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

Management factors influencing sow productivity in successful Swedish and Danish herds

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Examensarbete / Swedish University of Agricultural Sciences
Department of Animal Breeding and Genetics
400
Uppsala 2013

Master Thesis, 30 hp

Agriculture Programme
– Animal Science

Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science
Department of Animal Breeding and Genetics

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Managementfaktorer som påverkar suggans produktivitet i framgångsrika besättningar i Sverige och Danmark

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Credits: 30 hp
Course title: Degree project in Animal Science
Course code: EX0558
Programme: Agriculture Programme – Animal Science
Level: Advanced, A2E

Place of publication: Uppsala
Year of publication: 2013
Cover picture: Sophia Isberg
Name of series: Examensarbete / Swedish University of Agricultural Sciences, Department of Animal Breeding and Genetics, 400
On-line publicering: http://epsilon.slu.se

Key words: Pig, sow, productivity, weaned piglets, piglet, mortality, management, successful herds, Sweden, Denmark.

Stort tack till…

Stiftelsen Svensk Grisforskning för finansiering av mina resor till smågrisproducenterna i Sverige och Danmark.

Linda Engblom, Institutionen för husdjursgenetik på SLU, för att du varit en fantastisk handledare. Din öppenhet, vägledning och dina lugnande kommentarer har varit ovärderliga för mig under arbetets gång.

Barbro Mattsson, Svenska Pig, för att du varit en fantastisk biträdande handledare. Tack för all hjälp med att komma på idén till arbetet, för alla intressanta diskussioner och framför allt för all välbehövlig peppning inför (och under) den muntliga redovisningen.

Alla svenska och danska smågrisproducenter som tagit sig tid och deltagit engagerat och med stor glädje under mina besök under hösten. Ni har alla varit så otroligt gästvänliga och jag har lärt mig så mycket av Er. Tack också för att ni delat med er av er produktionsuppföljningsdata. Utan Er hade arbetet inte varit genomförbart och jag kan inte tacka Er nog!

Rikke Soegaard, Merial Norden, för att du ordnade de danska gårdarna åt mig och för att du ville följa med mig ut på danska gårdsbesök. Tack för en rolig och lärorik dag.

Louise Thott, Merial Norden, för att du ville följa med mig ut på de första danska gårdsbesöken och vara min tolk. Tack för en rolig och lärorik dag.

Gunnar Johansson, Svenska djurhälsovården, för hjälp med att kommunicera de danska kontakterna till mig.

Knut-Håkan Jeppsson, Institutionen för biosystem och teknik på SLU och Jan Olofsson, Institutionen för husdjurens utfodring och vård på SLU för att ni bistod mig med utrustning.

Per Wallgren, SVA och Institutionen för kliniska vetenskaper på SLU, för lånet av din IR-termometer.

Nils Lundeheim, Institutionen för husdjursgenetik på SLU, för att du varit min examinator och för alla värdefulla kommentarer.

Torun Wallgren för gott samarbete vid utformandet av intervjuformulären.

Alla ni som låtit mig bo hos er under mina resor runt om i landet. Ett särskilt stort tack riktas till Aino Cederström.

Daniel Kvist, mina vänner och min familj för att ni finns.

Sophia Isberg, Uppsala 2013-02-03

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1. ABSTRACT

The number of weaned piglets per sow and year is a good measurement of sow productivity since it is affected by the number of piglets born alive, the pre weaning mortality (*i.e.* mortality of live born piglets between birth and weaning) and the number of litters per sow and year. This measure is also closely connected to the number of piglets produced per year, which partly determines the profitability of the piglet producer. During this study, eleven successful piglet-producing herds were visited. Eight of the producers were Swedish and three of the producers were Danish. During the herd visits a qualitative interview, concerning general management and the most recent batch weaned, was performed with the producer. One farrowing batch per herd was also checked, where observations and measurements of different sow-, litter- and farrowing unit related parameters were recorded. Production data and key figures were also captured from herd-monitoring programs. Statistical analyses were performed to investigate which parameters had a significant impact on production results and in order to determine differences between Sweden and Denmark.

None of the investigated management factors had any significant impact on the number of piglets born alive or dead. The number of weaned piglets was significantly influenced by herd, the number of functional teats per sow, the rated udder health and the rated litter score (*i.e.* the rated litter appearance including size, homogeneity and vitality). The homogeneity of the litter was significantly influenced by the rated udder health of the sow. The rated litter score was significantly influenced by the body condition score of the sow and the rated udder health. Significant differences between the two countries were found for the total number of piglets born, the number of piglets born alive, the rated udder health, the body condition score, the rated leg health and the rated hoof health. The conclusions of the study are that the sow productivity can be affected through management, that the number of piglets born alive is largely affected by genetic material and that Swedish piglet producers have the opportunity to increase the number of weaned piglets per sow and year. This can be accomplished by improved piglet survival, decreasing the weaning to service interval and the number of non-productive days and increasing the farrowing rate. A system for nursing sows, applicable to Swedish herds, could improve the piglet survival. If Sweden imports genetic material from Denmark it can be expected that the number of live born piglets will increase, the pre weaning mortality may decrease, the number of weaned piglets per sow and year will increase, the weaning weights may decrease and the presence of shoulder lesions may decrease.

2. SAMMANFATTNING

Antalet avvanda per sugga och år är ett bra mått på suggans produktivitet eftersom det inkluderar antalet levande födda smågrisar, smågrisdödligheten (*i.e.* dödligheten bland levande födda smågrisar mellan födsel och avvänjning) och antalet kullar per sugga och år. Dessutom ligger detta mått nära antalet producerade smågrisar per år, vilket delvis avgör producentens lönsamhet. Under denna studie besöktes elva framgångsrika smågrisproducerande besättningar. Åtta av besättningarna var svenska och tre av besättningarna var danska. Under besöken utfördes en kvalitativ intervju med producenten som berörde generell management samt den senast avvanda omgången. Ett stallbesök i en grisningsomgång per besättning utfördes också, varpå observationer och mätningar av olika parametrar relaterade till suggan, smågrisarna och grisningsavdelningen registrerades. Produktionsdata och nyckeltal samlades också in via produktionsuppföljningsprogram. Statistiska analyser utfördes för att undersöka vilka parametrar som hade signifikant inverkan på olika produktionsparametrar samt för att analysera signifikanta skillnader mellan Sverige och Danmark.

Inga av de undersökta managementfaktorerna hade signifikant inverkan på antalet levande födda eller antalet dödfödda. Antalet avvanda smågrisar per kull påverkades signifikant av besättning, antalet funktionella spenar, den värderade juverhälsan och den värderade kullpoängen (*i.e.* kullens värderade helhetsintryck inklusive storlek, jämnhet och vitalitet). Kullens jämnhet påverkades signifikant av suggans värderade juverhälsa. Den värderade kullpoängen påverkades signifikant av suggans hullpoäng och värderade juverhälsa. Mellan de två länderna fanns det signifikanta skillnader i totala antalet födda smågrisar, antalet levande födda smågrisar, värderad juverhälsa, hullpoängen, värderad benhälsa och värderad klövhälsa. Studiens slutsatser är att suggans produktivitet kan påverkas av managementfaktorer, att antalet levande födda starkt påverkas av avel samt att det finns utrymme för svenska smågrisproducenter att öka antalet avvanda per sugga och år. Detta bör främst ske genom en minskad smågrisdödlighet, färre improduktiva dagar, färre galldagar och ökad grisningsprocent. Ett användbart system för användning av amsuggor, anpassat till svenska förhållanden, skulle kunna minska smågrisdödligheten. Om Sverige importerar danskt avelsmaterial kommer troligtvis antalet levande födda att öka, smågrisdödligheten att minska, antalet avvanda smågrisar per sugga och år att öka, avvänjningsvikten att minska samt förekomsten av bogsår minska.

3. INTRODUCTION

Profitability is essential in commercial piglet production (White et al., 1996). The number of produced piglets per sow and year, the retail price of the produced piglet and the cost of producing the piglet affect the profitability (Muregård, 2004; Alarik, 2012). The number of produced piglets per sow and year is closely connected to the number of weaned piglets per sow and year, since the main piglet mortality occurs during the nursing period (Tuchscherer et al., 2000; KilBride et al., 2012; Svenska Pig, 2012a; Vinther, 2012). The number of weaned piglets per sow and year is affected by the number of live born piglets per litter (Knox, 2005a; Gill, 2007), the pre weaning mortality (*i.e.* mortality of live born piglets between birth and weaning) (Bowman et al., 1996; White et al., 1996) and the number of litters per sow and year (Knox, 2005a; Gill, 2007).

Piglet producers in some countries (*i.e.* Denmark, the Netherlands and France) are approaching 30 weaned piglets per sow and year (Knox, 2005a; Gill, 2007; Ohlson, 2011). Swedish producers are not quite there (Svenska Pig, 2012a) while some Danish producers recently managed to reach this goal (Vinther, 2012). The 25 % most successful Danish piglet producers weaned on average 31.5 piglets per sow and year during 2011 (Nielsen & Nørgaard, 2012; Vinther, 2012) while the 25 % most successful Swedish piglet producers weaned on average 26 piglets per sow and year[1] (Svenska Pig, 2012a).

Danish piglet producers manage to wean more piglets per sow and year due to several causes. Primarily the number of piglets born alive was larger in Denmark (14.8) than in Sweden (13.1) during 2011 (Svenska Pig, 2012a; Vinther, 2012). The difference in live born piglets is partly due to genetics but may also indicate a more successful reproductive management. Secondarily, even though the pre weaning mortality is considered high in both Sweden and Denmark, the pre weaning mortality was lower in Denmark (13.9 %) than in Sweden (18.3 %) during 2011. Differences in animal welfare legislation may also affect production levels. The housing is largely influenced by animal welfare regulations, which differ between countries. Also management, *i.e.* lactation length, is influenced by animal welfare regulations. Both countries are bound to follow the council directives (98/58/EC; 2008/120/EC), since as well Sweden as Denmark are members of the European Union (EU), but Sweden have a stricter national animal welfare legislation (SJVFS 2010:15). The skill of the farm staff also has a major impact on the herd productivity.

The main objective of this study is to examine and survey the management of some of the most successful piglet producing herds in Sweden and Denmark. The second objective is to examine causes to why Danish piglet producers are more successful than Swedish producers, concerning the number of weaned piglets per sow and year. The third objective of this study is to examine whether there are differences between Swedish and Danish sows and if some observable factors have an impact on the number of weaned piglets per sow and litter. The goal of this study is to identify management factors that could be direct causes of the difference in production results and that could be used by Swedish piglet producers in order to improve them. To investigate the objectives mentioned above, analysis of production data in combination of herd visits, interviews with producers and examination of animals, in both Swedish and Danish piglet producing herds, will be performed. This task will be accomplished by sow data and production data collection and statistical analysis. The study will be performed in cooperation with the organization Svenska Pig.

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[1] 11.5 weaned piglets/litter * 2.26 litters/sow and year = 25.99 weaned piglets/sow and year

4. HYPOTHESES

The hypotheses of this study are that:

1) There are management factors that can affect the number of weaned piglets per sow and year.
2) There are differences in reproductive management between Sweden and Denmark that cause differences in the number of piglets born alive and the number of litters per sow and year.
3) There are management differences between Sweden and Denmark that cause differences in pre weaning mortality.
4) Legislation differences between the countries cause difference in the number of litters per sow and year due to different lactation lengths.
5) Legislation differences between the countries cause difference in total pre weaning mortality due to management of nursing sows.
6) Legislation differences between the countries do not cause difference in total pre weaning mortality due to different housing systems.
7) There are genetic differences between the sows in successful Swedish and Danish herds causing differences in the number of weaned piglets per litter.
8) Swedish piglet producers have the potential to increase the number of piglets born alive, decrease piglet mortality and increase the number of litters per sow and year by improving management.

5. LITERATURE STUDY

5.1 Pig production in Sweden and Denmark

Swedish and Danish agriculture have undergone the same development as in most industrialized countries. The trend has gone from many diversified farms with little arable land and few animals into fewer specialized farms with large quantities of arable land and animals (Boland et al., 1998; Danish Agriculture & Food Council, 2012). However, there are significant differences between the Swedish and Danish pig production since Denmark is one of the most significant pig producers in Europe (Danish Agriculture & Food Council, 2012). Despite the fact that Sweden by area is more than ten times as large as Denmark, Denmark has around 8.5 times as many pigs as Sweden has (Danish Agriculture & Food Council, 2012; Danmarks statistiks opgørelse af svinebestanden, 2012; Yearbook of agricultural statistics, 2012). There were around 1.5 million pigs present in Sweden during 2011 (Yearbook of agricultural statistics, 2012) while there were around 12.7 million pigs present in Denmark during the same year (Danish Agriculture & Food Council, 2012; Danmarks statistiks opgørelse, 2012). Danish herds also keep more animals than Swedish herds do on average (Danish Agriculture & Food Council, 2012; Svenska Pig, 2012a; Vinther, 2012; Yearbook of agricultural statistics, 2012). The difference in number of animals per herd supports that Danish piglet production is more extensive than Swedish production. The production goal is however basically the same in both countries *i.e.* to produce pork of high quality to a reasonable cost and that the consumers are willing to pay for (Christiansen, 2010). In contrast to Sweden, Denmark though has a clear objective to export large quantities of pork. Pork meat accounts for around 50 % of the Danish agricultural export and for around 5 % of the total Danish export (Christiansen, 2010).

