of liveborn and total born piglets per litter in the entire sow pool.

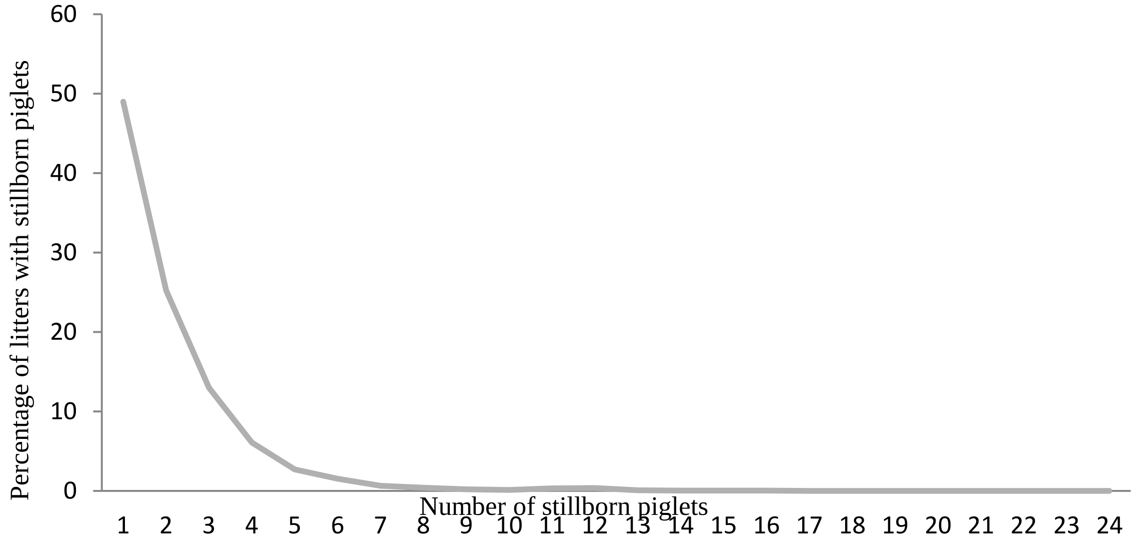


Figure 2. Percentage distribution of number of stillborn piglets per litter in the entire sow pool.

Batch level

The liveborn piglet mortality rate varied greatly between batches, as seen in Figure 3. Both the number of weaned piglets per sow and the liveborn piglet mortality during lactation show tendencies to be normally distributed when measured as continuous values (Figure 4 and Figure 5).

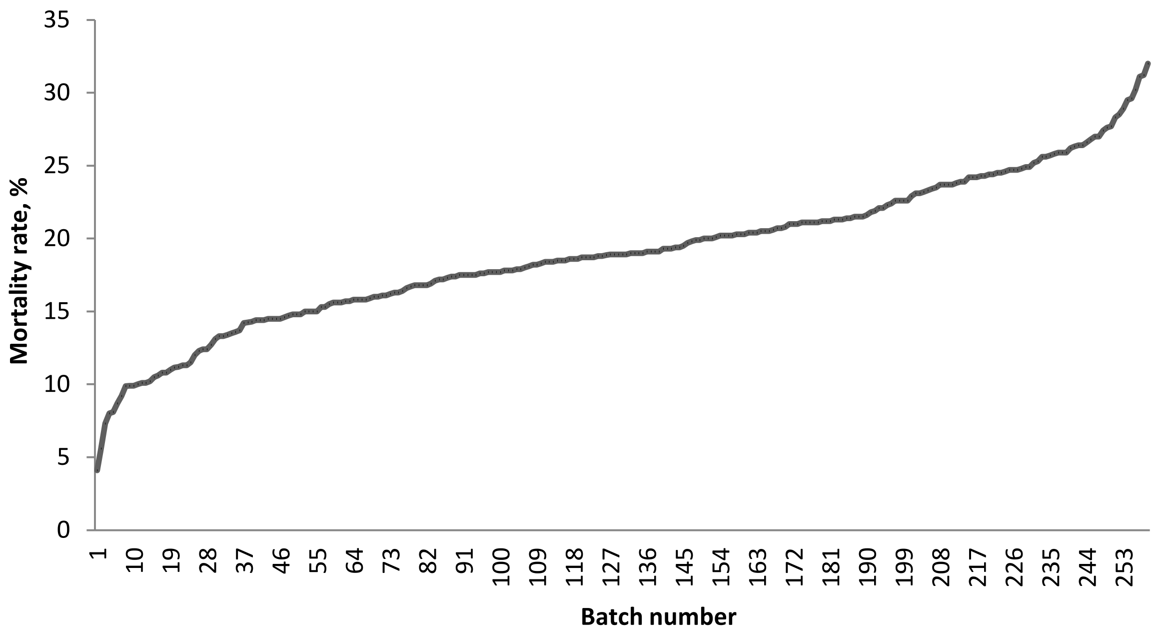


Figure 3. Variation distribution of in mortality rate between batches.

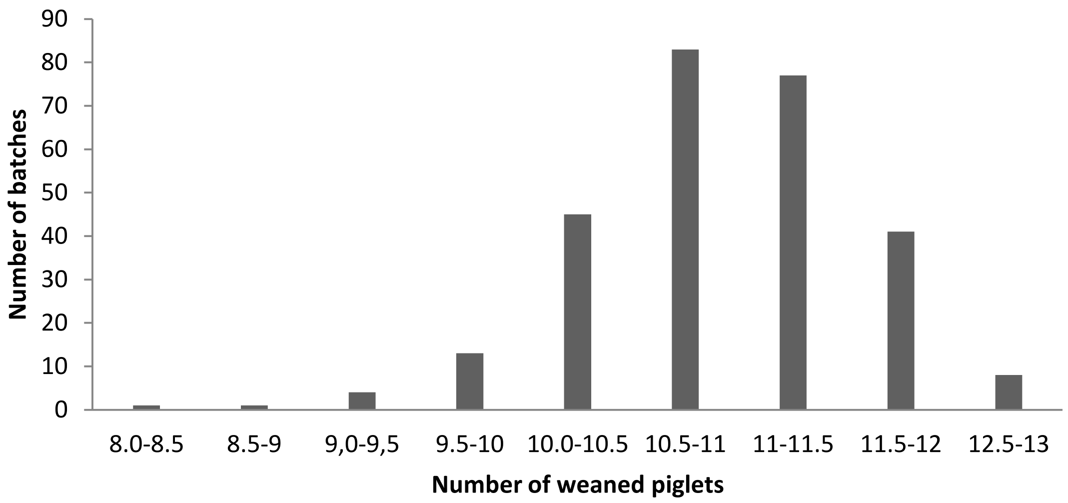


Figure 4. Distribution of average number of weaned piglets per litter, on batch level.

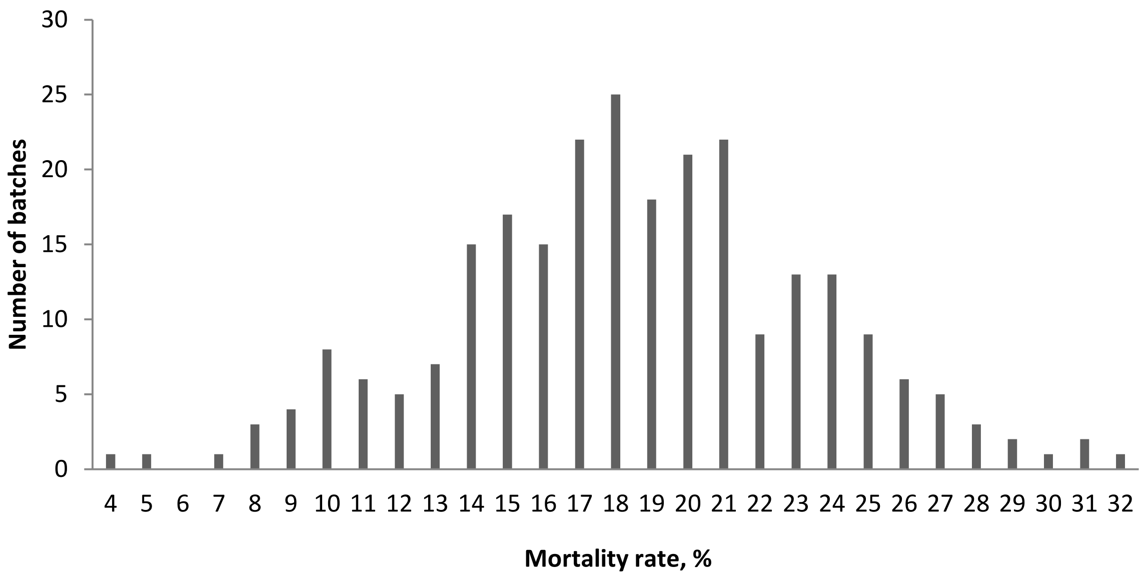


Figure 5. Distribution of piglet mortality during lactation on batch level.

Table 5. Production results per satellite herd, during the period studied. Satellite B/b, E/e and F/f belong to the same farm, but have differently constructed farrowing units/environments.

Satellite herd	Number of batches	Number of litters	Mean no. of liveborn piglets/litter ±SD [A]	Mean no. of stillborn piglets/litter ±SD[A]	Mean liveborn mortality rate± SD[B]	Mean no. of weaned piglets ± SD[B]
A	52	2260	13.8±3.7	1.0±1.8	22.1±3.8	10.8±0.6
B	22	837	13.6±3.3	0.9±1.3	20.9±5.5	10.6±0.6
b	10	398	14.0±3.2	0.8±1.3	19.7±2.3	11.2±0.3
C	29	1270	12.8±3.4	1.6±1.9	19.3±2.8	10.4±0.5
D	31	1352	12.8±3.1	0.8±1.4	12.8±4.2	11.2±0.5
E	10	406	13.9±3.2	1.0±1.5	22.5±4.1	10.7±0.4
e	21	794	13.4±3.4	1.1±1.6	19.6±4.1	10.8±0.5
F	22	569	13.5±3.5	1.1±1.7	21.8±5.1	10.5±0.9
f	11	291	13.3±3.6	1.6±2.2	20.6±4.7	10.6±0.9
G	16	664	13.5±3.3	0.9±1.5	15.8±5.5	11.4±0.5
H	16	745	13.8±3.3	0.9±1.5	17.2±3.9	11.4±0.5
I	15	542	13.7±3.3	0.8±1.1	17.0±2.9	11.3±0.6
J	15	698	13.0±3.4	1.7±2.0	15.8±3.9	10.9±0.7

[A] Results on litter level.
[B] Results on batch level

The production results calculated per satellite herd are presented in Table 5. The number of batches and litters recorded differed between satellite herds due to different batch sizes and batch intervals, even though the collection period was identical.

Production results

As seen in Table 7, the results in the satellites are in line with the Swedish average results, reported to PigWin in 2011 (PigWin, 2012). The average number of total born piglets per litter was 14.5, and the number of liveborn and stillborn piglets were 13.4 and 1.1 respectively. Furthermore, stillborn piglets occurred in 51% of the litters. The liveborn piglet mortality was on average of 18.9%, ranging from 4.1-29.5%, which is higher than the average results in Sweden. The average parity number within the sow pool was 3, with a range from 1 to 11

Table 6. Grouping of satellite herds according for piglet mortality during the lactation period, info in three classes.

	Definition	Percent of total data	Number of batches within the categories	Satellite
Lower quartile "*low piglet mortality*"	<16%	26.67	72	D,G,J
Middle quartiles	16-22%	48.52	131	B,b,C,e,F,f,H,I
Upper quartile "*high piglet mortality*"	>22%	24.81	67	A,E

Table 7. Average production results, compared to the mean results of Sweden

	Mean value	Range	Mean in Sweden 2011 [A]
No. total born piglets[B]	14.5	0-29	14.2
No. liveborn piglets[B]	13.4	0-25	13.1
No. stillborn piglets[B]	1.1	0-23	1.1
No. piglets weaned/litter[C]	10.9	8.2-12.4	10.7
Live piglet mortality, %[C]	18.9	4.1-29.5	18.3
Average parity number[C]	3 (3.4)	1-11	-

[A]Modified from PigWin (2012).[B]On litter level.[C] On batch level

Table 8. Level of significance of fixed effects

Analyzes on litter level	**Satellite**	**Parity number**	**Farrowing year**	**Farrowing month**
Number of stillborn piglets/litter	***	***	*	*
Number of liveborn piglets /litter	***	**	**	n.s.
Number of total born piglets /litter	***	***	***	n.s.
Analyzes on batch level	**Satellite**	**Mean parity number**	**Weaning year**	**Weaning month**
Mean number of weaned piglets /litter	***	*	n.s	n.s
Liveborn piglet mortality rate , %	***	***	***	*

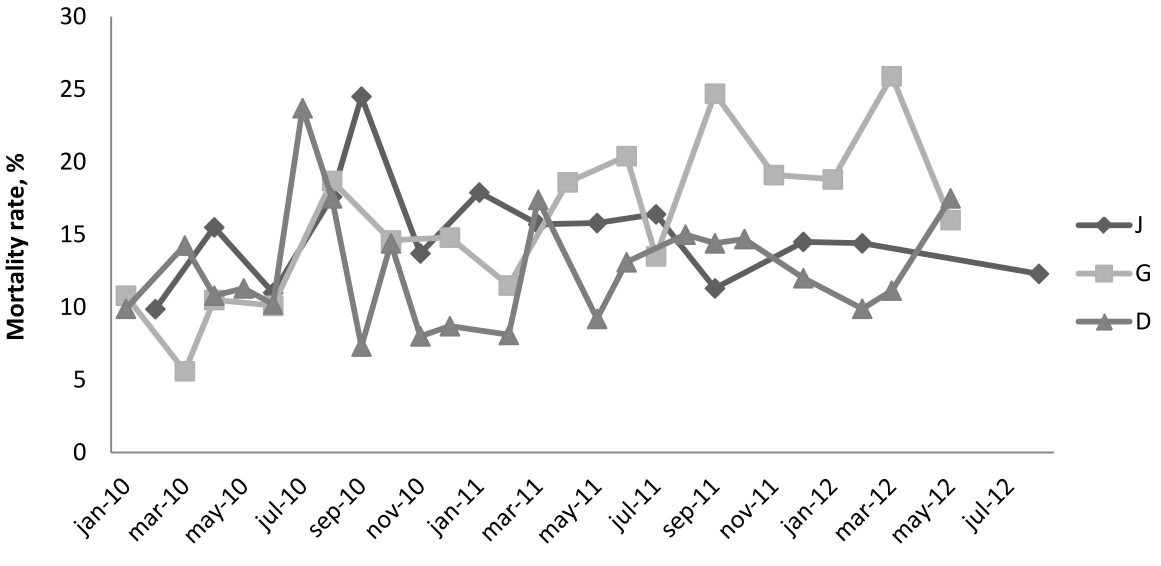


Figure 6. Variation in liveborn mortality (%) between batches within the three satellite herds with the lowest mortality