5.2 Factors affecting the number of weaned piglets per sow and year

When evaluating the productivity of piglet producing herds, the number of weaned piglets per sow and year is a suitable indicator to use (Bowman et al., 1996; Åkerblom, 2011). The number of weaned piglets per sow and year is closely connected to the number of produced piglets per sow and year, which is the indicator that determines the direct profit. Thus, the number of weaned piglets per sow and year is of economic importance to piglet producers (Aumaitre et al., 1976; van Arendonk et al., 1996). However, it also takes several other parameters, related to piglet production, into account such as sow fertility, sow long-term productive value (van Arendonk et al., 1996; Vanderhaeghe et al., 2010) and piglet mortality (Bowman et al., 1996; van Arendonk et al., 1996). The number of weaned piglets per sow and year is affected by the number of live born piglets per litter (Knox, 2005a; Gill, 2007), the pre weaning mortality (Bowman et al., 1996; White et al., 1996; Knox, 2005a; Gill 2007) and the number of litters per sow and year (Knox, 2005a; Gill, 2007).

Knox (2005a) and Gill (2007) used simulation models to set minimal levels for different production parameters in order to reach 30 piglets weaned per sow and year. Gill (2007) stated that: "The average number of pigs weaned per sow and year (PSY) in a herd is a function of empty days (E), number of piglets born alive per litter (N), % pre-weaning mortality (M), lactation length in days (L), the weaning to conception at first oestrus interval in days (W) and the constant (K_1) gestation length in days where: $PSY=(((365-E)/(L+W+K_1))* N)*((100-M)/100)$". Since the number of days in gestation (K_1) is a constant (Gill, 2007) and legislations regulate the lactation length (L) (98/58/EC; 2008/120/EC; SJVFS 2010:15), it is predominantly the number of empty days (E), the weaning to service interval (W), the number of piglets born per litter (N) and the pre weaning mortality (M), that are possible factors to affect through management. The weaning to service interval is individual and varies between as well herds as between animals, even though it is important to keep the interval as short as possible by, for example, correct feeding in order to decrease the risk of excessive weight loss during lactation. Thus, the number of empty days, the number of piglets born alive and the pre weaning mortality are the most important factors to focus on concerning management (Gill, 2007). The outcome of the simulation models was that: If a producer endeavors to produce 30 piglets per sow and year, the number of empty days must be ≤30 days, the farrowing rate must be >90 %, the number of piglets born alive must be ≥14 and the pre weaning mortality must be ≤8 % (Knox, 2005a; Gill, 2007). However, it is noteworthy that these simulation models are based on a nursing period of 21 days, which is not applicable to Swedish conditions, since the shortest lactation length allowed is 28 days (SJVFS 2010:15).

Key performance indicators for Swedish and Danish piglet production are shown in Table 1. The 25 % most successful producers in Denmark have recently managed to exceed 30 weaned piglets per sow and year (Vinther, 2012, see Table 1), while no known Swedish producer has managed to achieve this yet (Svenska Pig, 2012b). The Swedish average number of live born piglets was 13.1 per litter and 13.5 per litter for the 25 % most successful herds during 2011 (Svenska Pig, 2012a, see Table 1). The Danish average number of live born piglets was 14.8 per litter and 15.5 per litter for the 25 % most successful herds during 2011 (Vinther, 2012, see Table 1). Knox (2005a) and Gill (2007) recommended at least 14 live born piglets in order to achieve 30 weaned piglets per sow and year. Both the 25 % most successful and the average Danish herds manage to exceed recommended rates (see Table 1). However, neither the 25 % most successful nor the average Swedish herds manage to achieve this (see Table 1). The high number of live born piglets is probably the main cause to why Danish producers have managed to exceed 30 weaned piglets per sow and year (Gill, 2007).

In Sweden on average 1.1 piglets per litter were stillborn during 2011 (Svenska Pig, 2012a, see Table 1), whereas in Denmark on average 1.8 piglets per litter were stillborn (Vinther, 2012, see Table 1). In the 25 % most successful Swedish herds there was on average 1.01 stillborn piglets per litter (Svenska Pig, 2012a, see Table 1), whereas in the 25 % most successful Danish herds there was on average 1.8 stillborn piglets per litter (Vinther, 2012, see Table 2). The number of stillborn piglets is thus lower in Sweden than in Denmark, which is probably due to the larger litter sizes in Denmark. Increased litter sizes have frequently been reported to increase the number of stillborn piglets (Hanenberg et al., 2001; Canario et al., 2006; Oliviero et al., 2010; KilBride et al., 2012).

The average Swedish pre weaning mortality (*i.e.* mortality of live born piglets between birth and weaning) was for all herds 18.3 % and 14.9 % for the 25 % most successful herds during 2011 (Svenska Pig, 2012a, see Table 1). The corresponding Danish average pre weaning mortality was 13.9 % and 12.2 % for the 25 % most successful herds during 2011 (Vinther, 2012, see Table 1). The Swedish piglet mortality has increased by 0.9 % since 2010 whereas the Danish piglet mortality has decreased 0.3 % since 2010. Knox (2005a) and Gill (2007) recommended that the pre weaning mortality should be equal to or below 8-10 % in order to achieve 30 weaned piglets per sow and year. None of the four groups (*i.e.* Swedish average herds, Danish average herds, 25 % most successful Swedish herds or 25 % most successful Danish herds) managed to achieve such low mortality (see Table 1). It is thus clear that the greatest improvement opportunity lies within reducing the pre weaning mortality.

An average Swedish sow produced 2.21 litters during 2011 (Svenska Pig, 2012a) while an average Danish sow produced 2.26 litters (Vinther, 2012, see Table 1). Sows in the 25 % most successful Swedish herds produced 2.26 litters during 2011 (Svenska Pig, 2012a) while sows in the 25 % most successful Danish herds produced 2.32 litters (Vinther, 2012, see Table 1). Thus, Danish sows produce more litters per year than Swedish sows do. However, it is noteworthy that the 25 % most successful Swedish herds have sows that produce equal numbers of litters per year as the average Danish sow (see Table 1). To reach 2.32 litters per sow and year, as the 25 % most successful Danish herds have reached, represents a challenge for Swedish producers. The number of litters produced per sow and year is affected by the weaning to service interval, the number of non-productive days, the gestation length, the farrowing rate and the lactation length (Aumaitre et al., 1976).

The average weaning to service interval was during 2011 longer for Danish sows (6 days) (Vinther, 2012) than Swedish sows (5.7 days) (Svenska Pig, 2012a, see Table 1). The weaning to service interval, for sows present in the 25 % most successful herds, was also longer in Denmark (5.6 days) (Vinther, 2012) than in Sweden (5.3 days) (Svenska Pig, 2012a, see Table 1). Thus, this is one parameter analyzed where Swedish producers are more successful than Danish.

The average number of non-productive days per litter was during 2011 higher in Sweden (15.7 days) (Svenska Pig, 2012a) than in Denmark (13.8 days) (Vinther, 2012, see Table 1). The 25 % most successful Danish herds also had fewer non-productive days per litter (10.8 days) (Vinther, 2012) than the 25 % most successful Swedish herds (12.5 days) (Svenska Pig, 2012a, see Table 1). According to simulation models by Knox (2005a) and Gill (2007) the number of non-productive days should be equal to or below 30 days per year in order to achieve 30 weaned piglets per sow and year. The 25 % most successful herds in as well Sweden (28.3 days[2]) as Denmark (25.1 days[3]) managed to achieve this during 2011 (Svenska Pig, 2012a; Vinther, 2012). However, neither the average Swedish (34.7 days[4]) nor Danish (31.2 days[5]) herds managed to achieve this during 2011 (Svenska Pig, 2012a; Vinther, 2012). The Danish number of non-productive days per year has been almost static over time and is therefore not the predominant reason to the Danish success in the number of weaned piglets per sow and year (Gill, 2007).

The average farrowing rate was higher in Denmark (87.3 %) (Vinther, 2012) than in Sweden (84.6 %) (Svenska Pig, 2012a). The 25 % most successful Danish herds also had a higher farrowing rate (90 %) (Vinther, 2012) than the 25 % most successful Swedish herds (87.4 %) (Svenska Pig, 2012a, see Table 1). Knox (2005a) and Gill (2007) recommended a farrowing rate exceeding 90 % in order to achieve 30 weaned piglets per sow and year. Thus, it was only the 25 % most successful herds in Denmark that managed to achieve a farrowing rate above the recommended. However, Knox (2005a) stated that a farrowing rate of 85 % might be enough, a rate that was exceeded by all categories except the Swedish average (see Table 1).

Table 1. Key performance indicators in Swedish (S) and Danish (DK) piglet production

Average 2011	S	DK	Top 25 % S	Top 25 % DK
Weaned/sow/year	23.6[6]	28.8	26.0[7]	31.5
Piglets born alive	13.1	14.8	13.5	15.5
Stillborn per litter	1.1	1.8	1.01	1.8
Pre weaning mortality (%)	18.3	13.9	14.9	12.2
Litters/sow/year	2.21	2.26	2.26	2.32
Weaning to service interval	5.7	6.0	5.3	5.6
Non-productive days/litter	15.7	13.8	12.5	10.8
Farrowing rate (%)	84.6	87.3	87.4	90.0
Nursing period (days)	33.6	30.7	33.1	29.5

Modified from Svenska Pig (2012a) and Vinther (2012).

[2] 12.5 non-productive days/litter * 2.26 litters per sow and year = 28.25 non-productive days/year
[3] 10.8 non-productive days/litter * 2.32 litters per sow and year = 25.1 non-productive days/year
[4] 15.7 non-productive days/litter * 2.21 litters per sow and year = 34.7 non-productive days/year
[5] 13.8 non-productive days/litter * 2.26 litters per sow and year = 31.2 non-productive days/year
[6] 10.7 weaned piglets/litter * 2.21 litters/sow and year = 23.647 weaned piglets/sow and year
[7] 11.5 weaned piglets/litter * 2.26 litters/sow and year = 25.99 weaned piglets/sow and year

5.3. Management of reproduction to increase the number of weaned piglets per sow and year

5.3.1. WEANING TO ESTRUS AND SERVICE INTERVAL

The weaning to estrus interval is the time in days between weaning and estrus and an important reproductive trait (Tummaruk et al., 2000), that is individual and herd specific (Aumaitre et al., 1976; Gill, 2007). Post weaning, it is desirable that sows return to estrus as soon as possible. Belstra et al. (2004) found that the weaning to estrus interval was on average 4.6±0.1 days. Prolonged weaning to estrus intervals will shorten the estrus duration and the estrus to ovulation interval (Kemp & Soede, 1996; Nissen et al., 1997; Merks et al., 2000; Knox et al., 2002; Belstra et al., 2004; Gill, 2007). If the weaning to estrus interval increases from four into six days, the duration of estrus decreases from 56 to 46 hours (Gill, 2007). A shorter estrus duration and estrus to ovulation interval might cause service at a non-optimal time in relation to ovulation. Thereby a prolonged weaning to service interval is connected to lower litter sizes (Vesseur et al., 1994; Kemp & Soede, 1996; Gaustad-Aas et al., 2004) and should thus be avoided (Vesseur et al., 1994). Sows that return to estrus and are served within four to five days post weaning will obtain the highest number of piglets born in total and alive (Vesseur et al., 1994; Dewey et al., 1995; Le Cozler et al., 1997; Tummaruk et al., 2000; Knox, 2005a). Serving sows between five and ten days post weaning will generate the lowest litter sizes (Vesseur et al., 1994; Dewey et al., 1995; Le Cozler et al., 1997; Tummaruk et al., 2000; Gaustad-Aas et al., 2004) and also decrease the farrowing rate (Vesseur et al., 1994). However, if sows are served at nine to 12 days post weaning, litter sizes will start to increase again (Vesseur et al., 1994). Litter sizes, exceeding those obtained when serving within four days, can be obtained if serving sows after more than 11 to 21 days post weaning (Vesseur et al., 1994; Dewey et al., 1995; Le Cozler et al., 1997; Tummaruk et al., 2000). If aiming towards serving the sow at the first visible estrus, they should thus be inseminated at day four to five post weaning (Vesseur et al., 1994; Dewey et al., 1995; Le Cozler et al., 1997; Tummaruk et al., 2000; Knox, 2005a).

It is possible to control the weaning to service interval by management (Merks et al., 2000; Knox et al., 2005a), and different management strategies are used for estrus stimulation. The prerequisite for a short weaning to service interval and reproductive success is that the sows are in good body condition (*i.e.* that weight loss during lactation has been minimized) and that they are fed correctly during the transition period (Koketsu et al., 1997a; Knox, 2005a; Gill, 2007). It is also important to minimize stress (Knox, 2005a). Some producers use flushing in order to stimulate estrus and make sure that all weaned sows in a group returns to estrus at the same time (Knox, 2005a; Knox, 2005b). Sows can for example be fed fishmeal around weaning (Knox, 2005a) or be housed in close connection to a boar (Knox et al., 2002; Knox, 2005a; Knox, 2005b; Gill, 2007) in order to induce flushing. Boar contact can be used to accelerate the weaning to estrus interval and to induce distinct signs of estrus, such as the standing reflex (Hemsworth et al., 1984; Knox, 2005a; Knox, 2005b), if the sow is able smell, hear, see and have physical contact with the boar (Knox, 2005b). However, it is important to not overexpose sows to the boar, as overexposure might affect them in the opposite way, and the "surprise effect" should not be neglected (Hemsworth et al., 1984; Knox et al., 2002; Knox, 2005a; Knox, 2005b). The standing reflex of the sow lasts for 15 minutes and it takes around two hours before the sow will show this behavior again, if exposed to the same stimuli (Knox, 2005b). No matter what different types of management strategies used at the farm, the most vital factor is that the technician is able to detect estrus accurately in order to enable service at the right time (Kemp & Soede, 1996; Gill, 2007).

However, the weaning to service interval varies with farrowing season, which has been known since the 1970's (Aumaitre et al., 1976). Sows that farrow in the summer and are weaned in June to September will have a prolonged interval (Aumaitre et al., 1976; Knox, 2005a). The light quantity is of importance for sow reproduction. Gaustad-Aas et al. (2004) found that gilts were older at first service, fewer sows and gilts were served within five days post weaning and that the farrowing rate was lower in regions with less daylight than in regions with more daylight. The weaning to service interval is also longer for primiparous sows, for sows that have been lactating for less than 17 days and for pure bred sows (Aumaitre et al., 1976; Knox, 2005a). The time between weaning and service declines for every litter produced. Crossbred sows also have a shorter weaning to service interval than purebred sows due to the heterosis effect (Aumaitre et al., 1976).

In a simulation model by Knox (2005a) the weaning to service interval had marginal effect on the number of weaned piglets per sow and year. However, as the weaning to service interval is connected to the farrowing interval (Vesseur et al., 1994; Knox, 2005a) and the litter size (Kemp & Soede, 1996; Gaustad-Aas et al., 2004), it cannot completely be neglected (Knox, 2005a).

5.3.2. ESTRUS AND OVULATION

Estrus is defined as the period when the sow will allow mating. Estrus duration is on average 50-52 hours, but ranges from 32 to 69 hours (Belstra et al., 2004; Knox, 2005b; Gill, 2007) since the duration is as well farm specific (Gill, 2007) as individual (Belstra et al., 2004; Knox, 2005b). When the weaning to estrus interval increases from three days to ≥ seven days, the duration of estrus decreases as well as the time between estrus and ovulation (Kemp & Soede, 1996; Nissen et al., 1997; Merks et al., 2000; Knox et al., 2002; Belstra et al., 2004; Gill, 2007). There are several different signs of estrus, such as the standing reflex, swollen vulva and presence of mucus. The proper time for insemination is when the sow shows the standing reflex when subjected to back pressure, without resistance or vocalization. In order to detect estrus, and thereby enable insemination at the right time, it is important to check sows and gilts at least twice a day. It is also important to perform this check at the same time every day, including weekends (Knox, 2005b). Hemsworth et al. (1984) found that a larger proportion of sows in estrus were detected when checked in close connection to a boar.

Ovulation is defined as the shedding of oocytes and normally (*i.e.* in 70 % of the cases) occurs within the time of estrus (Gill, 2007). Ovulation start normally occurs from 42 to 44 hours after the beginning of estrus (Belstra et al., 2004; Knox, 2005b), which means during the first part of the last third of the standing heat (Gill, 2007). Oocytes are normally viable for six to eight hours after ovulation (Gill, 2007). The ovulation rate, *i.e.* the number of shed oocytes, increases with parity number until it reaches a maximum at fourth or fifth parity (Bidanel, 2011). Gilt puberty is defined as the moment of first ovulation and normally occurs at an age of on average six to seven months in commercial breeds (Bidanel, 2011).

Productivity and profitability of sows is connected to trained and skilled employees (Gill, 2007). Nutrition, housing and health are important for optimal ovulation rate and oocyte quality (Merks et al., 2000; Gill, 2007). However, the most important management factors for actual fertilization is to invest time in estrus detection and service at the optimal time (Kemp & Soede, 1996; Merks et al., 2000; Gill, 2007). In the literature, technology or tools for detecting the exact timing of ovulation for each individual sow has been requested in order to improve farm management and the productivity of the sow (Gill, 2007). Such, technology is available for humans in the market today (RFSU, 2012).

5.3.3. SERVICE AND CONCEPTION

A sow in estrus can be served and fertilized by performing either natural mating by a boar or by artificial insemination (AI). AI is defined as the artificial delivery of sperm into the female reproductive tract (Gill, 2007). After insemination, the sperm is transported through the oviduct by uterine contractions. This event takes about two to four hours (Knox, 2005b; Gill, 2007). It is therefore important that insemination takes place before ovulation (Knox, 2005b). Another important factor to take into account is the quality of the semen doses. Semen doses of good quality are characterized by 1) at least 60 % of the sperm in the dose have motility 2) at most 30 % of the sperm in the dose have an abnormal morphology 3) the sperm concentration is at least $25*10^6$ sperms/ml and 4) the semen dose volume is at least 70 ml. Alternatively, a semen dose with at least $2.5*10^9$ viable sperms may be classified as a semen dose of good quality. Semen doses that do not fulfill these criteria should be classified as having poor quality (Young et al., 2010). To provide semen doses of good quality is one of the most important management factors in order to avoid reproductive problems (Merks et al., 2000; Gill, 2007). Sperm are viable in the sow's reproductive tract for 24 hours if semen doses are treated correctly (Gill, 2007).

Productivity and profitability of sows is connected to trained and skilled employees (Gill, 2007). Success during estrus and insemination makes it possible to maximize the number of piglets born alive (Kemp & Soede, 1996; Gill, 2007). When aiming to decrease the risk of sows returning to estrus after service, increasing farrowing rate and maximizing the number of litters per sow and year, the most powerful management tool is to invest time in estrus detection and using a proper insemination technique. Litter size is predominantly related to the amount of fertile sperm inseminated (Knox, 2005a). The timing and number of inseminations are of main importance (Elbers et al., 1995; King et al., 1998; Knox, 2005a; Gill, 2007; Young et al., 2010). For optimal reproductive performance sows should be inseminated from between 28-24 h before and four h after ovulation (Kemp & Soede, 1996; Nissen et al., 1997; Knox, 2005b; Gill, 2007) and inseminations should be performed in 12- or 24-hour intervals (Belstra et al., 2004; Knox et al., 2002; Knox, 2005b). It is recommended to inseminate the sow at least two times per estrus in order to increase the chance of pregnancy, to increase litter sizes and to increase the farrowing rate (Flowers & Alhusen, 1992; King et al., 1998, Belstra et al., 2004; Knox, 2005b; Gill, 2007). To inseminate more than twice, *i.e.* three or four times, may be beneficial for production results but might be disadvantageous in a cost perspective, due to the high costs of semen doses and extra labor (Knox, 2005b). Boar contact in connection to service is also a widely used management tool, as this reduces semen leakage, enhances semen uptake and transport and decreases the insemination time (Knox, 2005a; Knox, 2005b). It has been suggested that leaving the catheter in the cervix of the sow for five to ten minutes after insemination may prevent backflow (Knox, 2005b).

The service strategy, *i.e.* choosing natural mating or AI, affects the reproductive performance of the sow (Flowers & Alhusen, 1992; Dewey et al., 1995; Tummaruk et al., 2000). There are several findings supporting that natural mating by a boar results in larger litters than when using AI. The difference were 0.1 to 0.4 in a study by Tummaruk et al. (2000), whereas Dewey et al. (1995) found that natural mating resulted in one additional piglet per litter in comparison to AI. However, Dewey et al. (1995) states that the result of AI depends on the skills of the technician performing the insemination. According to Tummaruk et al. (2000) the need for rebreeding after service is also higher when using AI instead of natural mating. Dewey et al. (1995) found no connection between the number of natural matings per estrus and litter size. However, according to Flowers & Alhusen (1992) less labor per animal was required when using AI instead of natural mating, if the number of served sows exceeded four. Gilts also demand more labor for service than sows do (Flowers & Alhusen, 1992). Whether service is performed through natural mating or

AI, it is always important to minimize stress during service, as stress may disable sperm transportation and fertilization (Gill, 2007).

5.3.4. FARROWING RATE

The farrowing rate is defined as the proportion of served sows that farrow (Tummaruk et al., 2000) and is a common measure of the reproductive performance of a herd. The farrowing rate of sows is normally within the range of 80-90 % (Bidanel, 2011) and according to Young et al. (2010) a rate over 85 % is considered high while a rate under 85 % is considered low. In simulation models by Knox (2005a) and Gill (2007) a farrowing rate exceeding 90 % is recommended in order to achieve 30 weaned piglets per sow and year. However, Knox (2005a) stated that 85 % might be enough.

Young et al. (2010) found increased farrowing rates when sows were checked for estrus at day four post weaning instead of at day three post weaning. Estrus checking in close connection to a boar can also increase the farrowing rate (Hemsworth et al., 1984; Knox et al., 2002). Knox et al. (2002) found no significant effect on the farrowing rate depending on if the sow was allowed boar contact once or more than once. However, moving one gilt into the boar pen instead of moving the boar into the gilt pen resulted in more precise estrus detection and a higher farrowing rate. This could be due to that it is harder for the employee to observe when the number of animals increases or that it is easier for the boar to check gilts more thoroughly one at a time (Young et al., 2010).

The prerequisite for a high farrowing rate is correct service timing (Elbers et al., 1995; Knox et al., 2002; Knox, 2005a; Young et al., 2010). Sows should be served within four to five days after weaning in order to obtain high farrowing rates and service at five to ten days post weaning should be avoided (Vesseur et al., 1994; Tummaruk et al., 2000). However, service at 20 days post weaning enhances the farrowing rate (Tummaruk et al., 2000). During insemination it is important that the AI-technician is completely focused on the sow as research has shown that using different equipment, that takes the focus away from the sow, lowers the farrowing rate (Young et al., 2010). According to Love & Wilson (1990), performing service early in the week increases the farrowing rate significantly in comparison to performing service later in the week. Specialized insemination technicians from the breeding station increased the farrowing rate in a trial, in comparison to the regular farm staff, which indicates that the skills and experience of the technician is of importance (Elbers et al., 1995). Young et al. (2010) found a significant connection between drying of the vulva before service and a decreased farrowing rate. Inseminating sows twice instead of once decreased the occurrence of sows returning to estrus due to increased chance of correct timing and fertilization (Flowers & Alhusen, 1992; Elbers et al., 1995; King et al., 1998). Serving sows at a non-optimal time, in relation to ovulation, will decrease the farrowing rate (Kemp & Soede, 1996; Gill, 2007).

Season, parity number, lactation length and whether the sow is pure- or crossbred affect the farrowing rate (Aumaitre et al., 1976; Vesseur et al., 1994; Koketsu et al., 1997b). The quality of the semen dose is also of importance (Knox, 2005a; Young et al., 2010). Variation in farrowing rate over the year has been found when inseminating sows during August and October, whereas the farrowing rate was not lowered when using AI during the other months of the year (Tummaruk et al., 2000). Variation in farrowing rate between parities, have been found and it was discovered early that sows have the lowest rate between the first and second parity (Aumaitre et al., 1976; Koketsu et al., 1997a, Koketsu et al., 1997b) and after parity nine (Koketsu et al., 1997a). Farrowing rates, in parity one and two, can be enhanced by using natural mating instead of AI (Tummaruk et al., 2000). Elbers et al. (1995) observed that using AI increased the risk of sows retuning to estrus in comparison to the use of natural mating. In a study by Young et al. (2010) it was found that herds, where a combination of AI and natural mating by the boar was used, had higher farrowing rates (*i.e.* fewer returns to estrus after service) and more litters per sow and year, than herds where only AI or only natural mating was used. The favorable effect on farrowing rate when using a combination of AI and natural mating has also been found in gilts (Flowers & Alhusen, 1992). However, the research in this area is limited (Young et al., 2010). When Young et al. (2010) compared herds in Ontario with high and low farrowing rates, herds with low farrowing rates had on average 642 sows and herds with high rates had on average 392 sows. Even though these are both large quantities of animals, this indicated that the more animals the harder to keep them all in high production. Elbers et al. (1995) also found that producing both piglets and finishing pigs decreased the farrowing rate.