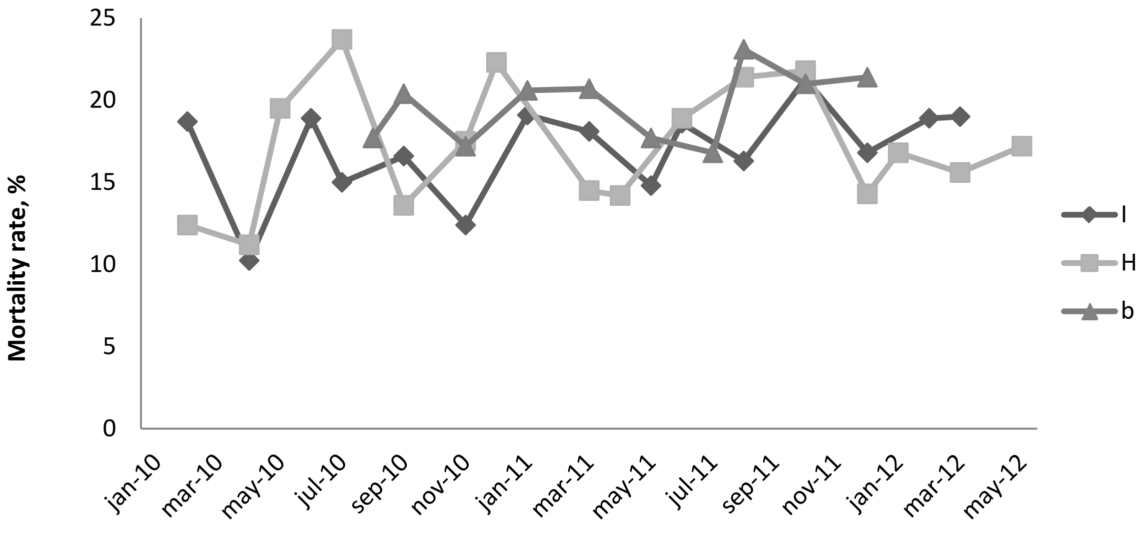


Figure 7. Variation in liveborn mortality (%) within the three satellite herds with the second lowest mortality

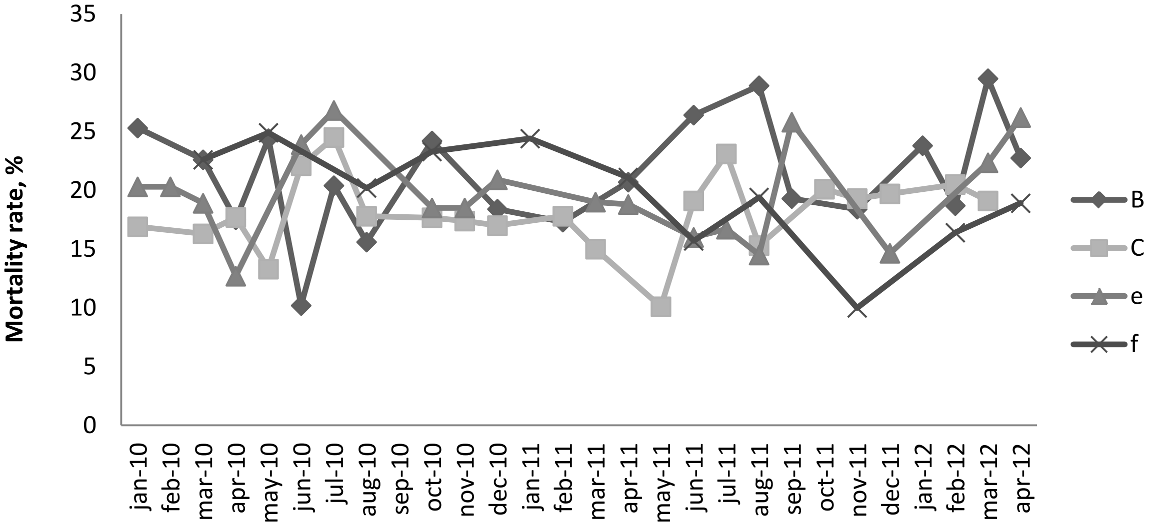


Figure 8. Variation in liveborn mortality (%) within the three satellite herds with the second highest mortality

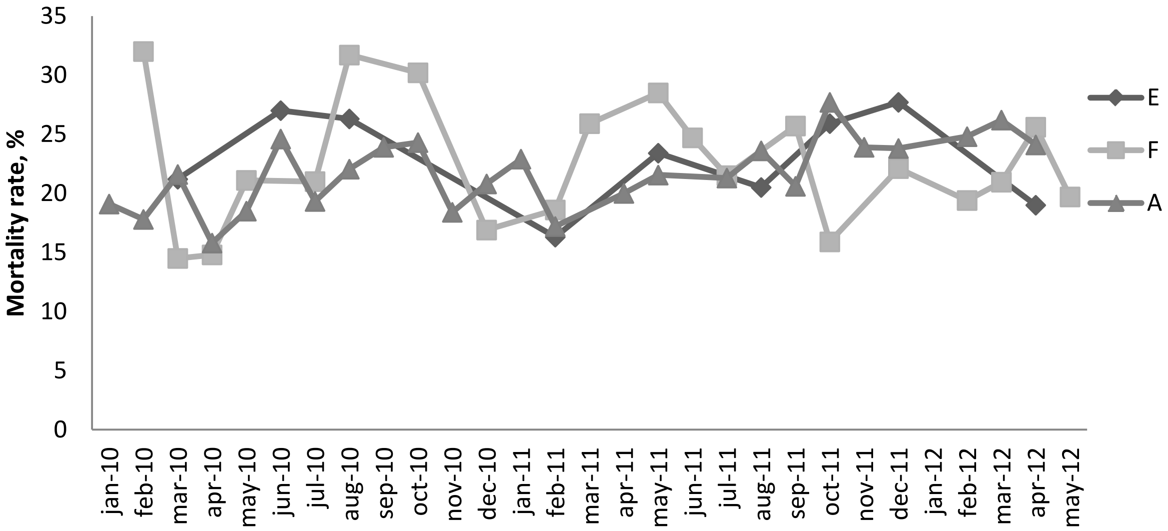


Figure 9. Variation in liveborn mortality (%) within the three satellite herds with the highest mortality

Table 9. Levels of significance of mortality class, weaning month, year and mean parity number on production and litter traits.

	Mortality class	**Weaning month**	**Weaning year**	**Mean parity number**
Liveborn piglet mortality rate		n.s.	***	***
Mean number of liveborn piglets	***	n.s.	**	n.s.
Mean number of stillborn piglets per weaned sow	n.s.	n.s.	n.s	*
Mean number of weaned piglets per weaned sow	***	n.s.	n.s.	*

Table 10. LS-means for mortality groups

	"Lower piglet mortality"	**Medium piglet mortality**	**"higher piglet mortality"**
Liveborn piglet mortality, %	14.9^{A}	20.2^{B}	22.5^{C}
Number of liveborn piglets/litter	13.1^{A}	13.5^{B}	13.9^{C}
Stillborn piglets, %*	6.9^{A}	7.9^{A}	7.6^{A}
Number of weaned piglets/sow	11.2^{A}	10.8^{B}	10.8^{B}

Means with one letter in common are not significantly different. * Percentage of total born piglets

As seen in Table 8, the number of stillborn piglets is significantly influenced by satellite, parity number, farrowing year and month. The number of stillborn piglets per sow increased with the parity of the sow. As are the number of liveborn piglets on litter level and mortality rates on batch level. The number of total born piglets was however not affected by farrowing month. The number of average weaned piglets per litter is only significantly affected by the satellite they are reared in, but not by the weaning year or weaning month.

The mean mortality rate was 18.9% (as seen in Table 5), and range from 4.1% to 29.5% on batch level (Table 5). The impact of mortality class on production results is presented in Table 9. When the litter size increased, the mortality rate class increased as well, as seen in Table 10 as well. The piglet mortality rates was also affected by season, and the mortality was higher in May, June and July, and older sows were more subjected to higher piglet mortality rates.

The differences between the mortality classes are presented in Table 10. The lower piglet mortality class did significantly differ from both other mortality classes for all production traits, except from number of stillborn piglets. The other two classes (medium and high piglet mortality class) were not always significantly separated from each other.

Interview

Additional results from the interview could be found in Appendix I.

Table 11. Summary of the most important results of the first part of the interview

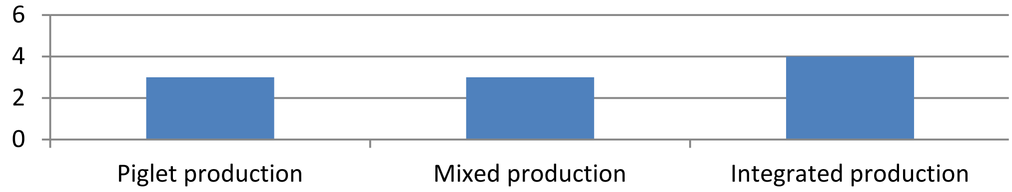
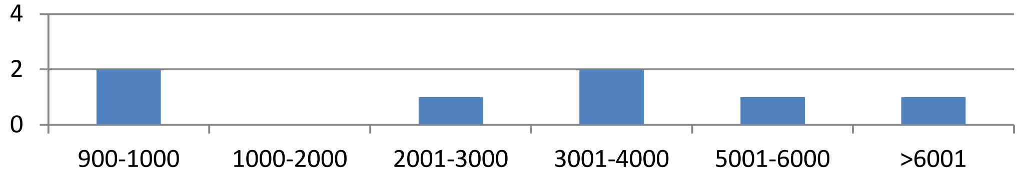
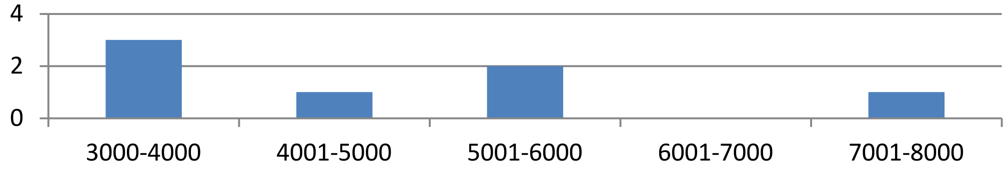
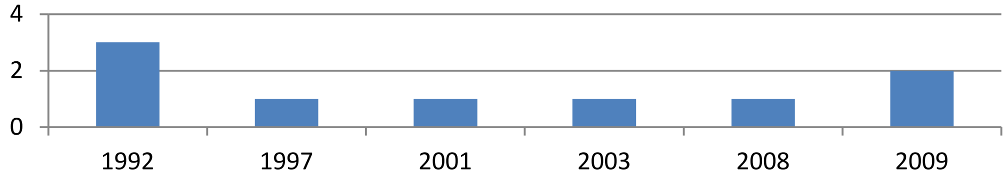
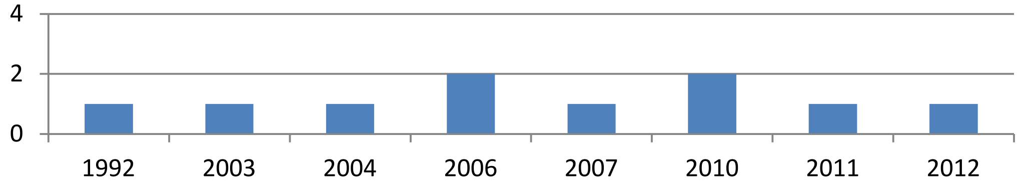
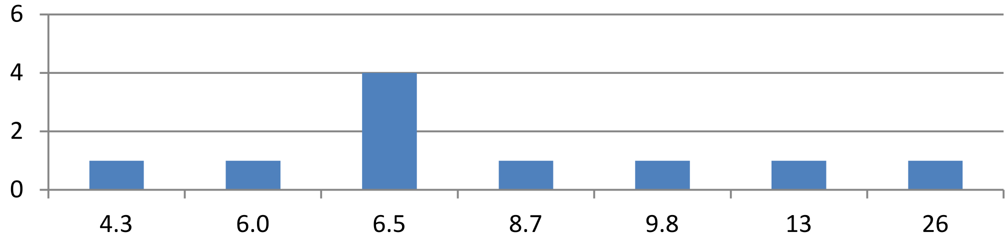
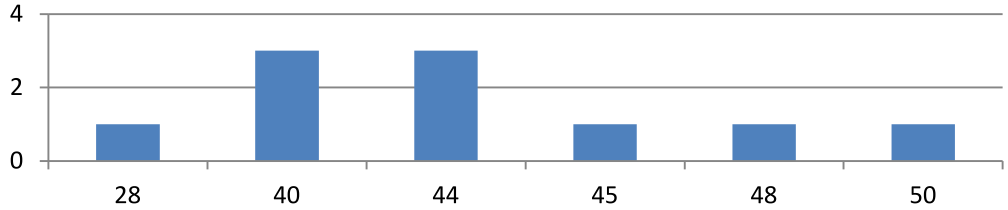
Production type	
Number of produced piglets per year	
Number of produced fattening pigs per year	
Joined the sow pool (year)	
Have had todays production since (year)	

Table 12. Summary of the most important results of the basic part of the interview.