5.3.5. GESTATION

It is important that fertilized sows maintain pregnant throughout the gestation period and that as many of the embryos or fetuses stay alive and grow (Knox, 2005a; Knox, 2005b). Management of gestating sows is therefore important for farrowing rates and litter sizes (Knox, 2005a). The length of sow gestation is normally 115 days but may vary between 110 to 120 days. The pregnancy is most vulnerable during the first days after service. On the 12th day of gestation the embryos attach to the uterus wall and it is important that the stress level is minimized until and during the occurrence of this attachment, in order to avoid miscarriages (Christiansen, 2010). Thus, sows should not be moved or regrouped during the first three to four weeks of gestation (Knox, 2005a). Gestating sows should also be housed properly (Gill, 2007) and the temperature in the gestation unit should not be too high during the beginning of gestation (Knox, 2005a). Ensuring that the sow gains or retains a desirable body condition during pregnancy is vital for the lactation period to come and for the possibility of rebreeding after weaning (Knox, 2005b). Sows should always be fed according to body condition (Knox, 2005a; Gill, 2007) but sows that need to gain weight should preferably do so during the beginning and middle part of gestation (*i.e.* between the third and eighth week) (Knox, 2005a; Knox, 2005b). A sow that is too thin will have difficulties in producing enough amounts of colostrum and milk during lactation and a sow that is too fat is exposed to increased risks of having stillborn piglets or other problems at farrowing. She will also be less motivated to eat during lactation (Knox, 2005b). Healthy sows are also a prerequisite for maintaining pregnancy Knox, 2005a).

A profitable herd has control of reproduction and thus pregnancy testing is a substantial management factor (Aumaitre et al., 1976). Pregnancy testing can be performed with an ultrasonic meter (*i.e.* "PREG-TONE") from 30-73 days after service, with an ultrasound scanner from 24-32 days after service (Taverne et al., 1985) or by the boar from 18-24 days after service (*i.e.* at the time of returning to estrus if not pregnant) (Knox, 2005b). Taverne et al. (1985) found that the accuracy of the ultrasound scanner was 100 % whereas the accuracy of the ultrasonic meter was 70.5 %. Sows, which are not pregnant after service, must be identified as soon as possible and thereafter rebred or culled (Knox, 2005b).

5.3.6. FARROWING

A high number of piglets born alive is a prerequisite for a high number of weaned piglets per sow and year (Knox, 2005a; Gill, 2007). The most important reason to why the number of weaned piglets has increased in many countries during the past years is the genetic selection for an increased number of piglets born (Knox, 2005a; Gill, 2007). In addition to genetic selection, improved management, nutrition, housing and health have also contributed to the increased number of piglets born (Merks et al., 2000; Knox, 2005a). In order to reach the full reproductive potential of the sow it is essential to have skilled, trained and experienced employees with knowledge of the different stages of the breeding cycle (Munsterhjelm et al., 2006; Gill, 2007). The litter size of the sow is also connected to the litter size of her previous parity (Dewey et al., 1995).

5.3.6.1. Stillbirths

As a consequence of farrowing complications, piglets may sometimes be stillborn. Farrowing complications connected to stillbirths are normally that one or several piglets are so large that they block the uterus (Friend et al., 1962) or too early rupture of the umbilical cord, causing some piglets to suffer from hypoxia (*i.e.* lack of oxygen) (Curtis, 1974; Malmkvist et al., 2006). Even though a piglet may survive cases where the placenta is detached too early during parturition, they might become weakened and thereby have difficulties finding an available teat in time. These piglets will later die from starvation (White et al., 1996).). Another predisposing factor for stillbirths is a prolonged farrowing duration (Friend et al., 1962; Canario et al., 2006; Pedersen et al., 2006; Oliviero et al., 2010). Friend et al. (1962) found that an increased farrowing duration (*i.e.* farrowings exceeding eight hours) was connected to an increase in the presence of stillbirths (*i.e.* from 2.4 %, which is considered normal, into 10.5 %). The farrowing duration should not exceed three hours (Friend et al., 1962) and is affected by factors such as breed, parity number, gestation time, the total number of piglets born, housing system, body condition of the sow and presence of constipation (Oliviero et al., 2010). The risk of stillbirths increases with parity number (Canario et al., 2006). Sows of parity six, eight, nine or over nine has increased incidences of stillbirths in comparison to first parity sows (KilBride et al., 2012). Increased litter sizes have frequently been reported to increase the presence of stillbirths (Marchant et al., 2000; Hanenberg et al., 2001; Knox, 2005a; Canario et al., 2006; Oliviero et al., 2010; KilBride et al., 2012). Lighter and male piglets were in a trial by Canario et al. (2006) more likely to be stillborn.

5.3.7. LACTATION

5.3.7.1. Pre weaning mortality of live born piglets

Pre weaning mortality (*i.e.* mortality of live born piglets between birth and weaning) represents substantial losses to the yearly production and profitability (White et al., 1996; Johnson et al., 1999; Tuchscherer et al., 2000; Grandinson et al., 2002; Rooke & Bland, 2002; KilBride et al., 2012). Reducing the pre weaning mortality is an important task at the herd level in order to enhance production results, profitability and animal welfare (Tuchscherer et al., 2000; Grandinson et al., 2002; Andersen et al., 2007; Gill, 2007). The majority of piglet deaths occur within the first three days after birth (Fahmy & Bernard, 1971; Hartsock & Graves, 1976; Dyck & Swierstra, 1987; Varley, 1995; Marchant et al., 2000; Tuchscherer et al., 2000; Knox, 2005a; Knox, 2005b; Malmkvist et al., 2006; KilBride et al., 2012) and 80 % occur within the first week of life (Friendship et al., 1986). The most common causes for mortality are crushing by the sow, starvation, chilling and disease (Curtis, 1970; Dyck & Swierstra, 1987; Cronin et al., 1996; White et al., 1996; Tuchscherer et al., 2000; Edwards, 2002; Knox, 2005b; Malmkvist et al., 2006; Weber et al., 2009; KilBride et al., 2012) where crushing and starvation are the ones of main importance (Dyck & Swierstra, 1987). Crushing by the sow is the most common cause for death in healthy piglets born alive (Varley, 1995; Cronin et al., 1996; Weber et al., 2009; KilBride et al., 2012). However, due to differences in management and environmental aspects, there is variation in mortality causes between herds (White et al., 1996).

It has frequently been reported that large litters are strongly connected to an increase in pre weaning mortality (Hartsock & Graves, 1976; Johnson et al., 1999; Marchant et al., 2000; Tuchscherer et al., 2000; Edwards, 2002; Knox, 2005a; Pedersen et al., 2006; Gill, 2007; Weber et al., 2007; Vasdal et al., 2011). This is partly due to the fact that larger litters also are associated to a larger proportion of low birth weigh piglets (Weary et al., 1998; Roehe, 1999) and larger size variability within litter (Marchant et al., 2000). Mortality is highest amongst low birth weight piglets (Roehe, 1999; Marchant et al., 2000; Roehe & Kalm, 2000) and piglets born later in the birth order (Tuchscherer et al., 2000). Pre weaning mortality due to disease is most often a result of diarrhea (Cronin et al., 1996; White et al., 1996; KilBride et al., 2012). White et al. (1996)

found in a study that the most common disease that caused mortality was colibacillosis, a disease connected to diarrhea caused by *Escherichia coli (E. coli)*.

There is a positive and unfavorable correlation between stillbirths and pre weaning mortality (Friendship et al., 1986; Pedersen et al., 2006). KilBride et al. (2012) found that the risk of pre weaning mortality was significantly higher in litters where two or more piglets were stillborn. Thereby, a prolonged farrowing duration also increases the pre weaning mortality (Tuchscherer et al., 2000). There is also a negative and unfavorable correlation between the total number of piglets born and maternal traits, indicating that sows become "worse" mothers when the litters are larger (Hanenberg et al., 2001; Lund et al., 2002). Piglets born with splay legs are also in great risk of mortality (Cronin et al., 1996).

Crushing

Crushing of piglets is a major problem in piglet production (Lensink et al., 2009). Since newborn piglets lack the ability of thermoregulation they are in constant need of an external heat source (Hartsock & Graves, 1976; Bowman et al., 1996). The purpose of providing the creep area with additional heat lamps, or other heat sources, is to attract the piglets to a safe resting area (Knox, 2005b). However, during the first days of life, piglets often tend to stay close to the sow, which produces large amounts of heat, instead of using the creep area. This behavior could be one of the reasons to why piglets get crushed (Andersen et al., 2007). Crushing of piglets is however also related to sow behavior (Lensink et al., 2009; Weber et al., 2009). The combination of chilled piglets and an overheated sow increases the risk of mortality due to crushing (Knox, 2005b). It has been shown that parity number and litter size significantly affect the presence of crushing (Lensink et al., 2009; Weber et al., 2009).

Both Lensink et al. (2009) and Weber et al. (2009) found that sows of higher parity numbers were more prone to crush piglets and a significant correlation between the litter size and the number of crushed piglets has been found (Weary et al., 1998; Lensink et al., 2009). However, sows of higher parities also give birth to larger litters (Weary et al., 1998; Lensink et al., 2009) why there is a possibility that there is a connection between these factors, *i.e.* that it is the larger litters that are the cause of the higher incidence of crushing. But other factors, such as the body weight of the sow, the presence of leg problems and larger variation in piglet size, all factors increasing in risk with parity number, could be the cause of the higher incidence of crushing (Lensink et al., 2009). Piglets that are vital and have a higher birth weight are at less risk of being crushed (Varley, 1995; Roehe & Kalm, 2000; Grandinson et al., 2002).

Chilling

Piglets are born with only one to two percent of body fat (Widdowson, 1950), and therefore have limited ability to thermo regulate (Hartsock & Graves, 1976; Bowman et al., 1996). Due to this, piglets are dependent on as well each other as on the sow to be able to stay warm (Hartsock & Graves, 1976). In addition to the limited thermo regulation, piglets are also subjected to evaporative cooling due to remnants of fetal membranes and fluids after birth. The evaporative cooling causes the body temperature of the piglet to drop, which increases the risk of mortality due to chilling (Curtis, 1970; Tuchscherer et al., 2000). A small piglet has a greater heat loss than a large piglet and a weak piglet has lower viability than a strong piglet. This means that a small and weak piglet is subjected to a higher risk of mortality (Bowman et al., 1996; Andersen et al., 2007). Drying or warming of small or inactive piglets after birth increases the chance of colostrum intake and survival (White et al., 1996; Tuchscherer et al., 2000).

Starvation

Piglets are born with low energy reserves (Widdowson, 1950; Bowman et al., 1996) consisting of small amounts of blood glucose, liver glycogen (Sampson et al., 1942; Lodge et al., 1978;

Tuchscherer et al., 2000) and one to two percent of body fat (Widdowson, 1950). These energy reserves are just enough to enable the piglet to reach the udder after birth. In order to refill energy, the piglet must ingest colostrum. Colostrum is produced during the first 24 hours after parturition and also contains large amounts of immunoglobulins. The task of immunoglobulins is to provide the piglet with passive immunity, until the piglet itself can produce antibodies and attain active immunity (Rooke & Bland, 2002; Baker, 2008). The ingestion of colostrum is thereby strongly connected to survival (Rooke & Bland, 2002; Malmkvist et al., 2006). Piglets that do not succeed to ingest colostrum will become weakened and in risk of dying from starvation, chilling or disease. Due to weakness and low alertness they are also at risk of being crushed (Knox, 2005b). It is common that death occurs as a result of a combination of these factors (Friendship et al., 1986; Edwards, 2002). This means that piglets recorded as dead due to starvation might have been weak from the beginning and could therefore not reach the udder or defend a teat or vice versa (KilBride et al., 2012).

The time between birth and reaching the udder or the creeping area is risky and if this time is prolonged the risk of mortality increases (Andersen et al., 2007). During the first hours after birth there is a large competition between piglets for teats, due to the establishment of the teat order (Hartsock & Graves, 1976; Rooke & Bland, 2002). The anterior teats produce more milk (Fraser & Rushen, 1992; Rooke & Bland, 2002) and immunoglobulins (Rooke & Bland, 2002) than the posterior. Piglets that are born early have more time to explore the udder and thereby have the opportunity to choose teats, which produce more milk. Meanwhile, they may also suckle some of the colostrum meant for other littermates, why the ingested amount may vary between piglets within litter (Hartsock & Graves, 1976; Le Dividich & Noblet, 1981; Rooke & Bland, 2002). Piglets that are large, heavy and vital also have increased possibilities to defend the teat that they have chosen in comparison to smaller, lighter and weaker littermates (Hartsock & Graves, 1976; Bowman et al., 1996; Rooke & Bland, 2002; Andersen et al., 2007). Piglets born early within a litter, that have a high birth weight and that are able to ingest colostrum in time are thereby more likely to survive (Hartsock & Graves, 1976; Roehe, 1999; Roehe & Kalm, 2000; Tuchscherer et al., 2000). Large litters also increases the competition at the udder, which in turn increases the risk of starvation of weaker piglets (Andersen et al., 2007).

In summary, surviving piglets are significantly heavier at birth, born earlier in the birth order, have a shorter interval between birth and reaching the udder, have a shorter interval between birth and first suckle and have lower drops in rectal temperature between birth and one hour post partum (Hartsock & Graves, 1976; Roehe, 1999; Tuchscherer et al., 2000). Roehe & Kalm (2000) found that male piglets were 1.5 times more prone to die than female piglets but Tuchscherer et al. (2000) found no impact on mortality depending on the sex. However, piglets that die may be less physiologically mature (Tuchscherer et al., 2000). Nonetheless, focus should lie on preventing piglets from becoming weak and lying close to the sow when not suckling (Knox 2005a).

5.3.7.2. Improving piglet survival and growth

Herd management can improve piglet survival. Large-scale herds generally have lower piglet mortality than small-scale herds and herds where mortality is high one year are more prone to also have a high mortality during the next year (Friendship et al., 1986). Trained and skilled employees are connected to good health, high welfare, productivity and profitability of pigs. A positive relationship between the pigs and the stockman is connected to low pre weaning mortality (Gill, 2007). According to Gill (2007) checking the piglets twice a day instead of once decrease the pre weaning mortality. However, Friendship et al. (1986) found no correlation between the time the producer stated to spend in the farrowing unit and the mortality. In order to decrease mortality, and thereby increase the number of weaned piglets, it is important to put extra effort and care during the first days of piglet life (Andersen et al., 2007). In order to keep as many alive as possible, special attention needs to focus on weak piglets (Gill, 2007) and on preventing death due to the combination of starvation, chilling and crushing (Bowman et al., 1996).

Biosecurity and high health status are prerequisites for low pre weaning mortality (Gill, 2007). Cleaning of the farrowing unit between batches is therefore a commonly used management tool for decreasing mortality (Bowman et al., 1996). Bowman et al. (1996) investigated management factors that affected the pre weaning mortality and found that the most important factor for improving survival was using batch wise production and all-in-all-out techniques with cleaning between batches. The most successful way of cleaning was by using pressure washing in combination with disinfection. Washing the sows before entering the farrowing unit improved piglet survival additionally. They also found statistically significant influences of the empty time between batches in the farrowing unit (*i.e.* at least two days). The authors concluded that when using all-in-all-out techniques, piglets were less prone to be affected by pathogens, the employees were able to focus on the farrowings when all sows farrowed at the same time and that cross fostering was facilitated. Friendship et al. (1986) however, did not observe any improvement in survival when using batch-wise instead of continuous production. Purchased animals should be isolated from other animals before entering the herd (Gill, 2007).

The most important factor during the nursing period is probably sow management. The energy- and nutrient intake of sows is important in order to secure production of sufficient amounts of colostrum and milk. According to Knox (2005b) sows should be fed three times a day in order to assure adequate energy intake. However, this depends on the energy content of the feed and the general feeding strategy and the most important parameter to consider is the body condition of the sow (Bowman et al., 1996). Obese sows should be avoided if the aim is to decrease piglet mortality (Gill, 2007). Using fibers as a complement to sow diets fed restrictively increases the feeling of satiety and thereby reduces restlessness, aggression and stereotypical behavior. The reduction in these behaviors could reduce piglet mortality due to crushing, trauma or infections originating from trauma (Andersen et al., 2007). Andersen et al. (2007) found that herds that fed sows a moderate amount of hay during gestation had fewer stillborns and lower pre weaning mortality than herds that did not use roughage. Some producers shut the piglets into the creeping area while feeding the sow in order to avoid crushing or trauma in connection to uprising and lying down. Berg et al. (2006) and Andersen et al. (2007) found no significant impact of shutting piglets in the creeping area during sow feeding on piglet mortality.

Attended farrowings

One early management factor for improving piglet survival, frequently mentioned in the literature, is attended farrowings (White et al., 1996; Tuchscherer et al., 2000; Knox, 2005a; Knox, 2005b; Gill, 2007). Attended farrowings may increase the number of live born piglets with 5 % (Knox, 2005a) or an additional 0.5 weaned piglets per sow and year (Knox, 2005b), due to less presence of stillbirths, piglets born weak and crushing or trauma (Tuchscherer et al., 2000). During farrowing it is important to monitor and make sure that birth intervals are normal (Gill, 2007). If the farrowing duration is excessively prolonged obstetric assistance must be provided (Christiansen, 2010; Nielsen & Nørgaard, 2012). Clearing of mucus in oral or nasal cavities may facilitate newborn piglet vitality (White et al., 1996; Gill, 2007). Since it has been shown that colostrum intake is strongly connected to survival (Rooke & Bland, 2002; Malmkvist et al., 2006), another important management factor in connection to farrowing, is to ensure that all live born piglets are able to ingest colostrum shortly after birth (Bowman et al., 1996; Tuchscherer et al., 2000; Andersen et al., 2007). Placing piglets by the udder directly after birth can facilitate colostrum intake (Andersen et al., 2007; Gill, 2007; Vasdal et al., 2011). In order to avoid death due to chilling it has been suggested that drying of piglets or placing them under heating lamps could improve survival (White et al., 1996; Andersen et al., 2007; Andersen et al., 2009; Gill, 2007; Vasdal et al., 2011). Andersen et al. (2007) could not prove that these management factors decreased mortality whereas Andersen et al. (2009) found that placing the piglets under the heating lamp directly after birth or drying the piglets, before placing them under the lamp, both decreased pre weaning mortality significantly. When piglets were both dried and placed under the heating lamp the mortality due to crushing was significantly lower. Vasdal et al. (2011) found increased mortality when placing piglets at the udder after birth but a decreased mortality when drying piglets and placing them at the udder. Drying or placing piglets in the creep area facilitated colostrum intake. Attended farrowings have also been found to increase the piglet weight at 21 days of age (White et al., 1996). To attend farrowings is time consuming (Andersen et al., 2007), but is facilitated by batch wise production (White et al., 1996; Andersen et al., 2007). Since attended farrowings decrease the pre weaning mortality, batch wise production therefore increases profitability and is economically defendable (White et al., 1996; Andersen et al., 2007).

White et al. (1996) studied the differences in piglet mortality and growth when using or not using a management protocol during farrowing. The management protocol included monitoring of the farrowing, drying piglets with a towel directly after birth, tying the umbilical cord, clearing of the nasal and oral cavities, supplying of oxygen gas, supplying of bovine colostrum and helping piglets to find an available teat. Piglets weighing more than one kg also had their needle teeth removed. Not using the management protocol meant no monitoring of the farrowings what so ever, which was the common herd practice according to the authors. The results of the study showed that sows in attended groups, where the protocol had been used, had more live born piglets and more piglets alive at 21 days after birth than sows in the unattended groups. The proportion of stillborn piglets was 1.6 % for sows where the protocol was used and 6.8 % for unattended sows. The total pre weaning mortality was 10.1 % for sows where the protocol was used and 18.2 % for unattended sows. The protocol especially decreased the presence of stillbirths and mortality due to starvation. One week post partum, the piglets in the attended groups weighed more than the piglets in the unattended groups. The use of this management protocol increased the number of piglets with 1.1 per litter or alternatively decreased the total piglet mortality by 44 %.

Milk replacer

A commonly used management tool to avoid starvation is the provision of milk replacer to large litters or litters of sows that does not produce sufficient amounts of milk (Bowman et al., 1996; Knox, 2005b). According to Knox (2005b) providing large litters with milk replacer from between three to ten days of age may increase piglet survival and growth. Bowman et al. (1996) however, found no significant effect on pre weaning mortality when offering milk replacer, which could partly be due to the fact that milk replacer does not contain immunoglobulins (Bowman et al., 1996).

Cross fostering

It is common that the number of live born piglets per litter exceeds the number of functional teats per sow. This exposes piglets of starvation risk (Andersen et al., 2007), since piglets have a fixed teat order established within the first week of life (Straw et al., 1998). In these cases cross fostering is the most accessible and common management tool used in order to save residual piglets (Neal & Irwin, 1991; Andersen et al., 2007). Cross fostering is the transfer of piglets from one sow to another and can be performed in order to ensure that all piglets have a functional teat to suckle (requires moving 5 % of piglets), equalize and balance litter sizes after the feeding ability of the sow and to create litters with piglets of similar birth weight and size in order to minimize competition (requires moving 15-20 % of piglets). The method is used with the purpose to improve piglet survival and growth (Price et al., 1994; Bowman et al., 1996; Straw et al., 1998; Wattanaphansak et al., 2002; Deen & Bilkei, 2004; Bierhals et al., 2011). In a study by Straw et al. (1998) cross fostering was used in 98 % of the herds.

Cross fostering is generally not a problem since pigs are less selective between biological and adopted offspring than for example cattle and sheep and sows will normally accept non biological piglets several days after farrowing (Grandinson, 2005). However, there are several factors affecting the outcome of cross fostering. Such factors are the chosen timing, the size and vitality of fostered piglets and the parity number of the biological and adoptive sows (Neal & Irwin, 1991; Price et al., 1994; Straw et al., 1998; Bierhals et al., 2011). During cross fostering, it is important to equalize and create litters with as homogenous piglets as possible, with regards to size and weight, since it has been found that moving small (*i.e.* low birth weight) piglets to large litters with large (*i.e.* high birth weight) piglets will increase mortality of cross fostered piglets (Neal & Irwin, 1991; Deen & Bilkei, 2004; English & Bilkei, 2004). However, if cross fostering small piglets into small litters (*i.e.* litter size ≤8) the survival of fostered piglets is not necessarily impaired (Deen & Bilkei, 2004; English & Bilkei, 2004).

Even though the concept of cross fostering is not very complicated, there are at least two different strategies used in order to obtain the best result. The first method is called limited cross fostering and aims towards transferring of piglets during the first one to two days of life only, before the establishment of the teat order. The other method is called continuous cross fostering, which allows fostering throughout the whole nursing period. Continuous cross fostering have in some cases resulted in decreased weaning weights (Wattanaphansak et al., 2002). In a study by Andersen et al. (2007) some herds consistently moved piglets to another sow when litter sizes exceeded 12 piglets, while some cross fostered when the number of functional teats were higher or lower than the litter size or based on the condition or vitality of the piglets. However, Andersen et al. (2007) points out that there is no need to move piglets if the litter seems to thrive, regardless of the litter size and number of functional teats.

That cross fostering of piglets is a management tool improving piglet survival has been reported frequently (Bowman et al., 1996; Straw et al., 1998; Wattanaphansak et al., 2002; Gill, 2007; KilBride et al., 2012). In a trial by KilBride et al. (2012) piglet mortality was reduced when three piglets were fostered into the litter in comparison to when no piglets were added to the litter at all. It has also been established that cross fostering *per se* does not increase the risk of piglet mortality (Andersen et al., 2007; Bierhals et al., 2011). However, the prerequisite for successful cross fostering is that it is performed early in life (Bowman et al., 1996; Andersen et al., 2007; Gill, 2007; Bierhals et al., 2011) and that the number of piglets in the litter does not exceed the number of functional teats to suckle (Wattanaphansak et al., 2002). Results may however vary between herds and litters (Friendship et al., 1986). Cross fostering should not be performed before colostrum intake from the biological mother (Wattanaphansak et al., 2002) and thus not prior to six hours postpartum (Bierhals et al., 2011). Most cross fostering is performed within 24 hours after birth (Price et al., 1994; Bowman et al., 1996; Bierhals et al., 2011), even if it is possible to foster piglets until three days postpartum. After this period of time, the teat order has been established and unsuckled glands have dried up. Cross fostering after three days postpartum should thus be avoided (Straw et al., 1998) as fostering of older piglets has been reported to result in impaired survival and weight gain (Price et al., 1994; Straw et al., 1998; Giroux et al., 2000). Straw et al. (1998) found that herds moving piglets up until over seven days of age had 1.56 % higher mortality than herds, only moving piglets before three days of age. In a trial by Giroux et al. (2000) piglets that were fostered at day five to seven of age only gained 76 % of the weight that non-fostered piglets gained between cross fostering and weaning. The authors interpreted the results as a confirmation that late fostered piglets have less access to the udder and that this compromises the welfare.

The quality of the colostrum of the biological mother as well as the quality of the milk of the adoptive mother has an impact on the viability and performance of fostered piglets. The quality of colostrum and the milk is in turn dependent on the parity number. However, whether the foster sow is primiparous or multiparous does not affect piglet survival (Bierhals et al., 2011). No significant effect within litter has been found on the weight of piglets, depending on if the foster sow is biological or not. However, the parity number of the foster sow affects the litter weight, regardless of if piglets are biological or not. Thus, if cross fostering piglets to a primiparous sow, lower weaning weight can be expected than if cross fostering to a multiparous sow. This could be due to the fact that colostrum and milk of older sows are richer in different types of immunoglobulins, which generates an advantage in health and thus in growth. This could also be due to that older sows produce larger amounts of milk, which promotes growth (Bierhals et al., 2011).