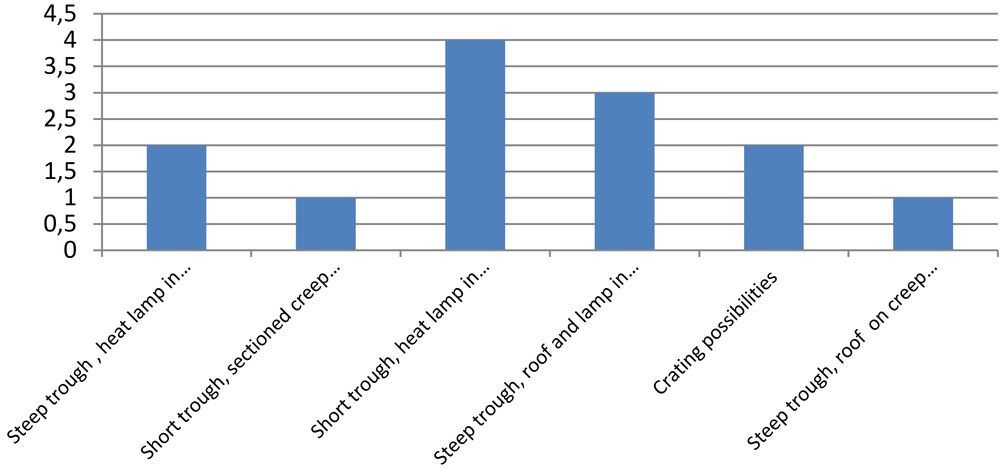
No. of batches /year



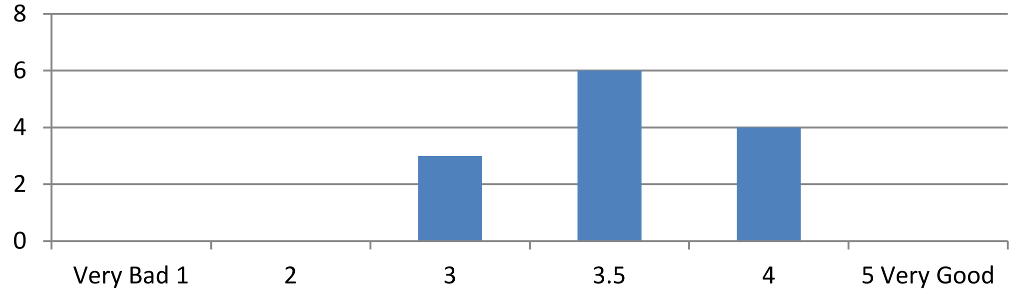
No. of sows/batch



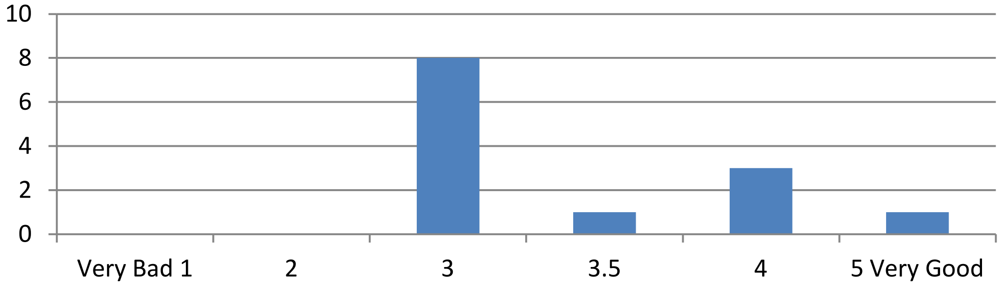
Pen type



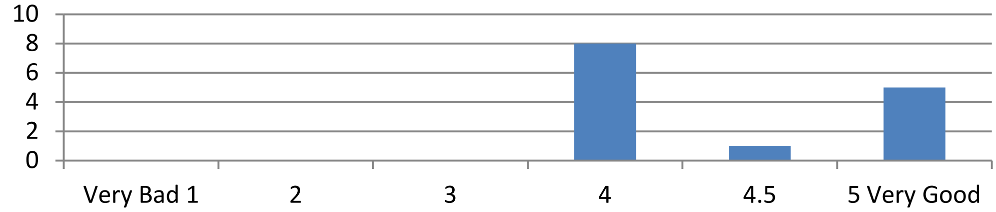
How does the production serve you today?



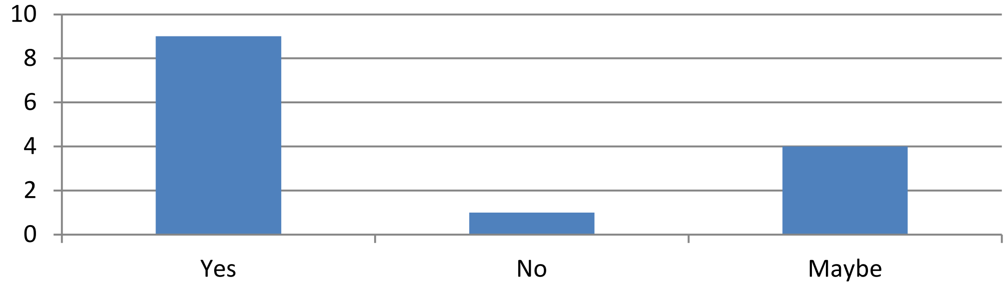
How is the piglet growth rate?



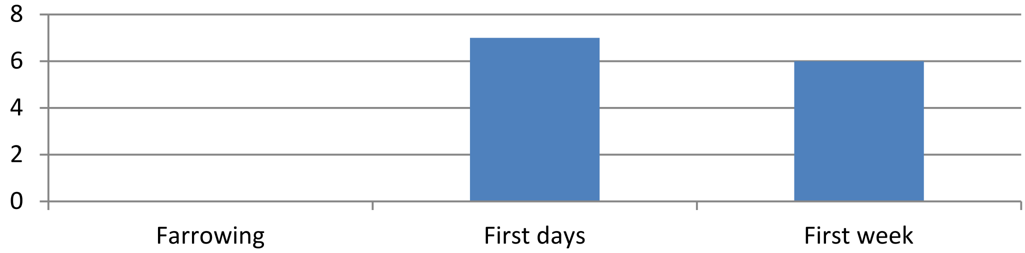
Is the number of born piglets satisfactory?



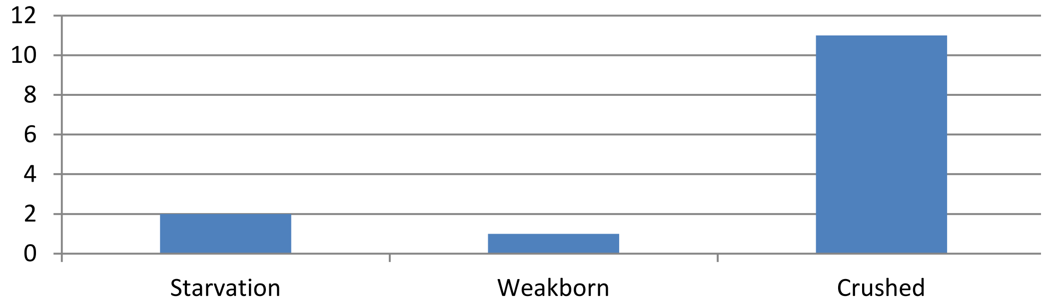
Is the piglet mortality an issue in the herd?



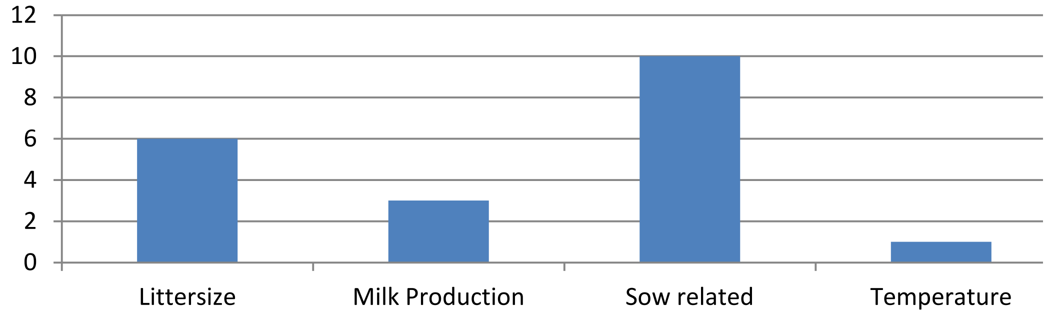
When do you loose most piglets?



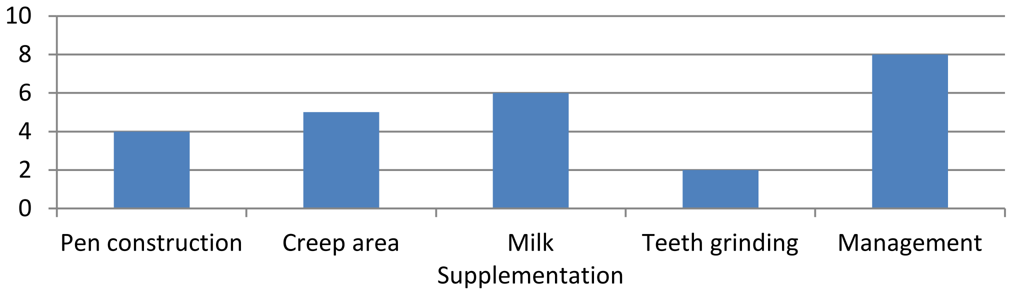
Which is the most common death cause?



What is the most common underlying death cause?



What is done to prevent piglet mortality?



As seen in Table 11, the herds in the study were a mix between piglet producers and integrated producers and some herds both delivered piglets and growing pigs to slaughter. The number of produced pigs varied greatly between herds and ranged from a total of 2500 produced piglets to 12000 produced pigs (piglets and growing pigs) in total. Some herds had recently changed their production concept, while most of them had had the same production for a longer time period.

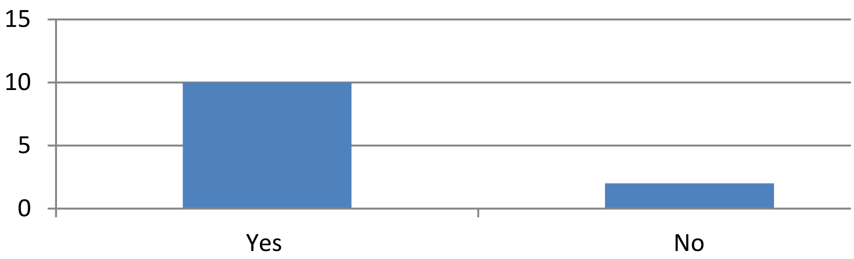
The most important answers in the basic part of the interview are presented in Table 12. The satellites are of different sizes and the sow groups are ranging from 28-50 sows, and 4-26 batches per year. The numbers of born piglets were overall satisfactory, even though some of the herdsmen did show concern of the too large litter sizes, making it hard to be able to keep all of them alive. Only one herd claimed that the piglet mortality was not a problem in their herd.

The piglet mortality did mainly occur the first days to the first week after farrowing. The most common death cause was said to be due to crushing. The litter size was again claimed to one of the main underlying reasons for piglet mortality, since big litters were considered to be associated to smaller, weaker piglets. The temperature in the stable was also claimed to be to have a big impact on the piglet mortality causes. Too hot temperatures caused the sow to lie down more often at wrong places, and lying down on piglets sleeping outside the creep area. The most common strategy to prevent piglet mortality was to improve the management, such as taking extra care of the sow, use of more straw and make sure that all piglets have got colostrum. Giving the piglets milk supplementation to care for large litters or bad milk production in the sow was quite commonly practiced. Also the pen construction was claimed to be an important part in the prevention of piglet mortality, partly by the usage of protection rails at the side of the pen, preventing the sow from crushing piglets when lying down. Another strategy was to try to increase the usage of the creep area, out of the way from the sow. This was practiced by increased usage of straw, locking in piglets in the creep area to learn where to lie, but also by adjusting the temperature in the creep area with floor heating and/or heating lamp. Two herds applied tooth grinding on whole litters, due to major problems with ulcers and sore udders of the sows.

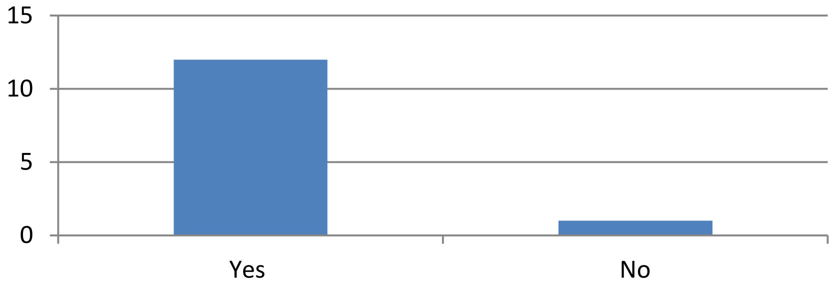
Table 13. Summary of the most important results of the stable part of the interview

Wash the stable cleaned before letting in the new sow group?

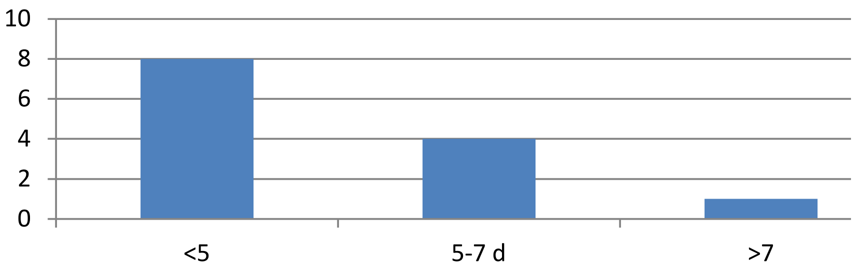
Was the stable disinfected between the batches?



Was the ceiling cleaned?



How many days were allocated for drying after washing?



In Table 13, the most important results of the questions about the stables and main routines are presented. All herds washed the stables before letting a new sow group in to the farrowing unit, and most of them did also disinfect and clean the ceilings in the unit. The days available for drying out the stables were however differing a lot between herds, although most of them had more than a week of drying, but some of them did only have one or a few days.

Table 14. Summary of the most important results of the feed part of the interview

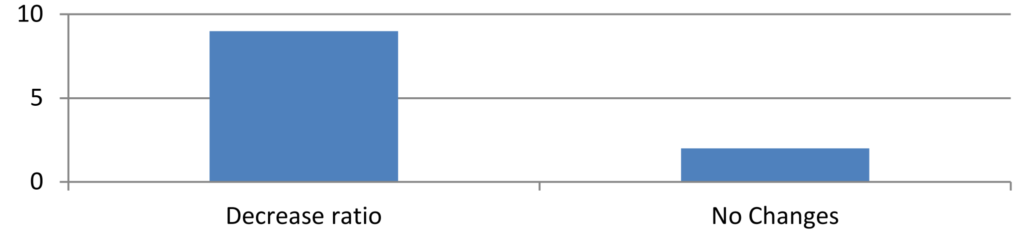
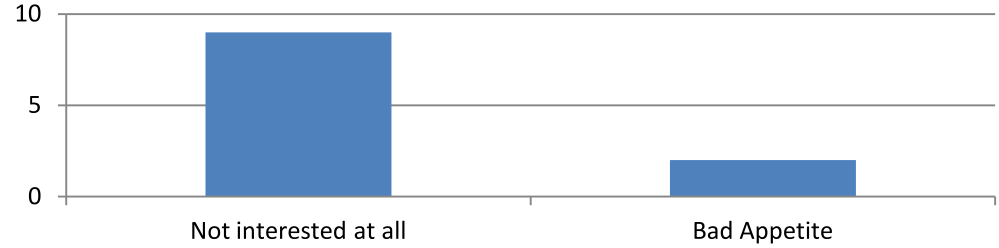
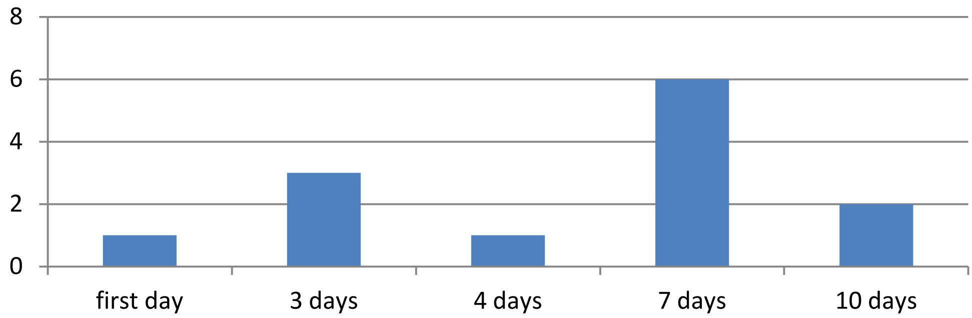
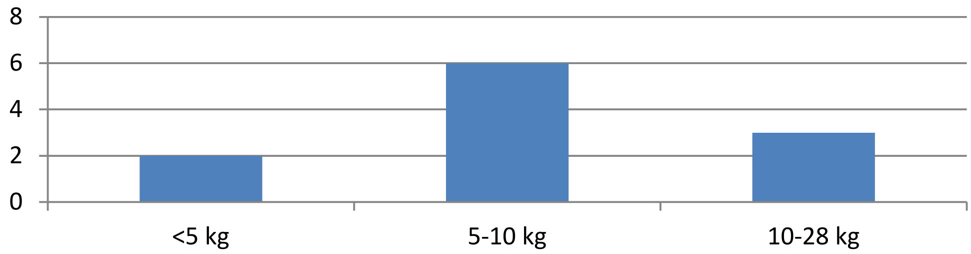
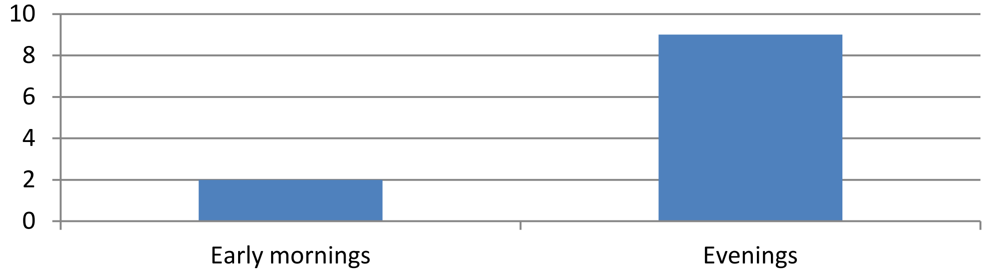
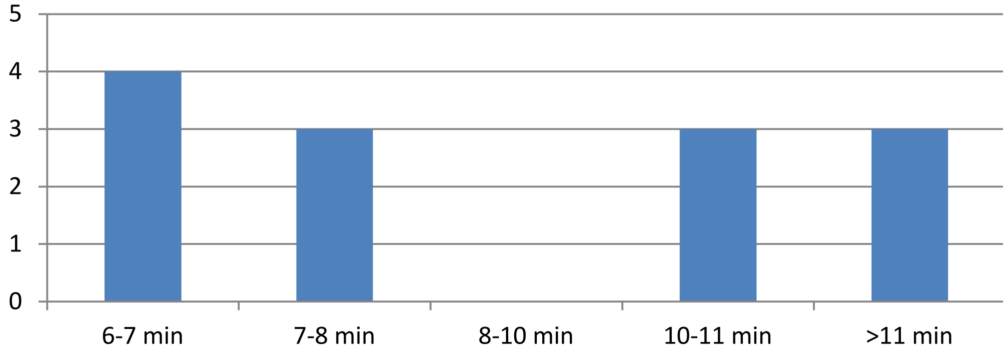
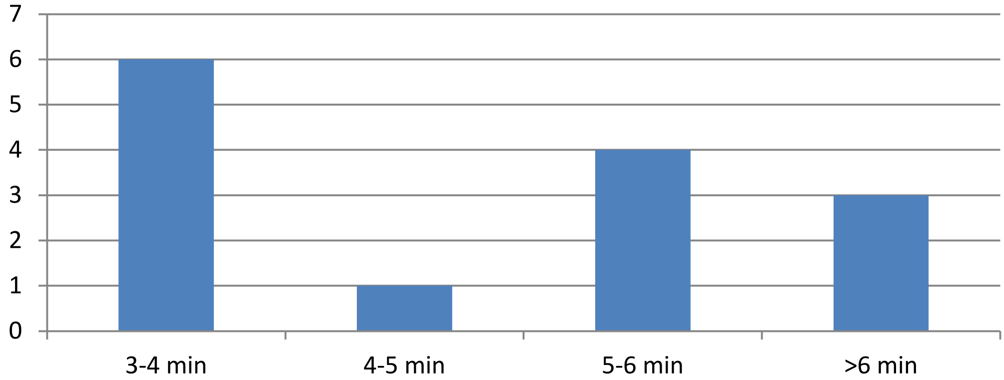
What feeding routines are practiced the days before farrowing	
How is feed refusal diagnosed?	
How old are the piglets when first given piglet feed? (days)	
How many kg piglet feed are consumed per litter and lactation period? (kg)	

Table 14 shows the main results from the interview questions mainly concerning the feed and feeding routines. The feeding routines the days before farrowing differed between two alternatives, either the herds removed or reduced the feed ratio or they did not do any changes at all. The piglets were offered solid feed their first day of life or up to the tenth. Commonly the piglets were first fed piglet feed when they were one week old. The total amount of fed piglet feed per litter during the lactation period ranged from 3.5 to 28 kilo in the visited herds.

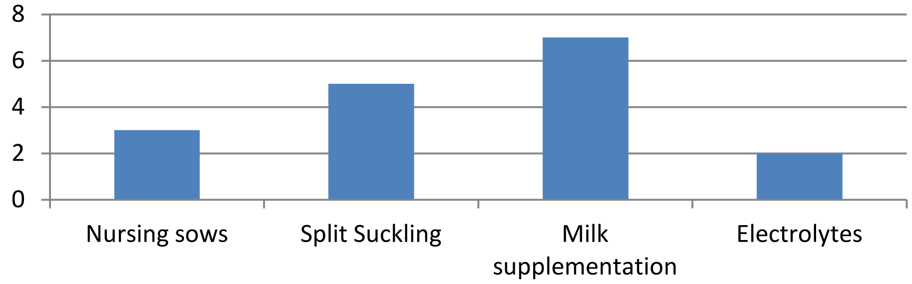
Table 15. Summary of the most important results of the supervision part of the interview

Do the pigs have extra supervision during the farrowing week?	
How much time is spent in the farrowing stable during the farrowing week? (minutes/sow per day)	
How much time is spent in the farrowing stable during the lactation period, except the farrowing week? (minutes/sow per day)	

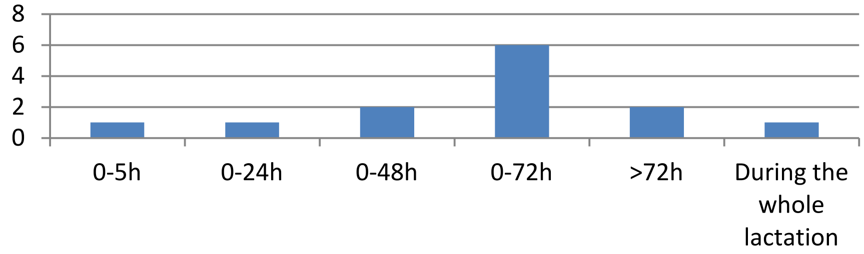
The most important questions about the supervision of the pigs are narrowed down in Table 15. Most herds provided extra supervision apart from the ordinary working hours during the farrowing week. The time spent in the farrowing stable differed between farrowing week and the rest of the lactation period, more time spent in the stable during the farrowing week.

Table 16. Summary of the most important results of the sow part of the interview

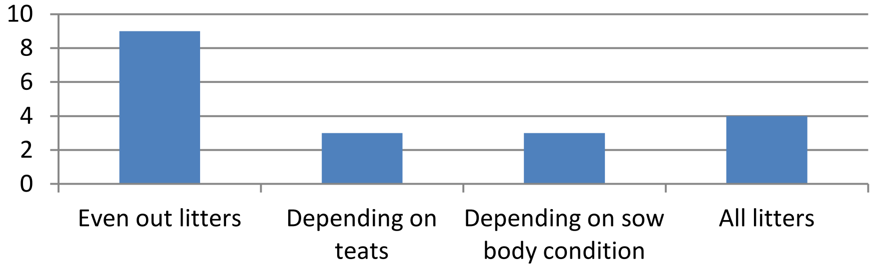
How do you handle litters larger than the number of functional teats?



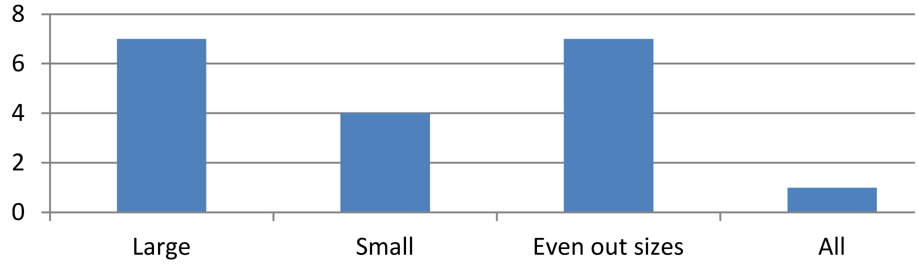
How old are the piglets when crossfostered?



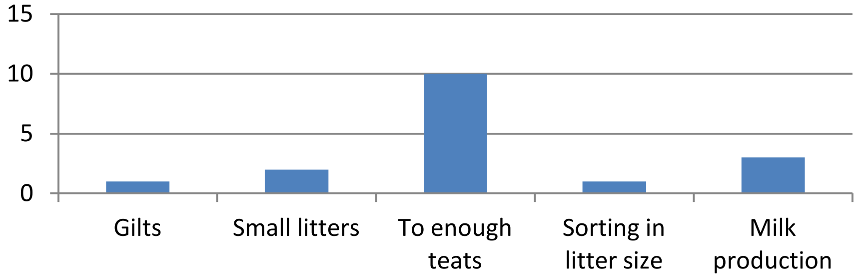
Why are litters crossfostered?



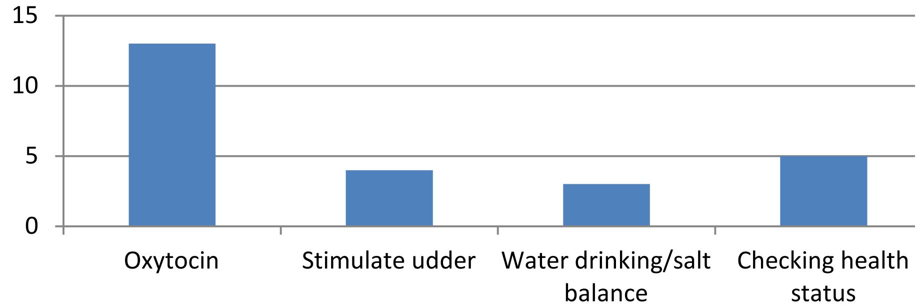
Which piglets are moved?



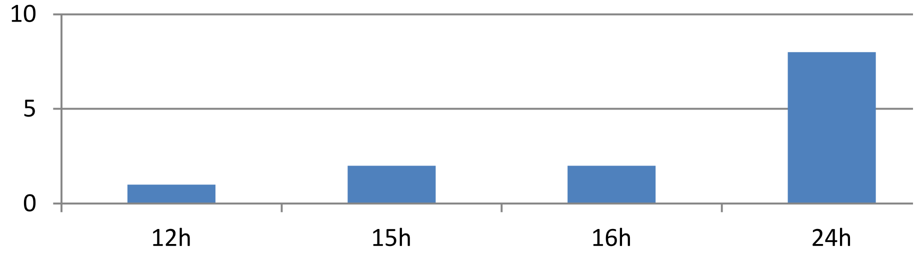
To whom do you move the piglets?



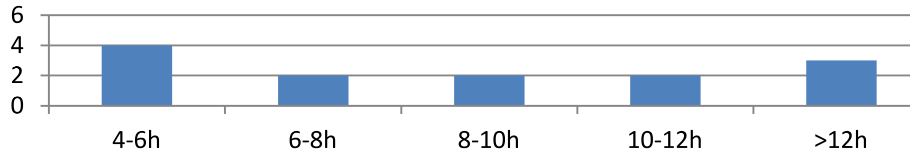
How is bad lactation handled?



How many hours per day are the lights turned on in the farrowing stable during the farrowing week



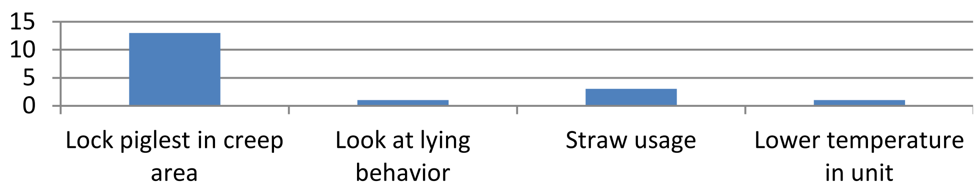
How many hours per day are the lights turned on in the farrowing stable during the lactation period, except during the farrowing week



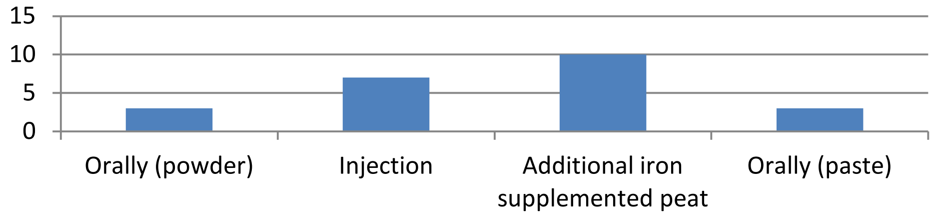
All herds in this study practiced crossfostering. Apart from crossfostering, litters that exceed the amount of functional teats were handled through usage of nursing sows, split suckling, milk supplementation and electrolytes, as seen in Table 16. Crossfostering mainly occurred within 72 hours after birth, and was often performed to even out of the litters in the sow group. The piglets were mainly moved to which ever sow with enough teats to feed the moved piglet. If a sow had problems with bad lactation, for example milk letdown or bad milk production, it was mainly handled by the usage of oxytocin and checking for health issues. The herds had 12-24 light hours in the farrowing stable during the farrowing weeks and 4-15 light hours during the rest of the lactation period.