Nursing sows

If all sows within a batch have given birth to a number of live born piglets exceeding the number of functional teats and if no piglets have died, cross fostering is not a possible solution to the lack of functional teats. In that case, nursing sows may be used. The system of using nursing sows is widely used in Denmark (Mattsson, 2013). According to Knox (2005a) the system is built as follows:

1. A first-parity sow from group A is weaned from her litter on lactation day 21.
2. The first-parity sow from group A is moved into group B, where she receives 13 large and healthy piglets, of five to seven days of age, from an older sow from group B.
3. The first-parity sow nurses these 13 piglets for 15 days and is thereafter weaned again. This means that the first-parity sow will be lactating for totally 35 days (20 + 15 days = 35 days). The biological litter of the first-parity sow will be nursed for 20 days. The litter fostered by the first-parity sow will be nursed for totally 20-22 days (5-7 days by biological mother + 15 days by foster mother = 20-22 days).
4. The older sow from group B, whose litter of large and healthy piglets were moved to the first-parity sow from group A, can then nurse surplus piglets from group B. She will thus have an extended lactation length of three to five days.

This is an example of a one-step-nursing sow (Mattson, 2013). According to Mattsson (2013), in a one-sep nursing sow system, the nursing sow should receive piglets of two to seven days of age. These piglets may also come from several different litters. In a one-step-nursing sow system two farrowing units are involved.

Danish herds occasionally also use a two-step-nursing sow system. In that case, a sow is weaned from her biological litter at 21 days postpartum and moved into a farrowing unit with piglets of two to seven days of age. The sow of the litter, that the nursing sow just received, is also moved to become a nursing sow for residual newly born litters. In a two-step-nursing sow system two or three units are involved. Danish research has shown that the piglet survival and growth is higher when using two-step-nursing sow systems (Mattsson, 2013). Midtgaard Rasmussen (2012) found that sows, chosen as nursing sows, were generally calm and had biological piglets that were well nursed, large and had a high homogeneity. Mattson (2013) stated that sows, chosen as nursing sows, should be young. However, second parity sows are generally more suitable than first parity sows since first parity sows are less successful in retaining body condition. The piglets that are moved to the nursing sow should be strong and vital, since it may take between six and 12 hours before successful nursing is performed (Mattson, 2013).

The use of the above mentioned nursing sow systems is not possible in Swedish herds, due to legislations, since no piglet can be weaned prior to 28 days of age (SJVFS 2010:15). However, there are modified versions of this system used in Swedish herds today. This may implicate lactation intervals of up to 56 days and it is important to consider both welfare aspects and productivity aspects of the subsequent litter. Even though Jensen & Recén (1989) found that Swedish Landrace pigs in a semi-natural environment have an average lactation length of 17.2 weeks, it is probable that the sow’s experience is different when housed under commercial conditions. The above-mentioned systems may also imply a biosecurity risk since the batch-wise production system is punctured when moving sows from one group into another (Mattson, 2013). Nonetheless, the use of nursing sows may decrease the pre weaning mortality (Knox, 2005b; Mattsson, 2013) and provides first-parity sows with additional time for uterus repair before next service, which can improve the litter size in the second parity (Knox, 2005a).

Split suckling
If all sows within a batch have given birth to a number of live born piglets exceeding the number of functional teats and if no piglets have died, cross fostering is not a possible solution to the lack of functional teats. In that case, split suckling may be used. Split suckling has also been suggested in order to ensure colostrum intake (Baker, 2008; Mattsson & Mattsson, 2012). According to Knox (2005a), split suckling may be managed by 1) Locking the piglets into the creep area for one hour 2) Allowing the ten smallest piglets to access the udder, while the largest piglets are still locked inside the creep area and 3) Unlocking the rest of the piglets to enable all piglets access to the udder. Mattsson & Mattsson (2012) suggested that the creep are should remain open, in order to decrease the risk of crushing or trauma, and that piglets that are not allowed to suckle should instead be placed in an additional plastic crate. At least eight piglets should be allowed to suckle at once in order to provide enough udder stimulation (Mattsson & Mattsson, 2012). The research concerning effects of split suckling on survival and weight gain is limited (Baker, 2008). However, Mattsson & Mattsson (2012) found that split suckled litters were 0.4 piglets more at weaning. Split suckling may improve piglet survival in litters larger than 12-14 live born piglets (Knox, 2005b; Mattson & Mattsson, 2012) if performed within 24 hours after birth (Gill, 2007). Mattsson & Mattsson (2012) found no significant effect on the weaning weight.

5.3.7.3. Length of nursing period
It has been known for a long time that it is important not to wean piglets too early (*i.e.* <15-17 days of age) in order to not disturb the reproductive physiology of the sow (Svajgr et al., 1974; Aumaitre et al., 1976; Knox, 2005a), to not decrease the number of piglets born in the subsequent litter (Svajgr et al., 1974; Le Cozler et al., 1997; Tummaruk et al., 2000) and to allow balancing of the metabolic status of the sow (Tummaruk et al., 2000). The lactation length must be long enough for the uterus to complete involution before weaning, in order to obtain normal estrus, conception and pregnancy. Histologically, the uterine involution of the sow is completed at 21 days after farrowing (Palmer et al., 1965). Short lactation lengths (*i.e.* <17-28 days) increase the weaning to service interval linearly (Svajgr et al., 1974; Tummaruk et al., 2000; Knox, 2005a). However, it has also been found that the duration of estrus decreases linearly when the lactation length is increased from ≤13 days into ≥20 days (Belstra et al., 2004), which may aggravate service at an optimal time. Koketsu et al. (1997a) found a significant increase in the incidence of reproductive failure in sows that had been lactating for less than seven days (*i.e.* a very short lactation length) but Tummaruk et al. (2000) found no significant differences in farrowing rate of sows that had been lactating for four, five, six or seven to eight weeks.

The lactation length affects the number of weaned piglets per sow and year, since it affects the litter size in the subsequent litter (Svajgr et al., 1974; Dewey et al., 1995; King et al., 1998; Koketsu & Dial, 1998; Tummaruk et al., 2000; Knox, 2005a), the weaning to service interval (Tummaruk et al., 2000) and the farrowing rate (Vesseur et al., 1994). The number of piglets born in total and alive in the subsequent litter increases linearly as the lactation length increases (*i.e.* lactation lengths of maximally eight weeks tested) (Svajgr et al., 1974; Dewey et al., 1995; Tummaruk et al., 2000; Knox, 2005a). The lactation length also affects the farrowing interval and thus the number of possible litters per sow and year why the nursing period may have negative effects on the number of weaned piglets per sow and year (Aumaitre et al., 1976; King et al., 1998). However, in simulation models by Knox (2005a) an increased lactation length, from 21 days into 30 days, resulted in an increase of the number of weaned piglets per sow and year with 1.8 due to an increased litter size in the subsequent litter.

The length of the nursing period is on average longer in Sweden than in Denmark. During 2011 the average lactation length in Sweden was 33.6 days (Svenska Pig, 2012a), while the average lactation length in Denmark was 30.7 days (Vinther, 2012) (see Table 1). The 25 % most successful Swedish herds had an average lactation length of 33.1 days (Svenska Pig, 2012a), while the 25 % most successful Danish herds had an average lactation length of 29.5 days (Vinther, 2012, see Table 1). These differences are primarily due to legislation differences. Since both Sweden and Denmark are members of the EU, both countries are bound to follow the council directive (98/58/EC) concerning the protection of animals kept for farming purposes and the council directive (2008/120/EC) laying down minimum standards for the protection of pigs. These directives are minimum demands for national legislation concerning piglet production within the union. According to the EU-directive (2008/120/EC): "No piglets shall be weaned from the sow at less than 28 days of age unless the welfare or health of the dam or the piglets would otherwise be adversely affected. However, piglets may be weaned up to seven days earlier if they are moved into specialized housings which are emptied and thoroughly cleaned and disinfected before the introduction of a new group and which are separated from housings where sows are kept, in order to minimize the transmission of disease to the piglets."

In practice this means that, as long as the producer conforms to a batch wise production system, piglets may be weaned from three to four weeks of age (Christiansen, 2010). Danish producers generally wean their piglets at 28 days or four weeks of age. Some piglets in the batch might however be younger (and some might be older) (Christiansen, 2010; Vinther, 2012) since all sows are generally weaned at the same day even though the farrowing dates vary (Christiansen, 2010). EU-members are however allowed to incorporate higher demands into their national legislation (McCormick, 2008; Palmqvist, 2012). In Swedish legislation, the weaning age has been specified additionally and it is stated that: "Piglets must not be weaned until they have reached four weeks of age and they shall then be used to creep feed" (SJVFS 2010:15). In practice, this means that Swedish producers wean their piglets at five weeks of age in order to ensure that all piglets have reached at least four weeks of age (Tummaruk et al., 2000; Ivarsson, 2012; Svenska Pig, 2012a). Thus, the lactation length is a parameter difficult to improve under prevailing conditions and can therefore hardly be considered as a factor possible to improve by management.

5.3.8. NON-PRODUCTIVE DAYS

The number of non-productive days is the number of days that the sow is neither pregnant nor lactating. Factors affecting the number of empty days are the weaning to estrus interval, the skill to detect estrus, insemination skills, the skill to detect sows that are returning to estrus after insemination and skills in choosing which sows to cull (Gill, 2007). Minimizing the number of non-productive days is the key factor in order to improve sow productivity (Gill, 2007) and to achieve 30 weaned piglets per sow and year (Knox, 2005a). Reducing the number of non-productive days is primarily a product of management (Knox, 2005a; Gill, 2007). Management factors connected to this is keeping a high health status, minimizing the weaning to service interval, struggling to have few servings per sow and parity, having effective tools for detecting pregnancy so that non-fertilized sows are discovered in time and conforming to a strict culling policy (Knox, 2005a; Gill, 2007). The timing of gilt introduction into the herd is also important (Gill, 2007). To detect sows which are not pregnant after insemination is an important factor for reducing the number of non-productive days (Knox, 2005a). King et al. (1998) found that the number of non-productive days increased when a larger proportion of breeding females were gilts.

5.3.9. CULLING AND REPLACEMENT GILTS

Sows with reproductive disturbances (*i.e.* that fails to return to estrus after weaning or that aborts) should be culled (Aumaitre et al., 1976; Gill, 2007), since this lowers the productivity (Aumaitre et al., 1976) and profitability (Jalvingh et al., 1992) of the herd. Sows that return to estrus after service twice must be culled immediately, since this might be due to inherited infertility (Knox, 2005a). The most common cause for culling is reproductive failure (Jalvingh et al., 1992; Koketsu et al., 1997a; Engblom et al., 2007), which constitutes around 30 % of the culling. Thereafter, the most common causes for culling are the age of the sow (*i.e.* old), udder problems (Engblom et al., 2007), low productivity (Jalvingh et al., 1992; Koketsu et al., 1997a; Engblom et al., 2007), lameness or foot problems (Knox, 2005a; Engblom et al., 2007) and traumatic injuries (Engblom et al., 2007).

The total number of piglets born per sow increases for each parity number up until parity eight, when litter sizes start to decrease again. However, the total number of piglets born in parity eight and over nine are still higher than in early parities (Vesseur et al., 1994). Research shows that sows obtain their largest litters from parity three to ten (Vesseur et al., 1994; Dewey et al., 1995; Koketsu, 2005).

The herd-culling rate is normally around 50 % per year (Jalvingh et al., 1992; Engblom et al., 2007) and the average parity number at removal is 4.4 in Sweden (Engblom et al., 2007). When the average parity number at culling increases (*i.e.* when the culling rate is low), the number of piglets produced increases (Jalvingh et al., 1992; Houška, 2009; Engblom et al., 2007) and the number of non-productive days decreases (Engblom et al., 2007; Houška, 2009), since primiparous sows have a longer weaning to service interval (Aumaitre et al., 1976). However, Jalvingh et al. (1992) found that a high culling rate decreases herd age and thus also the number of non-productive days. An excessive culling rate may decrease profitability (Houška, 2009) and the number of weaned piglets per sow and year (King et al., 1998). If a sow is culled too early she is unable to reach her optimal parity (Knox, 2005a). In a herd where many sows are old and the culling rate is high for a period of time, there is a risk that immature gilts enter reproduction during a non-optimal time. This might affect production and the longevity (Knox, 2005a). Gilts should be inseminated for the first time during their second or third estrus and when they are at least 210 and at most 240 days of age (Knox, 2005a). Lack of enough replacement gilts may lead to unfilled groups or that sows which should actually be culled are kept (Knox, 2005a). Keeping the herd stable, with a combination of sows of different parity numbers and gilts, is important for the herd productivity (Koketsu, 2005).

5.4. Housing to increase the number of weaned piglets per sow and year

Farrowing crates

In order to minimize the pre weaning mortality an optimal pen must be provided (Gill, 2007). The most common way of housing sows during the nursing period worldwide is in farrowing crates (Ahmadi et al., 2011). The purpose of farrowing crates is to protect piglets from being crushed by the sow (Grandinson, 2005; Baxter et al., 2011; KilBride et al., 2012). This is accomplished by a design that restricts the sow's motility (*i.e.* she can not walk or turn) and lying behavior (Cronin et al., 1996; Weber et al., 2007; Weber et al., 2009; Baxter et al., 2011; KilBride et al., 2012). Housing sows in farrowing crates generates a higher annual net margin than loose farrowing systems (Ahmadi et al., 2011). However, it has also been found that housing sows in farrowing crates increase stress in connection to farrowing (Jarvis et al., 2001) and that maternal behaviors are reduced (Cronin et al., 1996). In a Danish study it was found that 41 % of observed crated sows had difficulties when lying down, 15 % of observed crated sows were lame, 20 % of observed crated sows had skin lesions on hind feet and 20 % of observed crated sows had skin lesions on shoulders (Bonde et al., 2004). Farrowing crates, as a routine, are prohibited in Sweden, Switzerland and Norway (Andersen et al., 2007; Weber et al., 2007; Weber et al., 2009; SJVFS 2010:15; KilBride et al., 2012).