Table 17. Summary of the most important results of the piglet part of the interview

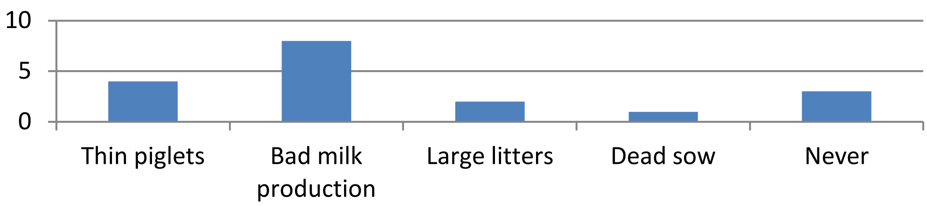
How do you try to increase the usage of the creep area?



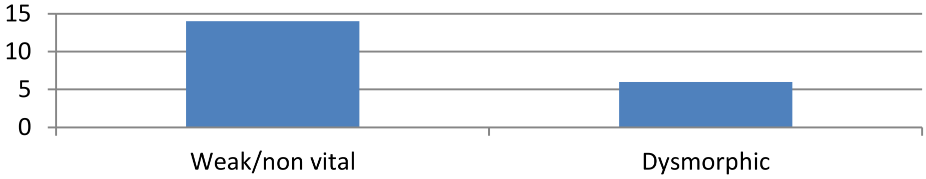
How is iron supplementation given?



When do you give milk supplementation?



Which piglets are put to death?

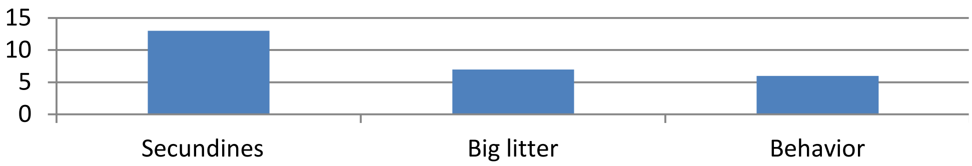


As seen in Table 17, all herds tried to increase the usage of the creep area by locking the piglets in the creep area for some time the day/days around farrowing. To use more straw and adapting heating lamp and floor heating according to the lying behavior of the piglets in the creep area to keep the temperature according to the piglets need was commonly done in order to increase the usage of the creep area. Lowering the temperature in the unit was practiced so that it would be uncomfortable to lie outside of the heated creep area. Most herds used milk supplementation occasionally, to thin or hungry piglets, or piglets in large litters. Some herds claimed to never give milk supplementation due to it supposedly decreased the sows own milk production.

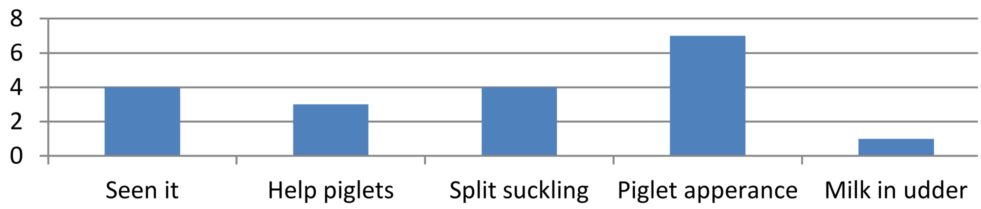
Producers were asked which piglets that were put to death by the herdsmen, and not died out of natural causes. Most answered that very weak piglets, that had none or very small chances of surviving were put to death. Also, some dysmorphic piglets were put to death even though their issues might not be life threatening but have a significant relation to the production of the piglet.

Table 18. Summary of the most important results of the "at farrowing" part of the interview

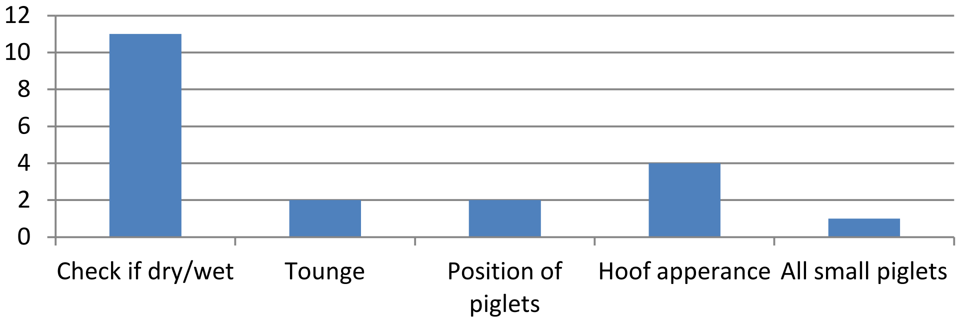
How do you know that the farrowing is finished?



How do you make sure that all piglets have had milk?



How are stillborn piglets separated from piglets that have died shortly after birth?

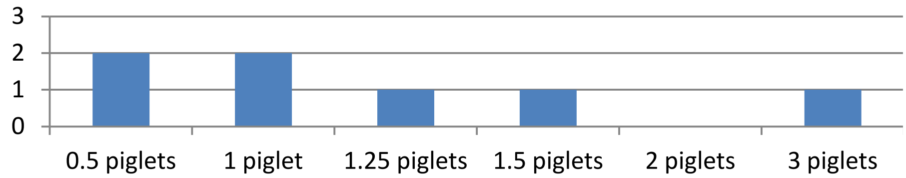


As seen in Table 18 the herdsmen mainly used the sight of the secundines as a sign of the farrowing being finished. With the farrowing being finished, the supervision of the sow would be decreased. Some herds however did also check at the size of the litter and sow behavior to confirm the farrowing as over.

To separate stillborn piglets from piglets dying after birth most herdsmen looked to see if the piglets were still in their foetal membranes, and if they were, they were considered stillborn. Also looking if the hooves were torn or not was commonly practiced as determining if the piglet was stillborn or not. One herd did also register very small, not vital, liveborn piglets as stillborn.

Table 19. Summary of the most important result of the "at castration" part of the interview

How many piglets are lost per litter at the time of castration , excl. stillborn piglets (approximately)



In Table 19, the results from the question of how many piglets that was lost before castration, which was most commonly practiced about two to four days after birth. The results varied between about half a piglet per litter to three piglets per litter, with a mean of 0.7 piglets per litter. Five herds did not answer this question, due to not being able to estimate a good answer.

Merging the production results with the interview results

The piglet interview questions from high and low mortality classes conducted from the production results was compared to find if there were differences in management routines or production conditions. The results presented in tables in this part were proven to have a significant impact on the mortality rate.

Table 20. Questions from the basic information of the interview that had an impact on the mortality rate

	Categories	Mean liveborn mortality rate, %	No. of observations
Production type	Piglet production	19.4	4
	Partly integrated	15.0	2
	Integrated	19.5	7
Have had todays production since (year)	<2004	15.3	3
	2004-2010	18.9	6
	>2010	20.7	4

The production type had an effect on the piglet mortality rate, and those herds that sold both growing pigs and piglets had a lower mortality rate, as seen in Table 20. The mortality rates between the integrated and piglet producing herds were almost the same, and only two herds did produce both piglets and growing pigs. Herds that recently had a production change had a higher piglet mortality rate than herds that had had no production changes for a longer period.

Table 21. Questions from the basic part of the interview that had an impact on the mortality rate

	Categories	**Mean liveborn mortality rate, %**	**No. of observations**
How does the production serve today?	1 (very bad)		0
	2	17.4	2
	3	18.9	9
	4	21.1	2
	5 (very good)		0
How is the piglet growth rate?	1(very bad)		0
	2		0
	3	20.1	8
	3.5	17.0	1
	4	17.9	3
	5 (very good)	12.8	1
What is the most common underlying death cause?	Littersize (1)	17.0	1
	Sow-related(2)	20.1	5
	1+Milkproduction(3)	20.3	2
	1+2	15.3	3
	2+3	18.3	1
	2+Temperature in the stable (4)	22.1	1
What is done to prevent piglet mortality?	Pen construction(1)	22.1	1
	Management (2)	15.8	1
	1+2	12.8	1
	Usage of creep area(3)	17.2	1
	2+3	20.3	3
	2+Milk supplementation(4)	18.8	3
	4+Tooth grinding(5)	21.1	2
	1+3+4	17.0	1

As seen in Table 21, herds that thought that their production functioned less well had a lower piglet mortality rate than herds that thought that their production was better functioning. Herds considered to have a good piglet growth rate had a lower piglet mortality rate than did those herds who thought that the piglet growth rate was less satisfying. The highest piglet mortality rate was considered to be related to the sow, temperature in stable and failure in milk production (as low milk production, or bad milk let down).

There were a lot of different management routines practiced in order to prevent the piglet mortality. The lowest piglet mortality rate was found in herds that practiced extra management routines (such as usage of much straw, extra caretaking of sows and keeping pen clean) along with the support of a good pen construction, such as fixation of sows, good climate in the creep area and protection rails.

Table 22. Questions from the feed part of the interview that had an impact on the mortality rate

Question	Categories	Mean mortality rate, %	No. of observations
What feeding routines are practiced the days before farrowing	Decrease ratio(1)	20.2	9
	No changes (2)	15.7	4
How is feed refusal diagnosed?	Not interested at all(1)	19.5	7
	Bad appetite(2)	19.9	3
	1+2	12.8	3

As seen in Table 22, herds practicing the same feeding routines days before farrowing as before had a lower mortality rate than herds that decreased the feed ratio or took away the feed. Concerning feed refusal, or rather when actions were taken against sows that were not eating properly, herds that took both bad appetite and sows that were not interested in feed at all into consideration when to take action rather than only one of the alternatives had a lower piglet mortality rate.

Table 23. Questions from the supervision part of the interview that had an impact on the mortality rate

	Categories	Mean mortality rate, %	No. of observations
How much time is spent in the farrowing stable during the lactation period (except the farrowing week? (min/sow)	<3.5	20.8	5
	3.5-6	16.5	4
	>6	18.5	4

How much time that was spent in the farrowing stable during the lactation period had an effect on the mean mortality rate in the herd (Table 23). The more time spent in the stable did not have only positive impact on the mortality rate. The herds that only spent one or two hours in the farrowing stable during the lactation period had a higher mortality rate than the herds that spent more time in the farrowing stable. Most herds spent 1-2 hours in the farrowing stable while only a few herds spent more in the farrowing stable during this period.

Table 24. Questions from the sow part of the interview that had an impact on the mortality rate

	Categories	Mean mortality rate, %	No. of observations
How do you handle litters larger than the amount of functional teats?	Crossfostering (1)	19.3	7
	1+ Nursing sows (2)	17.2	1
	1+ split suckling (3)	12.8	1
	1+2+3	20.3	2
	1+3+Milk supplementation + Electrolytes	21.1	2
Which litters are crossfostered?	To even out litters (1)	20.0	4
	Depending on amount of teats (2)	21.1	2
	All litters(3)	18.3	1
	1+2	17.0	1
	1+3	21.2	2
	1+Depending on sow body condition and history (4)	14.3	2
	3+4	15.8	1
Which piglets are moved?	Large (1)	20.3	3
	Gilts (2)	15.7	5
	Boars(3)	22.1	1
	1+ Small(4)	21.1	2
	1+3+4	20.3	2
To whom do you move the piglets?	Small litters (1)	20.3	3
	Where there are enough teats(2)	15.7	5
	Even out litter sizes (3)	22.1	1
	2+Good milk production(4)	21.1	2
	2+4+Gilts (5)	20.3	2
How is bad lactation handled?	Oxcytocin (1)	14.3	2
	1+Stimulate udder(2)	20.4	4
	1+Water drinking/salt balance (3)	21.1	2
	1+Check health status/treatment(4)	19.0	4
	1+3+4	15.8	1
How many hours per day are the lights on in the farrowing stable during the lactation period, except during the farrowing week	4-5	20.7	4
	6-10	19.2	5
	11-15	16.3	4

Herds that practiced both crossfostering and split suckling had a lower mortality rate than herds with other routines when the littersize exceeds the number of functional teats, as seen in Table 24. Milk supplementation did however seem to have a negative effect on the mortality rate. Most herds crossfostered in order to even out the littersizes in the batch. The lowest piglet mortality rate was however found if litters were crossfostered in order to even out litter sizes and making sure that there were enough teats available for all piglets to feed at the same time. Some herds crossfostered depending on the sows body condition and previous history of weaned piglets. The highest piglet mortality was found in herds where all litters were crossfostered in order to even out litter sizes or by only looking at the amount of functional teats in the sow. The producers were asked which piglets from each litter that was preferably moved, most herds claimed to move gilts, and these herds also showed the lowest mortality rate. Herds which crossfoster to sows or gilts with enough functional teats available for the crossfostered piglets had the lowest piglet mortality rates. If bad lactation occurred, as in low milk production, problem with milk let down etc, the lowest mortality rates were found in herds were this was only treated with oxytocin. How many light hours there were per day during the lactation period did also seem to have an effect on the mortality rate, where the more light hours practiced, the lower mortality rates there were.

Table 25. Questions from the piglet part of the interview that had an impact on the mortality rate

	Categories	Mean mortality rate, %	No. of observations
Which piglets are put to death?*	Weak(1)	20.4	6
	Dysmorphic(2)	18.1	5
	Non vital(3)	18.3	1
	2+3	12.8	1

*Piglets that were put down was also added to the mortality rates.

Which piglets that were put to death seemed to have an impact on the mortality rates. Herds that put down dysmorphic, not vital piglets rather than letting them stay in the litter to concur with the other piglets for milk had a lower mortality rate than the other routines practiced, as seen in Table 25.