Loose farrowing systems

Housing sows in crates involves a conflict between piglet survival and sow welfare, which has led to the introduction of systems that allow the sow to move freely (Grandinson, 2005; Weber et al., 2007; Wechsler & Weber, 2007; Weber et al., 2009) and that improves sow welfare (Cronin et al., 1996; Ahmadi et al., 2011). In loose farrowing systems, like farrowing pens, the sow is able to move freely and turn within the pen (KilBride et al., 2012). A farrowing pen normally has a lying area designated for the sow, a creep area designated for the piglets and a dung area with for example slatted floors (Vasdal et al., 2011). In a farrowing pen the sow is generally offered litter, at least before and during farrowing, in order to let her express the behavior of nest building (KilBride et al., 2012). The added capital cost for farrowing pens have been calculated to 92 % higher in comparison to farrowing crates, primarily due to the required additional building space per animal (Baxter et al., 2011). However, if sow productivity is included into economical calculations, the net margin for sows housed in pens is higher than for sows housed in crates (Ahmadi et al., 2011). Some producers worldwide also compromise between crated and loose farrowing systems by keeping sows in crates during farrowing and the first days of the nursing period (*i.e.* day one to three) before releasing them into a pen (KilBride et al., 2012). In a study by KilBride et al. (2012) 33 % of the herds conformed to this practice.

There are also loose farrowing systems outdoors. In these systems the sow generally farrows in a hut but is able to move freely within a paddock (KilBride et al., 2012). The added capital cost for loose farrowing systems outdoors have been calculated to 249 % higher in comparison to farrowing crates (Baxter et al., 2011).

Creep area and provision of litter

Regardless of housing system, the creep area is provided with a heat source (KilBride et al., 2012) and fulfills the need of reduced heat loss after birth. The purpose of the creep area is to attract the piglets to rest there, instead of near the sow, where the risk of crushing is significant. In order to attract piglets to prefer the creep area it is important that it is warmer and more comfortable than staying close to the sow. Bowman et al. (1996) and Knox (2005b) found that the provision of an additional heat source was significantly associated with decreased pre weaning mortality but in a study by Andersen et al. (2007), neither the design of the creep area nor the amount of litter provided in the creep area, significantly affected the pre weaning mortality. However, it was common that the amount of litter in the creep area was generous during farrowing and strongly reduced in later lactation (Andersen et al., 2007).

Providing sows housed in farrowing pens with straw during farrowing has however been found to be important for piglet survival. That piglet mortality decreases when straw is provided in the pen could be due to reduced piglet heat loss against the concrete floor (*i.e.* insulation) or due to that the sow is more comfortable during farrowing and nursing if straw is provided, which in turn may cause her to move less (Andersen et al., 2007). Malmkvist et al. (2006) found that the use of floor heating decreased the time between birth and first suckle, as well as the pre weaning mortality due to chilling. Providing sows housed in farrowing crates with straw did in a study by Friendship et al. (1986) not have any effect on pre weaning mortality.

Effects on mortality

Swedish producers often state that one reason why European countries, such as Denmark, have lower pre weaning mortality is due to the fact that they are allowed to use farrowing crates as a routine. Loose farrowing systems have traditionally been associated with higher pre weaning mortality in comparison to crates (Weber et al., 2007; Weber et al., 2009; KilBride et al., 2012). Several studies have also been able to verify that the pre weaning mortality is higher in pens than in crates (Friendship et al., 1986; Cronin & Smith, 1992; Blackshaw et al., 1994; Marchant et al., 2000). Blackshaw et al. (1994) found that the mortality in pens (3.9 m^2) where 32 % whereas in crates 14 % and Marchant et al. (2000) found that mortality due to crushing was 14-17 % in pens (4.1 m^2) and 8 % in crates. KilBride et al. (2012) also found a trend (*i.e.* not significant) towards higher mortality, due to crushing of healthy piglets, in farrowing pens compared to farrowing crates. Other studies could however not establish any differences in the number of weaned piglets between crates and pens (Cronin et al., 2000). In an extensive study by KilBride et al. (2012) the effects of different housing systems were investigated in relation to the presence of stillbirths and pre weaning mortality. The housing systems in the study were farrowing crates, crates/pens (*i.e.* sow crated during farrowing and the first days after birth), farrowing pens and outdoor farrowing in huts. KilBride et al. (2012) found that mortality due to other causes than crushing of healthy piglets, *i.e.* low viability, starvation, crushing of sick piglets and diarrhea, was significantly higher in farrowing crates than in farrowing pens. Thus there was no significant difference in total piglet mortality between the systems and thereby no improvement in survival in farrowing crates compared to alternative systems, even if the causes of death varied. Cronin et al. (1996), Cronin et al. (2000), Gill (2007) and Weber et al. (2007) also found that there was no significant difference in total pre weaning mortality between sows housed in farrowing pens (8.2-12 m^2) and crates. Since the pen size was smaller in studies that found a higher mortality in pens than in crates (Blackshaw et al., 1994; Marchant et al., 2000) compared to studies that found no difference in mortality (Cronin et al., 1996; Cronin et al., 2000; Weber et al., 2007), it is probable that the pen size is important for piglet survival. Danish studies have shown that farrowing pens ≥6 m^2 are optimal for both sow and piglets (Aarestrup Moustsen & Lohmann Poulsen, 2005).

When designing pens it is important to include the welfare of the piglet by reducing the risk of crushing (Cronin et al., 1996). Thus, pens are often designed with sloping walls, or alternatively protection rails along the sides of the walls, with the purpose to protect the piglets from getting crushed between the wall and the sow (Andersen et al., 2007; KilBride et al., 2012). Producers consider the use of rails as an important factor for decreasing piglet mortality due to crushing. However, there are few studies investigating the benefit of these rails (Andersen et al., 2007). Two studies (Danholt et al. (2011) and Andersen et al. (2007)) found reduced mortality when protection rails or sloping walls were present whereas Weber et al. (2009) found no significant effect of protection rails. Housing sows in farrowing pens during the nursing period puts greater demands on the maternal abilities of the sow and the management around farrowing (Andersen et al., 2007; Wechsler & Weber, 2007; Baxter et al., 2011). It is important that sows are careful and respond to warning signals from their piglets in order to reduce incidences of crushing (Grandinson, 2005). Sows kept in farrowing pens express more behaviors against their piglets (*i.e.* sniffing, touching or calling on piglets), are more responsive to screaming piglets and are more careful when lying down than sows housed in crates (Cronin et al., 1996). The management also has a greater impact on piglet survival in comparison to farrowing crates (Andersen et al., 2007; Wechsler & Weber, 2007).

KilBride et al. (2012) found that the number of stillborn piglets was significantly lower in loose-housed outdoor systems than in farrowing crates. According to the authors, this was probably due to that sows housed outdoors were able to move more before farrowing and thus had shorter farrowing durations and perhaps experienced reduced maternal stress. However, the number of crushed healthy piglets was significantly higher in loose-housed outdoor systems than in farrowing crates (KilBride et al., 2012) and the number of piglets weaned lower (Le Cozler et al., 1997). Mortality due to other causes than crushing was significantly higher in farrowing crates than in loose-hosed outdoors systems (KilBride et al., 2012).

Friendship et al. (1986) found that larger farrowing units, containing more farrowing crates or pens, were associated with higher pre weaning mortality. According to the authors, this could be due to that larger units are harder to clean and that it is harder to maintain a stabile climate in a large unit than in a small. Variations in climate may lead to an increased frequency of the sow standing up or lying down, which in turn may lead to more incidences of crushing. They also found the presence of certain "problem crates" or "problem pens" in close connection to fans, doors or isles. Providing an appropriate thermal environment during farrowing and during the first days after birth is important for piglet survival (Tuchscherer et al., 2000). In trials by White et al. (1996) and Tuchscherer et al. (2000) the average temperature in the farrowing unit was set to 20-22°C and the average temperature in the creep area was set to 32°C. Control of temperature in the unit is significantly correlated to low mortality (Knox, 2005b; Gill, 2007). The combination of chilled piglets and an overheated sow increases the risk of piglets being crushed (Knox, 2005b). Munsterhjelm et al. (2006) found that housing sows on floors of high quality was connected to the number of weaned piglets per sow and year. Light also has an impact on sow productivity as Gaustad-Aas et al. (2004) found that sows in regions where the hours of daylight were few, had a higher number of piglets born alive than sows in regions with many hours of daylight. It is probable that the amount of artificial light is higher in regions with less daylight and this might be one cause to the influence on litter sizes. In that case, the amount of artificial light would affect sow productivity.

5.5. Breeding to increase the number of weaned piglets per sow and year

Number born alive

Genetic selection on litter size is possible (Merks et al., 2000; Hanenberg et al., 2001). The most important cause to the increased number of weaned piglets, seen in many countries, is the genetic selection for an increased number of piglets born alive (Gill, 2007). Selection, during the past ten years, has increased the total number of piglets born per sow and year with at least two piglets in the Large White breed and more than three piglets in the Landrace breed (Knox, 2005a). Denmark has especially succeeded to increase the number of live born piglets by genetic selection (Gill, 2007; Vinther, 2012). Several different reproductive events determine the subsequent litter size. Clear signs of estrus are important in order to be able to detect estrus and thereby serve the sow at the right time (Knox, 2005b). The ovulation rate, *i.e.* the number of shed oocytes, determines the potential number of embryos (Knox, 2005a). Semen doses of high quality are a prerequisite for successful conception (Young et al., 2010). After conception it is also important that the embryos or fetuses are able to survive in the uterus why the uterus capacity has an impact. The gestation length as well as the events during farrowing, such as the farrowing duration and possible need for obstetric assistance, may also influence the number of live born piglets. However, all these traits have low to moderate heritabilities (see Table 2), indicating that environmental factors also have substantial influence (Hanenberg et al., 2001; Knox, 2005a; Bidanel, 2011). Heritabilities for litter size (*i.e.* total number born or number born alive) are thus also low (Roehe, 1999; Hanenberg et al., 2001; Lund et al., 2002; Bidanel, 2011, see Table 2). Still, selection for these traits has occurred successfully for a long time (Knox, 2005a). A prerequisite for successful selection of low heritability traits demands data and information from many offspring in order to obtain high accuracy (Simm, 2000), which is facilitated due to the large litter sizes of pigs.

Table 2. Estimated heritabilities for traits related to litter size

Trait	Heritability (h^2)	Source
Estrus symptoms	0.21	Bidanel, 2011
Ovulation rate	0.32	Bidanel, 2011
Semen volume	0.19	Bidanel, 2011
Sperm concentration	0.19	Bidanel, 2011
Sperm motility	0.11	Bidanel, 2011
% abnormal sperm	0.10	Bidanel, 2011
Gestation length	0.29	Hanenberg et al., 2001
Prenatal survival	0.15	Bidanel, 2011
Total no. piglets born	0.10-0.14	Roehe, 1999; Hanenberg et al., 2001; Lund et al., 2002; Bidanel, 2011
No. piglets born alive	0.06-0.10	Roehe, 1999; Hanenberg et al., 2001; Lund et al., 2002; Bidanel, 2011
Farrowing duration	0.07	Bidanel, 2011
Obstetric assistance	0.05	Bidanel, 2011

Litter size is included in the breeding evaluation for the Swedish Yorkshire dam-line (*i.e.* the number of piglets born alive in parity one to three) (Nordic Genetics, 2012), the Norwegian Landrace dam-line (21 % weight) (Norsvin, 2012), the Danish Yorkshire dam-line and the Danish Landrace dam-line (Nielsen & Nørgaard, 2012).

Improved piglet survival

Breeding programs often focus on increasing the number of piglets born in maternal lines (Grandinson et al., 2002), which has lead to larger litters (Johnson et al., 1999; Holl & Robison, 2003; Vanderhaeghe et al., 2010). The effects of increased litter sizes are lower birth weights (Hartsock & Graves, 1976; Weary et al., 1998; Johnson et al., 1999; Roehe, 1999; Roehe & Kalm, 2000; Quiniou et al., 2002) and greater variation within litter (Quesnel et al., 2008). The increased litter sizes have also led to increased presence of stillbirths (Hanenberg et al., 2001; Knox, 2005a; Oliviero et al., 2010; KilBride et al., 2012) and increased pre weaning mortality (Hartsock & Graves, 1976; Johnson et al., 1999; Tuchscherer et al., 2000; Hanenberg et al., 2001; Grandinson et al., 2002; Knol et al., 2002b; Knox, 2005a; Gill, 2007; Bidanel, 2011). Breeding for larger litters can therefore not guarantee larger litters at weaning (Hanenberg et al., 2001; Knol et al., 2002b; Grandinson et al., 2002).