Table 26. Questions from the "at farrowing" part of the interview that had an impact on the mortality rate

	Categories	Mean mortality rate, %	No. of observations
How do you know that the farrowing is finished?	Secundines (1)	18.3	4
	1+Big litter (2)	19.8	3
	1+Behavior(3)	14.3	2
	1+2+3	20.8	4
How do you make sure that all piglets have had milk?	Seen it (1)	12.8	1
	Piglet appearance(2)	19.5	4
	1+Help piglets(3)	17.0	1
	1+2	22.1	1
	1+ Milk in udder(4)	15.8	1
	3+Skiftesdigivning(5)	21.1	3
	2+5	20.3	2

As seen in Table 26, herds that both looked to the behavior and presence of secundines when deciding whether the sow had finished farrowing or not, had a lower mortality rate than herds including the presence of a big litter or looking for secundines alone. Most herds claimed to make sure that all piglets had had milk by the appearance of the piglets. This was described as seeing to that the piglet was lying down sleeping, looking satisfied rather than trying to find a teat or stimulating the udder while the rest of the litter was fast asleep. The lowest piglet mortality rate was though found to be in herds that only considered the piglets as being fed if they had seen it. The distribution of the answers were however very large and few herd practiced the same routines.

Impact of management routines on piglet mortality rate

Questions from the interviews, where different management strategies were seemed to have an impact on the piglet mortality rate on batch level were statistically analyzed using analysis of variance, accounting for the effect of average parity number, weaning month, weaning year, satellite (random effect). The results were conducted using the PROC MIXED.

Table 27. Different feeding routines impact on the piglet mortality rate

What feeding routine is practiced the days before farrowing?	Decrease ratio	No changes
Mortality rate, %	20.7	16.1

Table 28. Different diagnosis of when to act against feed refusal, and its impact on the mortality rate

How is feed refusal diagnosed?	Not interested at all	Bad appetite	Not interested at all + Bad appetite
Mortality rate, %	20.3	20.2	15.9

As seen in Table 27, herds that did not make any changes to the feeding ratio days before farrowing had a significantly lower mortality rate than the herds that decreased or removed the feed all in all. Those herds that took action against feed refusing sows by taking both bad appetite and no interesting feed at all had a lower mortality rate than herd that took action only considering one of the management routines at the time, as seen in Table 28.

Table 29. Time spent per sow and day during the lactation period, impact on the piglet mortality rate

How much time (min/sow per day) is spent in the farrowing stable during the lactation period (except for the farrowing week)	<3.5	3.5-6	>6
Mortality rate, %	20.8	16.5	18.5

Table 30. Light hours in the farrowing stable during the lactation period and its impact on the piglet mortality rate

How many hours per day are the lights turned on in the farrowing stable during the lactation period (except for the farrowing week)	4-5	6-10	11-15
Mortality rate, %	21.2	19.8	16.7

As seen in Table 29 and 30, the time spent in the stable and the number of light hours had an effect on the mortality rate. Spending only one or two hours in the farrowing stable had a negative impact on the mortality rate. The more light hours the lower the piglet mortality rate.

Table 31. Impact of which piglets that are put to death on the piglet mortality rate

Which piglets are put to death?	Weak	Dysmorphic	Non vital	Dysmorphic + Non vital
Mortality rate, %	21.0	18.7	18.6	13.1

Which piglets that were put to death by the stocks person, rather than letting them stay in the litter had a significant impact on the piglet mortality rate. Herds that took away dysmorphic and non vital piglets had lower piglet mortality than other herds, as seen in Table 31. Herds that put down weak piglets had a significantly higher piglet mortality rate than other herds.

Table 32. Impact on how to check that the sow has finished farrowing on the piglet mortality rate

How do you know that the farrowing is finished?	Secundines	Secundines + Big litter	Secundines + Behaviors	Secundines + Big litter + Behavior
Mortality rate, %	18.9	20.1	14.9	21.2

How the stockperson decided that the sow had finished farrowing, and thereby not keeping her under extra supervision any more had a significant impact on the piglet mortality in the herd (Table 32). To check that the sow have had secundines and also started to have "normal" behavior again, such as standing up, eating and being active, had a lower piglet mortality rate than other management routines.

Discussion

The production and mortality results from the satellites in the study are in line with the PigWin results from 2011 (See Table 7). This implies that the results from the study are comparable with other Swedish farm results. The piglet mortality causes were also in line with previous studies on the subject. Piglet mortality rates were highest the first days to the first week of life, which is what has been shown in previous studies, further implying that the results of this study could be compared to other farms (Glastonbury, 1976; Cecchinato et al., 2008; KilBride et al., 2012). The producers thought that the most common death cause was crushing followed by weak born piglets and starvation/lack of colostrum, which also is in line with previous studies (Grandinson et al. 2002; Pedersen et al., 2010; KilBride et al.,2012; Paredes et al., 2012; Rothe, 2012). If crushing really were the most common death cause could not be investigated in this study since death cause was not recorded, but all producers agreed that this was the most common death cause.

The underlying causes of the piglet mortality were thought to be very sow related. Most producers thought that the underlying cause of the high mortality was higher in old sows that were clumsy and have bad udders and few functional. This is supported by several other studies (Vanderhaege et al., 2010b; KilBride et al., 2012; Miller et al., 2012). Older sows were also suggested to more often have issues with poor contractions at labor which was thought to prolong the birth interval. Prolonged farrowing has been shown to increase the number of stillborns in the litter (Baxter et al. 2012; Pedersen et al., 2010l). It was also proven in the study the number of stillborn and liveborn piglets per litter, as well as the number of weaned piglets and piglet mortality rates per batch were all significantly affected by the parity of the sow. The higher parity of the sow, the larger the number of stillborn was. The piglet mortality rate also affected by year and month, and sows with a higher parity had higher survival rates. These findings are supported by Cecchinato et al. (2008) and Weber et al. (2009).

Large litter sizes were also identified by the farmers as a major underlying cause of high mortality rate. The large litter sizes were thought to influence both vitality and birth weight of the piglets negatively. Similar relationships have been found by Grandinson et al. (2002), Persdotter (2012) and Pedersen et al. (2010). Furthermore, producers thought that sow milk production was considered a major issue, and the produced milk not being enough to feed all piglets. This is supported by Pedersen et al. (2002) and Pedersen et al. (2011). At the same time, many producers were skeptical to the usage of milk supplementation, since it was associated with further lowering the sow milk production. Too high stable temperature was also considered an issue, due to its negative impact on sow behavior (increased risk of crushing), and reduced feed intake, also this is supported by previous studies (Malmkvist et al., 2012).

The interviews held in this study was mainly consisting of closed questions with fixed answers such as yes or no, or on a scale basis. Many of the questions were however open, and the interviewed could decide freely what to answer, such as what the most common cause of piglet mortality was. The answers were then categorized to enable statistical analyses. The interviewed were always able to express their opinions outside of the answering options, and these opinions were taken into consideration when analyzing the results, even if they were not a part of the statistics. It would however have been possible to conduct the interviews in a different way, for example by deep interviews. A deep interview could for example be analyzed by focusing on what is ment as described in Kvale & Brinkmann (2009). Due to the different characteristics of the two interviewing methods the results could probably differ. The interview technique used in this study was chosen in order to be sure of being able to do statistical calculations and find significant results.

Herd averages

It was evident that there was variation in piglet mortality both between batches within the herds and between the herds in a sow pool. Litter traits at birth, as total born and stillborn, did however not vary a lot. As seen in both Figure 1 and Table 5 the number of liveborn piglets per litter peaked at 14 piglets when investigating all litters recorded, and varied between 13-14 piglets per litter at satellite average. The number of stillborn piglets had a peak at one stillborn piglet per litter, and varied from 0.8-1.7 per litter at satellite level. Even though there were no large differences in litter size at birth, the mortality rates varied the more. The mean mortality between herds shown in Table 5 shows that the mortality varied between 12.8-22.5% and the range between batches was even higher (Figure 5). The litter sizes and mortality rates are in line with previous findings (Marchant et al., 2000; Cecchinato et al., 2008; Pedersen et al., 2010; Pedersen et al., 2012).

It was evident that there were differences in mortality rates between satellite herds, which are shown in Figure 3-6 and Table 5. The mean mortality rate did also seem to differ between different units within the same satellite herd, see herd B/b, E/e and F/f in Table 5. Herd G, I and H were also partly managed by the same staff, even though these units did not belong to the same satellite. The mean mortality rate of herd G differed from herd I and herd H, which implies that the fact that mortality rates from differently shaped units within the same herd, might not only be due to them belonging to the same satellite. This shows that there are differences between satellites in mortality rates, even though they share the same animal material. Indicating that the mortality rates are affected not only by genetics and or how the sows were kept during insemination and gestation period, but also by the management during the farrowing and lactation period, as is supported by a number of studies (Merchant et al., 2000; Pedersen et al., 2010; KilBride et al., 2012). It was also shown that the same satellite had large variation between batches reared in approximately the same way. This could be an indicator that mortality rates is not only affected by the construction of the stables or pens for example, but also factors differing between batches, such as season and staff appearance.

Also number of stillborn and liveborn piglets per litter as well as mortality per batch were significantly affected by satellite herd. Since all sows had the same treatments during the period from weaning until three weeks prior to expect farrowing date, these results imply that the results have got to do with the time spent at the satellite herd. The number of stillborn piglets per litter could be affected by the farrowing supervision provided by the herd staff, since many stillborns die due to prolonged farrowing intervals etc (Baxter et al., 2012). During the interviews no clear evidence on different recording practices of stillborn piglets was detected, and therefore that the differences should be due to different types of recordings should be minimal. The stillborn rate was also significantly influenced by the parity number of the sow, which is supported by Vanderhaege et al. (2010a).

In Figure 6 to 9 the 13 units were divided into four groups, ranked from highest to lowest lactation piglet mortality rate. The piglet mortality rate per batch is represented and accounts for the variation in piglet mortality between batches within the same herd. Here it is again evident that the mortality rates vary between batches. Even those herds with the highest mortality averages can have batches with a very low mortality rate and vice versa. This shows that the mortality rates is not static and implies that the mortality rate is both easily affected and multifactorial, as has also been stated by Pedersen et al. (2010).

The satellites were also divided into three groups, high, medium and low mortality, based on the mean mortality rates of number of liveborn piglets (Table 6). The three satellites considered low mortality herds, had an average mortality lower than 16 % whilst the high mortality herds had a mean mortality rate that was higher than 22%. The rest of the satellites were in the medium group. When comparing the low and high mortality class satellites (Table 9 and 10) it was shown that the piglet mortality rate differed significally between the two groups, as were the number of live born, stillborn and weaned piglets between the herds. The medium group were however not always be significantly differed from the high piglet mortality group. There was no evidence that herds that had a lower piglet mortality average had less variation in their mortality results than herds that had a higher average mortality rate. This shows that herds with a lower piglet mortality average do not have more stable production results than herds with higher mortality averages, which otherwise could have been assumed.

The comparisons of mortality groups also showed that the piglet mortality rate was influenced by the mean litter size. The higher litter size, the higher mortality rate, which is supported by several previous studies (Grandinson et al., 2002; Pedersen et al., 2010; Vanderhaege et al., 2010a). The satellites in the lower mortality class had smaller litter sizes and fewer liveborn piglets, but somewhat higher stillborn rates. If liveborn piglets are recorded as stillborn, either because they are dead the first time the stockperson found them or because they are prognosis to not being able to survive, the liveborn mortality will appear to be lower than in reality (Pedersen et al., 2010). The stillborn rate in the top herds were only 0.13 higher than in the bottom herds, but it could still be an indication of how stillborn piglets are recorded. As previously mentioned however, there were no major differences in recording of stillborn piglets between the herds. Only one herd claimed to record weak and tiny, but alive, piglets as stillborn, and they were not included in the top or bottom herds. Instead, the top herds had more criteria they looked at to decide whether the piglet was stillborn or not. This could be interpreted as the produces wanting stillborn piglets to fulfill several criteria in order to be registered as stillborn or them being more likely to register as stillborn due to registering piglets from several different criteria only. Some piglets may also have died due to an elongated birth or farrowing issues, which could, or could not, have been prevented by good farrowing supervision (Pedersen et al., 2010; Baxter et al., 2012).

Influence of management routines on piglet mortality

During the interviews it became evident that the management routines in the herds were very similar, but also in many cases very different from each other. For example, all herds claimed to crossfoster piglets, but when asked why and how, the routines differed between herds. This could influence the results and it was evident that the questions following up how the management routines were conducted were very important. In the interview results it was also clear that the small number of satellite herds studied could become an issue. For many questions, the frequency behind each answer was so low that it would not be possible to make further investigate the impact of the specific management routine. Instead of investigating the actual management routine, it could easily become a comparison between satellites instead. To avoid this problem, many questions were not further investigated due to uneven answer distribution, and some of the answers were instead categorized to even out the distribution and enable investigation on impact on the piglet mortality rate. This is also part of the reason why the interview so comprised, as a way to make sure that some of the questions could be used for further investigation, even if the majority of questions should be proved to be useless for further investigation in this area. It should also be noted that only a few satellites had written instructions for the routines practiced in the herd, and since the interview did not always include all staff members, the actual management routines may differ somewhat to the results in the interview.

Tendencies of an increased piglet mortality rate could be related to recent production changes. Herds that had not changed the production (rate or otherwise changed production) recently seemed to have a lower mortality rate than herds that had changed the production within the last few years. Also, the most common underlying cause of piglet mortality was claimed to be sow related, as old, clumsy sows being more likely to crush piglets or have bad lactation which is supported by Pedersen et al. (2010) and Vaenderhaege et al (2010a). The staff working in both loose housing systems and crated systems had different opinions on the differences in the mortality rates, and the influence of crating sows during the first period of the lactation had. While some of the staff thought that the mortality rates were not affected by crating (which is supported by KilBride e al., 2012), some of the staff members thought that it had a positive impact on the mortality rate, since there were less crushing (supported by (Glastonbury, 1976). There were however suggested that there were more problematic farrowings in the crated systems, which was suggested to be due to the fact that the sows could not move. This was most commonly sorted out if the sow could have some exercise. Fact is that the one satellite in the study with only pens with possibilities to crate, which were used for the first days after farrowing, was included in the “low mortality group”, even though this could not be said to be or not be due to the pen construction in the farrowing unit.

Three of the satellite herds were managed by the same staff, and some herds had several farrowing units, bur were treated as different herds in the study due to different pen constructions in the units. They had different mortality rate results between these units even though they supposedly had the same management routines, suggesting that the stable and pen construction had an impact on the mortality rates. Andersen et al. (2007) however could not find a significant effect of the creep area construction on the piglet mortality, which is in line with the findings in this study. The review by Pedersen et al. (2010) did however suggest that improvement of the creep area could improve the piglet mortality rates. The main thing, other than pen construction that differed between these satellites in the management routines was the time spent in the farrowing stable, and the presence of growing pigs in the satellite or not. The time spent in the farrowing stable did turn out to have a significant effect on the mortality rates. The presence of growers in the satellite could not be found be found to have an effect on the mortality rates however.

Differences in the mortality rates between different management routines with acceptable answer distribution were statistically analyses. Some of the differences in piglet mortality rates could be associated to the feeding routines of sows. Herds that did not change the feeding routines the days before farrowing had a lower mortality rate than herds that changed the feeding routines by decreasing or even removing the feed the day of /days before farrowing. Many of the herds thought that feed refusal in the sows were quite common in the production. To prevent that poor feed intake should have a negative impact on the lactation and health status of the sow, the staff was asked when action was taken against feed refusing sows (See Table 28). Herds that took both bad appetite and no interest in feed at all into consideration had considerably lower piglet mortality rate than herds that took only one factor into consideration. This could be due to these management routines making it easier to find sows that are really ill, instead of disturbing healthy sows or missing unhealthy sows simply because they do not fit the "description". Several studies (Andersen et al., 2007; Pedersen et al., 2010; Vaenderhaege et al., 2010) have pointed out the importance of how and what to feed sows, but none of the studies in this literature review has studied how the feeding routines before the farrowing or how to manage feed refusing sows. This further points out the importance of further investigation of sow feeding routines through research.

The amount of time spent in the farrowing stable during the farrowing week did not seem to have such an impact as during the lactation week, even though several studies has suggested increased farrowing supervision, and supervision during the first days after farrowing to be an important tool in reducing piglet mortality (Pedersen et al., 2010). Friendship et al. (1986) could not identify an impact of the amount of time spent in the farrowing stable on the piglet mortality rates. In this study, there was a significant effect on time spent in the farrowing stable during the lactation period (except for the farrowing week). The reason why Friendship et al. (1986) could not find significant results could however be due to not relating the time spent in relation to the number of sows in the stable. Farms that spent less than 3.5 minutes per sow during the lactation period (except for the farrowing week) had a significantly lower mortality rate than those who spent 3.5-6.5 minutes per sow (See Table 29). There were however no significant differences in mortality rates between herds that spent more than 6.5 minutes per sow. Farmers that spent less time per sow had tendencies to have higher mortality rate, is not very hard to understand. If the time spent is low, it could mean that there is no time for other than the basic routines. For example, less time is available to recognize low producing sows or piglets that are falling behind in development. One could think that more time spent per sow would be better, but the results indicate otherwise since there were no clear statistical differences between the different categories. This could have to do with how the farmers use the time spent in the stable. The fact that these satellite herds that spent the most time in the stable had a high mortality could mean that they are spending their time doing the wrong things. For example several herds spent a lot of time trying to get the piglets to lie under the heating lamps, but the piglets tended to lie in other places in the pen anyway. This could be an example of time consuming activities which have a low or moderate impact on the mortality results. Another cause for high time consumption per sow without affecting the mortality rates significantly could be poor environment or old stables, such as draught or poor pen construction etc. This may reduce the impact that the extra management efforts have on the mortality rates. The herds that spent the most time in the stables all claimed that the piglet mortality rates were an issue, but so did 8 of the environments investigated. Only one herd (the herd with crating possibilities) claimed that the piglet mortality rates were not an issue. There were no other indicators that the herds that spent the largest amount of time in the stables had other issues within the production that would cause them to need spending that amount of extra time. This implies how important how important it is to do the *right* things when working in the stables, rather than how much time you spend there.

The number of light hours seemed to have an impact on the mortality rate, and the more light hours during the lactation period (except for the farrowing week), the lower the piglet mortality seemed to be, see Table 30. This has also been suggested by several other studies and could be due to piglets being less active during dark hours, and also less observant of the sows lying behavior (O'Reilly et al., 2006; Johnson et al., 2009). The number of light hours has also been suggested to affect the immune status of the piglet, but whether it has a good or bad influence discussed. Much light seemed to have a good impact on the maturation of the phagocytic cells but a negative effect on the novel antigens (Lessard et al., 2012).

Some piglets are put to death by the herdsmen, mainly due to abnormality or weaknesses that would severely decrease the piglets ability to survive in the litter (see Table 31). Herds that took away all weak and non vital piglets had a slightly higher mortality rate than herds removing only dysmorphic piglets and keeping weak piglets. To remove these piglets could be thought to decrease the competition between the remaining piglets, instead of having to compete with piglets that are not likely to make it until weaning. Removing weak piglets could also mean to take away piglets that have the possibility become large, vital pigs at weaning, and thus increase the pre weaning mortality unnecessarily. Removing dysmorphic piglets and its impact does naturally depend on how the abnormality appears, so removing piglets with minor abnormalities which would not interfere with the growth rate the mortality rate could of course be negatively influenced.

Good farrowing supervision has been claimed to be a way to decrease the piglet mortality (Pedersen et al., 2010). Pedersen (2010) claimed that 50% of the piglet mortality is due to stillborn piglets, which may have died during the farrowing, due to long inter pig interval and prolonged farrowings etc. (Spicer et al., 1986; KilBride et al., 2012). To decide when a farrowing is finished, and thereby decrease the supervision of her, could therefore be considered a part of farrowing supervision. Herds that only checked for secundines, or the appearance of a big litter to see if the sow has finished her farrowing, had a higher mortality rate than herds taking the sow behavior, as standing up, eating and being alert, in to account, see Table 32. By taking behavior into account except for only secundines will also help the staff members to find any health issues in the sow, such as MMA that will decrease the ability to rear piglets. Sick sows are also more susceptible to stress, which both increase the risk of stillborn, and are more likely to crush the piglets (Pedersen et al., 2010).

During the stable visits, extra attention was taken to the creep areas which have been suggested to have an impact on the piglet mortality rate, as studies have suggested the micro climate having impact on the piglet mortality (O'Reilly et al., 2006; Pedersen et al., 2010). The temperature in the creep area bedding was measured along with the surface temperature in the pen and ambient temperature in the stable. Also the amount of straw in the creep area was noted, and notes were taken if piglets seemed to prefer to lie in other places than the creep area. Several herdsmen found it to be a problem that piglets chose to lie in other places, such as close to the sow, than in the creep area and spent much time on placing piglets in the creep area as a routine. The problem seemed to be more common when the creep area was not heated with a lamp. The climate in the creep area did not vary much between herds, and all herds used sufficient amount of straw and provided with a clean creep area. Most herds did also lock in piglets in the creep area the days around farrowing to make sure that they knew where to lie. Herds that had many piglets lying outside the creep area (at the stable visit) had no different routines or creep areas that could be identified compared to those herds were most piglets lie in the creep area. This is supported by Andersen et al. (2007) who could not find any significant impact of the quality nor the amount of straw used in the creep area.

Conclusions

Piglet mortality is not only dependent on animal material, but also highly dependent on management routines and housing. No particular management routine or housing systems could in this study be directly connected to high or low mortality rates but some routines are associated with lower mortality rates. Keeping many light hours during the lactation period is beneficial for low piglet mortality rates, as are routines where the feed ratio is unchanged around the time for farrowing. A routine for identifying sows refusing to feed and detecting the end of a farrowing has also been connected to low mortality rates. The piglet mortality is also dependent on season, parity number and number or liveborn piglets in the litter, where the older sows, summer months (mainly May, June and July) and large litter sizes are more subjected to piglet mortality. Further investigation of especially the management factors identified and associated with low mortality rates is needed to establish low mortality rate-routines in the future.

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APPENDIX I
INTERVIEW – PIGLET MORTALITY

Herd: ………………………………………………………………………………………...
Interviewed:………………………………………………………..Employed:□Owner□
Education...
Type of production:………………………………….
Number of produced pig per year: Piglets:……….Slaughtering pigs:…………………..
Veterinarian:………………………………..Date of herd visit:…………………………
Last completed batch:…………..
Number of farrowing units:..Do the farrowing units have the same design?...
For how long has the herd been a part of the sow pool?.........................
For how long has the herd had todays production?.........................

Answers according to the Yes(1)/No(2)-principle, categories, or a scale 1-5 where 5 is good/high and 1 is Bad/Low.

BASIC		Categories	Range	Median	
1	No. Of groups/year		**4.33-26**	**6.5**	
2	No. of sows/group		**28-50**	**40**	
3	When was the unit built?	**year**	**1992-2010**	**2003**	
4	Pen-type	**Steeptrough, lamp in creep area (1)** **Short trough, sectioned creep area (2)** **Short trough, lamp in creep area(3)** **Steep trough, roof and lamp in creep area(4)** **Fixed (5)** **Steep trough, roof on creep area(6)**	**1-6**	**4**	
5	Where are the sows held between arrival and moving to the farrowing unit?	**Deep straw bedding (1)** **"Slaughtering pig pens" (2)**	**1-2**	**1**	
6	How many days before farrowing are the sows moved in to the farrowing unit?	**days**	**0-5**	**3**	
7	Which weekday does the farrowings start?	**Monday(1) Tuesday(2) Wednesday(3) Thursday(4)** **Friday(5) Saturday(6) Sunday(7)**	**1-6**	**4**	
8A **8B**	Weaning age? Weaningweekday?	**Days** **Monday(1) Tuesday(2) Wednesday(3) Thursday(4)** **Friday(5) Saturday(6) Sunday(7)**	**30-35** **5**	**35** **5**	
9	Is there acess to extra pens for sick sows?	**Yes (1)** **No(2)**	**1-2**	**2**	
10	How does your production serve today?	**1 2 3 4 5**	**3-4**	**3.5**	
11	Is the pig production profitable?	**1 2 3 4 5**	**2-4**	**3**	

12	How is the piglet growth rate?	**1 2 3 4 5**	**3-5**	**3**	
13	Are thenumber of born piglets satisfying?	**1 2 3 4 5**	**4-5**	**4**	
14	Are the number of weaned piglets satisfying?	**1 2 3 4 5**	**3-4**	**3**	
15	Is the piglet mortality an issue in your herd?	**Yes (1)** **No(2) Maybe(3)**	**1-3**	**1**	
16	When do you lose most of your piglets?	**At farrowing (1)** **The first days (2)** **The first week (3)**	**2-3**	**2**	
17	Which is the most common death cause	**Stillborn (1)** **Starvation/Not had colostrum (2)** **Weakborn(3)** **Crushed (4)** **Illness (5)** **Dysmorphic (6)** **Other(7)**	**2-7**	**4**	
18	What is the most common underlying cause of the piglet mortality?	**Littersize (1)** **Milkproduction (2)** **Sow-related (3)** **Piglet-related (4)** **Temperature in the stable (5)**	**1-5**	**1+2**	
19	Do you do anything to prevent the piglet mortality?	**Yes (1)** **No(2)**	**1**	**1**	
20	What?	The pen construction (1) Usage of Creep area (2) Milk supplementation (3) Tooth-grinding (4) Management (5)	**1-5**	**2+5**	
21	How is the piglet mortality registred?	Individual registration (1) Cause (2) Time(3) Only number of born and weaned(4) Only number of born and weaned, but have other info(5)	**2-5**	**4**	
22	What counceling are you using?	Veterinarian(1) Counceling(2) Other satellites(3) No(4)	**1-3**	**2**	
23	Does it work well with the veterinarian?	**1 2 3 4 5**	**2-5**	**4**	
24	Do you change shoes/clothes between units?	**Shoes (1)** **Clothes(2)** **Stalosan trough / wash shoes(3)** **Between slaughtering/farrowing units (4)** **No (5)**	**1-5**	**5**	
25	Are hands washed before entering/changing unit?	**Yes(1)** **No(2)**	**1-2**	**2**	

DURING YOUR LAST WEANED BATCH: (when was it__________)

STABLE		**Categories**	**Range**	**Median**
1	At farrowing; too	**1 2 3 4 5**	**3-4**	**3**

	hot/cold			
2	At farrowing:too dry/moist?	**1 2 3 4 5**	**1-3**	**1**
3	At farrowing: air quality?	**1 2 3 4 5**	**1-5**	**5**
4	At weaning: too hot/cold	**1 2 3 4 5**	**1-3**	**2**
5	At weaning: too dry /moist?	**1 2 3 4 5**	**3-4**	**3**
6	At weaning: Air quality?	**1 2 3 4 5**	**1-4**	**3**
7	Draught in the stable?	**1 2 3 4 5**	**2-5**	**4**
8	How is the sound level in the stable	**1 2 3 4 5**	**2-5**	**3**
9	What type of ventilation system do you have?	**Balanced(1)** **Underpressure(2)** **Draught(3)**	**1-3**	**2**
10	Is the ventilation system working properly?	**1 2 3 4 5**	**1-5**	**3.25**
11	Did you wash the stable before inserting the new batch?	**Yes(1)** **No(2)**	**1**	**1**
12	Was the stable desinfected?	**Yes(1)** **No(2)**	**1-2**	**1**
13	With what compound?	**Greppo (1)** **Virkon(2)** **Envirolyte(3)** **P73(4)**	**1-4**	**2**
14	Was the walls washed?	**Yes(1)** **No(2)**	**1**	**1**
15	Was the floors washed??	**Yes(1)** **No(2)**	**1**	**1**
16	Was the interior separetly washed?	**Yes(1)** **No(2)**	**1-2**	**1**
17	Was the ceilings washed?	**Yes(1)** **No(2)**	**1-2**	**2**
18	How many empty days were there in the stable?	Days	**1-16**	**7**

FEED		**Categories**	**Range**	**Mean**
1	What kind of sow feed do you have?	**Diva(1)** **Stina(2)** **Gårdsspec(3)** **2527(4)** **Milla di(5)** **Milla enh(6)** **Rakel (7)** **Kompakt(8)**	**1-8**	5
2	Do you change feed between dry/lactation period?	**Yes(1)** **No(2)**	**1-2**	2
3	If yes, when?	**When moved to farrowing unit (1)**	**1**	**1**
4	How often are the sows	**2-3 times a day (1)**	**1-5**	**3**

	fed (per day)?	**3 times a day(2)** **4 times a day (3)** **1-5 times a day (4)** **2-4 times a day (5)**		
5	Arethe sows fed wet or dry feed?	**Wet (1)** **Dry (2)**	**1**	**1**
6	Baseratio?	**MJ**	**18-150**	**32**
7	Maxiumratio?	**MJ** **if 1 then no specific maximum rate**	**1-146.3**	**12**
8	How many days befor reaching maximum ratio?	**Days** **0 days= increase the ratio the whole lactation period**	**0-14**	**7**
9	What feed routines do you have the days before farrowing?	Decrease ratio (1) Take away feed (2) Other (3) no changes (4)	**1-4**	**1**
10	How common is it with sows that refuse to eat?	**1 2 3 4 5**	**1-5**	**3**
11	Hw is feed refusal diagnosed	**Not interested at all (1)** **Bad appetite(2)**	**1-2**	**1**
12	How do you handle sows that refuse to eat?	**Offer other feed(1)** **Lower ratio/takes away feed all together(2)** **Medicine(3)**	**1-3**	**1+2**
13	Do you have written routines for this?	**Yes(1)** **No(2)**	**1-2**	**2**
14	What feed are you giving to the piglets?	**Kvarnby (1)** **Solo(2)** **Tryggve (3)** **Own (4)** **Tempo (5)**	**1-5**	**3**
15	How old are the piglets when you start to feed them?	**Days**	**0-10**	**7**
16	How many kg feed are consumed per litter and lactation period?	**KG**	**3.5-28**	**10**
17	How are the piglets fed?	**On the ground (2)** **“raised from the ground”(3)**	**2-3**	**2**

SUPERVISION		**Categories**	**Range**	**Median**
1	How many persons work in the stable during farrowing?	**Number of persons**	**1-2**	**2**
2	Do you have certain demands on education/experience in your staff?	**Yes(1)** **No(2)**	**1-2**	**2**
3	Is it always the same persons that work in the stable during farrowing?	**Yes(1)** **No(2)**	**1-2**	**1**
4	Does anyone have the main responsibility?	**Yes(1)** **No(2)**	**1-2**	**1**
5	Is it the same person that has the main responsibility in all	**Yes(1)** **No(2)**	**1-2**	**1**

	farrowing units?			
6	Do you have other staff in the weekends?	**Yes(1)** **No(2)**	**1-2**	**2**
7	Between what hours doo you work with the pigs?		**-**	
8	Do the pigs have extra supervision during the farrowing week?	**Evenings(1)** **Mornings(2)**	**1-2**	**1**
9	Approximately, how much time is spent in the farrowing stable during the farrowing week?	**hours**	**4-9**	**5.5**
10	Approximatley, how much time is spent in the farrowing stable during the rest of the lactation period?	**hours**	**2-5**	**3.5**
11	Is it common with extended farrowings?	**1 2 3 4 5**	**1-3**	**2**
12	What is classified as extended farowings?	Dry, small number of piglets (1) Long inter pig interval (2) Total farrowing time (3)	1-3	**3**
13	What is the main cause of the extended farrowings?	**Bad condition of the sow (1)** **Old2)** **Bad pushing of the sow (3)** **Big piglets(4)** **Fixated sow(5)**	**3-5**	**1+2+4**
14	How is extended farrowings handeled?	**Exercise (1)** **Palpate sow (2)** **Oxytocine (3)** **Check for fever (4)**	**1-5**	**2+3**
15	Do you have written routines how to manage extended farrowings?	**Yes(1)** **No(2)**	**1-2**	**2**
16	How do you handle a situation when a sow does not come in to labor, and passes the expected farrowing date.(if the sow does not appear to be sick)	**Oxytocine(1)** **Wait(2)**	**2**	**2**

SOWS		**Categories**	**Range**	**Median**
1	Are there routines for checking the body fat of the sows?	**Yes(1)** **No(2)**	**1**	**1**
2	When are they checked?	**When moved into the farrowing stable (1)** **After farrowing (2)**	**1-2**	**1**
3	What were the overall status of the sows att farrowing?	Body fat **1 2 3 4 5** overall health status **1 2 3 4 5** did it affect the milk production? **1 2 3 4 5**	**1-5** **2-5** **1-4**	**3.5** **4** **2**
4	What were the overall status of the sows at weaning?	Body fat **1 2 3 4 5** overall health status **1 2 3 4 5**	**2-4** **2-5**	**3** **4**

		did it affect the milk production? **1 2 3 4 5**	**2-4**	**2**
5	How do you handle litters that are larger than the amount of milk producing teats?	Crossfostering (1) nursingsows(2) split suckling (3) Milksupplementation(4) Electrolytes (5)	**1-5**	**6.5?**
6	Are there written routines for how to handle this?	**Yes(1)** **No(2)**	**1-2**	**1**
7	Do you crossfoster?	**Yes(1)** **No(2)**	**1**	**1**
8	When?	**0-5h (1)** **0-24h (2)** **0-48h (3)** **-3 days(4)** **over three days old (5)** **During the whole lactation period (6)**	**1-6**	**4**
9	Whichlittersare crossfostered?	**To even out the litters (1)** **Depending on the amount of teats (2)** **Depending on the sow body condition and history (3)** **All (4)**	**1-4**	**4**
10	Whichpigletsaremoved?	**Large (1)** **Small(2)** **Gilts(3)** **Boars(4)** **To even out sizes (5)** **All (6)**	**1-6**	**3**
11	To whom do you move the piglets?	**Gilts(1)** **Small litters (2)** **Where there are enough teats(3)** **Sorting litter size (4)** **Good milk production (5)**	**1-5**	**3**
12	Do you use nursing sows?	**Yes(1)** **No(2)**	**1-2**	**2**
13	When do you use nursing sows?	-		**2**
14	How is the nursing sows introduced in to the new group?	-		**1**
15	How do you handle bad lactation?	**Oxcytocin (1)** **Stimulate udder (2)** **Water drinking/ salt balance(3)** **Check if sick, treatment(4)**	**1-4**	**1+3**
16	Did you have any unwanted behavior in your sows?	**No(1)** **Mean (2)**	**1-2**	**1**
17	Did you observe nesting before farrowing?	**1 2 3 4 5**	**3-5**	**5**
18	What type of straw is used?	**short straw (1)** **Peat (2)** **wood shavings (3)** **Stalosan (4)**	**1-4**	**1+2**
19	Approximately how much straw is given per sow /day?	**KG**		

20	Do you straw any different at the time around farrowing?	**Yes(1)** **No(2)**	**1**	**1**
21	How?	**Peat(1)** **Extra(2)**	**1-2**	**2**
22	Is it common with agressions between sows in the pens next to eachother?	**1 2 3 4 5**	**1-3**	**1**
23	How many hours per day are the lights on in the farrowing unit, during the farrowing week?	**hours**	**12-24**	**24**
24	How many hours per day are the lights on in the farrowing unit, duiring the rest of the lactation period?	**hours**	**4-15**	**9**
25	Are there fm-radio in the stable/headphones?	**Headphones (1)** **In the unit (2)** **No(3)**	**1-3**	**1**
26	How often do a sow die during the lactation period? Per year	**Per year**	**0.25-26**	**3**

Piglets		**Categories**	**Range**	**median**
1	How is the creep area constructed?	**Lamp (1)** **Roof (2)** **floor heating (3)** **three walls (4)** **separated lying area/feeding area(5)**	**1-5**	**2+3**
2	What kind of straw is used in the creep area?	**Short straw (1)** **Peat (2)** **Wood shavings (3)**	**1-3**	**1**
3	Do you try to increase the usage of the creep area by any means?	**Yes(1)** **No(2)**	1	**1**
4	What?	**Lock in piglets in the creep area (1)** **Look at the lying behavior (2)** **Straw usage (3)** **Lower the temperature in the unit (4)**	1-4	**1**
5	Is there any written routines of how to do this?	**Yes(1)** **No(2)**	**1-2**	**1**
6	How is iron supplementation given?	**Orally (pulver)(1)** **injection (2)** **Pite (3)** **Orally (paste)(4)**	**1-4**	**2+3**

Piglets		**Categories**	**Range**	**Median**
7	When do you give milk supplementation?	**Thin piglets (1)** **Bad milk production (2)** **Large litters (3)** **Dead sow (4)** **Do not use milk supplementation (5)**	**2-4**	**5**

8	How often do you havet o give milk supplementation?	**1 2 3 4 5**	**1-5**	**2**
9	Do you have any written routines for when to give milk supplementation?	**Yes(1)** **No(2)**	**1-2**	**2**
10	How often do you give milk supplementation per day?	**Times/day**	**2-3**	**2**
11	How much milk supplementation do you give per feeding?	**Liters** **If 0- then as long as they are eating**	**0-2**	**1**
12	How is the milk supplementation fed/served?	**Automat (1)** **Bowl (2)**	**1-2**	**2**
13	Which piglets are put to death?	**Weak(1)** **Dysmorpic (2)** **Non vital (3)**	**1-3**	**1+2**
14	Hur avlivas de?	**Floor (1)**	**1**	**1**

AT FARROWING		**Categories**	**Range**	**Median**
1	How do you know that the farrowing has started?	**Behaviour(1)** **Milk(2)** **Expected date (3)**	**1-3**	**1+2**
2	How do ypu know that the farrrowing is finished?	**Secundines (1)** **Big litter (2)** **Behaviour (3)**	**1-3**	**1+2**
3	Howwere the litters?	Small/large litters **1 2 3 4 5** small/large piglets **1 2 3 4 5** many /few stillborn **1 2 3 4 5** many/few weakborn **1 2 3 4 5** Many became weak **1 2 3 4 5**	 **2-5** **2-5** **2-5** **3-4** **2.5-4**	 **4** **4** **3** **3** **3.25**
4	Were there any specific injuries or illnesses in the piglets?	**Yes(1)** **No(2)**	**1-2**	**2**
5	What?	**Diahorrea (1)** **Stepped on(2)** **"fläkt" (3)** **Black foetus (4)**	**1-4**	**2**
6	Did all piglet get milk within hours after birth?	**1 2 3 4 5**	**3-5**	**4.5**
7	How do you make sure that all piglets have had milk?	Seen it (1) Help piglets (2) Split suckling (3) Looks of the piglet (4) Milk in the udder (5)	**1-5**	**1+3**
8	How are stillborn piglets separated from piglets that have died short after birth?	Check if dry/wet (1) Tongue(2) Position of the piglet (3) Hoof apperance (4) Also small piglets are recorded as dead (5)	**1-5**	**5**
9	Do you grind teeth?	**Yes(1)**	**1-2**	**2**

		No(2)		

AT CASTRATION		Categories	Range	Median
1	At what day do you castrate?	day	2-4	3
2	Were there any complications at the procedure?	Hernia (1) chryptorchism (2) No(3)	1-3	3
3	What routines are practiced when castrating?	Anodyne(1) aneshesia (2) wagon(3) On free hand(4) desinfection (5) Punsch (6) scalpel (7)	1-7	1+3+5+7
4	Do you do other procedures along with the castration?	Iron supplementation (1) No(2)	1-2	1
5	Was there a even distrubution of meales /females in the litters?	1 2 3 4 5	1-5	3
6	Was there a even size distribution in the litters?	1 2 3 4 5	2-4	3.5
7	Had the piglets grown as expected?	1 2 3 4 5	3-4	3
8	Do the piglets get any other vaccinations /treatments?	Yes(1) No(2)	1-2	1
9	What?	PMWS/PCW(1)	1-2	1
10	How many piglets per litter were lost at the time of castration (mean value) ?	Amount	0.5-3	1.125

HEALTH

In the last weaned batch:

Sows:

1. MMA YES☐ NO☐ ____________________
2. MastitisYES☐NO☐ ____________________
3. Teat ulcers YES☐NO☐ ____________________
4. Bad milk production YES ☐ NO☐ ____________________
5. Arthritis/lame YES☐ NO☐ ____________________

6. Shoulder ulcerYES☐ NO☐____
7. Other Ulcers YES☐ NO☐____
8. OtherYES☐ NO☐____

Piglets:

1. Erysipelas YES☐ NO☐____
2. Diahorrea YES☐ NO☐____
3. Arthritis YES☐ NO☐____
4. Hoof inflamation YES☐ NO☐____
5. Crushed YES☐ NO☐____
6. ”Pellar” YES☐ NO☐____
7. Weak YES☐ NO☐____
8. Paralyzed YES☐ NO☐____
9. Dysmorpic YES☐ NO☐____
10. ”Skakgrisar” YES☐ NO☐____
11. ”Fläkgrisar” YES☐ NO☐____
12. ”Svartfoster” YES☐ NO☐____
13. Stillborn YES☐ NO☐____
14. Other YES☐ NO☐____

APPENDIX II

STABLE

Herd: ……………………………………………………………………………………...

Production type:…………………………………. No. Of produced pigs /year :…………

No. of sows that had farrowed :..

Mean Litter size:...................................

Date of the visit:…………………………First farrowings in this batch:......…........………...

Time of stable visit:…………………………Unit:……………………………………………..

Basic			**Comments**
1	No. of pens		
2	No. of sows		
3	Type of pens		
4	Long side	**m**	
5	Short side	**m**	
6	Litter type		
7	Amount of litter		
8	Type of creep area		
9	Long side	**m**	
10	Short side	**m**	
11	Diagonal	**m**	
12	Litter type		
13	Amount of litter		
14	Noise level		
15	Air quality		
16	Over all impression		

Biosecurity			**Comments**
1	Handbasin		
2	Foot bath		
3	Shoe change		
4	Walks between pens in pre determined order		
5	Change of clothes		
6	Change of tools		
7	Visitors list		
8	Each unit has its own tools		
9			
10			
11			
12			
13			
14	Over all impression		

Sows			**Comments**
1	No of sows that had farrowed		
2	No of sows in good body condition?		
3	No of sows in bad body condition? (thin)		
4	No of sows in bad body condition? (fat)		
5	No. of shoulder ulcers		
6	No.of teat ulcers?		
7	No. of gilts?		
8	Awareness of piglets?		
9	Long hoofs?		
10	Are the sows calm?		
11			
12			
13			
14	Over all impression		

PIGLETS			**Comments**
1	Size of piglets Good growth rate? Even in size?		
2	No of. ”pellar”?		
3	Are the piglets active?		
4	Ulcers in the face?		
5	Diahorrea?		
6	Limping?		
7	Climate in the creep area?		
8			
9			
10			
11			
12			
13			
14	Over all impression		

Staff			**Comments**
1	Stressed/calm		
2	Secure/unsecure		
3			
4			
5			
6	Over all impression		