Thus, breeding for increased piglet survival could increase the productivity and profitability of piglet producers. Due to the fact that selection for larger litters result in increased mortality, it is important to include the sow's capability of raising large litters into breeding programs. However, since heritabilities for mortality and survival traits are low (see Table 3), the potential genetic progress is low (Grandinson et al., 2002). There are no physiological limits to selecting for piglet survival (Hanenberg et al., 2001; Knol et al., 2002a; Knol et al., 2002b). However, if breeding for larger litters without breeding for increased resources, piglet mortality will increase. The breeding for lean carcasses has, for example, broken the favorable relationship between birth weight and piglet survival, since piglets with high birth weights have become less mature at birth (Herpin et al., 1993; Knol et al., 2002b). An increased birth weight does not necessarily mean higher chance of survival, since the sow may be unable to release enough body reserves in order to nurture large litters of large piglets (Grandinson et al., 2002).

When discussing the possibility to breed for increased survival, it is important to consider the genes of the piglet (*i.e.* the vitality), the genes of the sow (*i.e.* the uterus quality) and the genes of the sow fostering the piglet (*i.e.* maternal traits). Thus, as well direct as indirect, maternal effects need to be included in the breeding evaluation (Lamberson & Johnson, 1984; van Arendonk et al., 1996; Knol et al., 2002a; Lund et al., 2002). Since piglets that die are generally smaller and lighter than surviving piglets (Hartsock & Graves, 1976; Bowman et al., 1996; Weary et al., 1998; Roehe, 1999; Roehe & Kalm, 2000; Tuchscherer et al., 2000; Rooke & Bland, 2002; Andersen et al., 2007), there has been focus lying on breeding for heavier litters. Litter weight is a trait that is mainly affected by the sow (Roehe, 1999; Grandinson et al., 2002; Knol et al., 2002a). Heritabilities for birth weights are low to moderate (see Table 3), even if the maternal heritability is higher than the direct heritability (Grandinson et al., 2002; Knol et al., 2002a). The litter weight at three weeks of age is included in the breeding evaluation for both Swedish Yorkshire (Nordic Genetics, 2012) and Norwegian Landrace (Norsvin, 2011). The daily gain from birth to 30 kg is included in the breeding evaluation for Danish Yorkshire, Danish Landrace and Danish Duroc (Nielsen & Nørgaard, 2012).

However, even though Swedish and Danish piglets are bred for high litter weight the pre weaning mortality remains high (Svenska Pig, 2012a; Vinther, 2012). Grandinson et al. (2002) found that there is a positive (unfavorable) genetic correlation between birth weight and stillbirths, *i.e.* heavier piglets are in greater risk of being stillborn. Thus, the genetic correlation between birth weight and total piglet survival is low (Grandinson et al., 2002; Knol et al., 2002b). If aiming towards improved survival through breeding programs, it is preferable to breed for vital piglets rather than for heavy piglets since breeding for birth weight alone is not the solution to decreasing the total pre weaning mortality. An increased birth weight may result in fewer piglets being crushed (Varley, 1995; Grandinson et al., 2002) but may also result in larger numbers of stillborn piglets (Grandinson et al., 2002). There is a genetic correlation between piglet survival and variation in birth weight within litters. Thus, in order to decrease the pre weaning mortality, the variation between piglets within litter should be decreased and selection for vital piglets should be superior to selection for heavy piglets (Knol et al., 2002b). The heritability for litter homogeneity at birth is however low (see Table 3).

Still genetic selection for piglet survival is possible (van Arendonk et al., 1996; Hanenberg et al., 2001; Knol et al., 2002a; Knol et al., 2002b; Lund et al., 2002). The Danish breeding program has, since 2004, included litter size at day five (*i.e.* the LG5 breeding goal) and this has successfully decreased piglet mortality at the same time as the number of live born piglets has increased (Christiansen, 2010; Klingenberg Jørgensen, 2011; Vinther, 2012). The purpose of the LG5 breeding goal is to increase the number of live born piglets per litter on the fifth day of life and is used in the Yorkshire and Landrace dam lines (Christiansen, 2010). The positive effects of this breeding goal could first be observed between the year 2010 and 2011 (Vinther, 2012). Thus, it took seven years of selection before commercial piglet producers could gain from the LG5 breeding goal. The gain has reported to be around +0.5 piglets per sow and year (Christiansen, 2010; Nielsen & Nørgaard, 2012). Piglet survival is not included in the breeding evaluation for Swedish Yorkshire dam-lines (Nordic Genetics, 2012) but is included in the breeding evaluation for the Norwegian Landrace dam-line (maternal traits have 22% weight) (Norsvin, 2012). However, piglet survival is one out of 26 traits included in the breeding goal (Norsvin, 2011), which means that the weight of this particular trait is probably low.

Table 3. Estimated heritabilities for traits related to piglet survival

Trait	Heritability (h^2)	Source
Litter homogeneity at birth	0.08	Bidanel, 2011
Birth weight (maternal)	0.15-0.20	Grandinson et al., 2002; Knol et al., 2002a
Birth weight (direct)	0.04	Grandinsson et al., 2002; Knol et al., 2002a
Litter weight at birth	0.24	Bidanel, 2011
Stillbirths	0.04-0.05	Hanenberg et al., 2001; Grandinson et al., 2002
Crushing	0.01	Grandinson et al., 2002
Total pre weaning mortality	0.02-0-07	Roehe & Kalm, 2000; Grandinson et al., 2002
Maternal ability	0.03	Hanenberg et al., 2001
Pre weaning survival	0.04-0.05	Knol et al., 2002b; Bidanel, 2011
Pre weaning survival (direct)	0.11	van Arendonk et al., 1996
Pre weaning survival (maternal and nurse sow)	0.02-0.09	van Arendonk et al., 1996; Knol et al., 2002a
Survival pre three weeks	0.01-0.08	Lund et al., 2002
No. weaned piglets	0.08	Bidanel, 2011

Litters per sow and year

It is possible to select for the number of litters per sow and year, the farrowing rate and weaning to service interval (Merks et al., 2000). The selection should primarily be performed on the weaning to service interval (h^2=0.07, see Table 4) and age at first insemination (h^2=0.32, see Table 4), since there is a positive genetic correlation between these traits (Hanenberg et al., 2001). However, Bidanel (2011) found a higher heritability for the weaning to estrus interval (0.22, see Table 4) why selection for this trait might be preferable. Hanenberg et al. (2001) thought that selection on farrowing rate should be avoided due to the low heritability (0.01, see Table 4). However, Bidanel (2011) found a significantly higher heritability for farrowing rate (0.10, see Table 4) than Hanenberg et al. (2001) did. The weaning to service interval is included in the breeding evaluation for the Swedish Yorkshire dam-line (Nordic Genetics, 2012). Reproduction has only one percent weight in the breeding evaluation for the Norwegian Landrace dam-line (Norsvin, 2011). In the Danish Yorkshire and Landrace dam-lines the culling rate and sow longevity are the only reproductive traits included in the breeding evaluation (Nielsen & Nørgaard, 2012).

Table 4. Estimated heritabilities for traits related to the number of litters/sow and year

Trait	Heritability (h2)	Source
Weaning to service interval	0.07-0.22	Hanenberg et al., 2001; Bidanel, 2011
Farrowing rate	0.01-0.10	Hanenberg et al., 2001; Bidanel, 2011
Rebreeding interval	0.23	Bidanel, 2011
Age at first insemination	0.32	Hanenberg et al., 2001

6. OWN STUDY

6.1. Materials and methods

6.1.1. SELECTION OF SUCCESSFUL HERDS

Swedish successful herds were identified and selected through the top list of the ten most successful piglet-producing herds in the country, published by the Swedish organization Svenska Pig each year. The list is based on the average number of produced piglets per sow and year, a key performance indicator closely connected to the number of weaned piglets per sow and year. Herds on the list must use the herd-monitoring program PigWin Sugg and have agreed to participate in the competition by allowing production results to be published. Thus, there might be unknown herds that are actually more successful than herds on the list. Twelve herds qualified into the top list of 2011, as three herds shared the tenth place. These herds were contacted and asked to be a part of the study. Eight of the 12 producers were reached and had the opportunity to participate in the study.

Danish successful herds were identified and selected by the contacts of Svenska Pig, Svenska Djurhälsovården and the animal health company Merial. Danish veterinaries from Merial contacted three Danish herds that were asked to be a part of the study and they all agreed. The criterion, set for selected herds, was that they should wean more than 30 piglets per sow and year.

6.1.2. COLLECTION OF DATA

The eleven herds (*i.e.* eight Swedish and three Danish herds) were visited. Swedish herds were visited during September, October and November 2012 and Danish herds were visited during November and December 2012. Herd data and sow data collection was performed during the herd visits. Herd production data, including key performance indicators, from herd monitoring programs (*i.e.* PigWin Sugg, Agrosoft and SvineIT) was collected electronically after the visits.

6.1.2.1. Interviews and herd data collection

During the herd visits, face-to-face qualitative interviews were performed with the herd owner and, in some cases, an employee at the farm. A standardized interview questionnaire (see Appendix I) was used and answers were noted directly on this questionnaire. The interview was performed in all herds but some questions were left out at some visits, since not all questions were applicable to all herds. Sometimes questions were cancelled due to shortage of time. The questions concerned general information about the farm (production, housing, feed etc.) as well as different management questions concerning routines during estrus, service, gestation, farrowing, the nursing period and weaning. The first part of the questionnaire contained general questions about the farm and questions about routines etc. The second part of the questionnaire contained questions concerning the most recent batch weaned. When producers were asked questions concerning the most recent batch weaned they were not allowed to answer them according to routines etc. in order to avoid answers corresponding to normal or desired management. Thus, producers were supposed to answer on the basis of what happened during one particular batch. Questions were predominantly designed so that producers could answer either yes/no or on a graded scale from one to five. Questions were also designed so that the producer could choose from different alternatives or in some cases direct (*i.e.* How many piglets do you produce per year? I produce 5000 piglets per year). However, questions were asked in an open way so that the producers were able to give whatever answers they wanted in order to avoid bias. The interviewed producer always had the opportunity to provide further information. The interview questionnaire is shown in Appendix I.

6.1.2.2. Sow-, litter- and farrowing unit data collection

Collection of sow-, litter and farrowing unit data was performed for one batch, containing lactating sows and nursing piglets, per herd. Sow- and litter data was recorded on litter level. The criteria for chosen batches were that all sows should have farrowed so that it would be possible to, for example, count the number of piglets. Besides this criterion, there were no other demands, *i.e.* the age of the piglets varied between a few days and five weeks of age. A standardized protocol (see Appendix II) was used and observations and measures were noted directly on this protocol. Observations and measures were noted in actual numbers, as an answer to a question (*i.e.* yes or no) or on a rated scale from one to four or one to five. The same person (I) performed all observations and measures in order to avoid bias. Observations were performed in all herds visited but the number of observations per herd varied, due to variation in the number of sows per batch between herds. Due to shortage of time it was generally not possible to collect data for all sows in the batch visited. In such situations, for example, two out of four rows in the unit were chosen for observation. Rows containing only gilts or purebred sows were in such situations avoided. Sometimes, other reasons than shortage of time caused failure of observation. Some herds did, for example, not use sow cards, which made it impossible to collect data of the number of stillborn or live born piglets. It was also not possible to count the number of functional teats or rate the body condition score of sows that were lame or unable to stand up. Sow/litter data were either collected from the sow card or collected manually from each sow/litter. Parameters collected manually were estimated or rated visually, by palpation, by measurement with suitable equipment or by combinations of these. Sow- and litter data collection was performed in absence of the producer in order to avoid bias. In total, data from 209 sows and litters was recorded, of which 179 sows were Swedish and 30 sows were Danish.

Parameters recorded from the sow card were:

- Sow id
- Parity number
- Total number of piglets born
- Number of piglets born alive
- Number of stillborn piglets
- Whether the litter had been subjected to cross fostering
- In case of a cross fostered litter, how many piglets that had been added to or subtracted from the litter
- The planned farrowing date
- The actual farrowing date
- Whether any complications had occurred during farrowing
- Whether the sow had been subjected to Mastitis-metritis-agalactiae (MMA)
- Whether the sow had received any medical treatment
- Number of live born piglets that had died and the causes for death.

Parameters recorded manually for each sow were:

- Sow id (if not available on sow card)
- The current number of piglets in the litter
- Rated hygiene in the pen (score 1-5)
- Number of available water nipples for the sow
- Number of available water nipples for piglets
- Water flow in sow nipples (score 1-5)
- Water flow in piglet nipples (score 1-5)
- Presence or no presence of additional protection rails
- Rated homogeneity of the litter (score 1-5)
- Litter rating (score 1-5) *i.e.* the overall impression of the litter appearance including size, vitality and homogeneity

- Presence or no presence of feed in through
- Floor surface temperature in the creep area
- Floor surface temperature in the sow lying area
- Number of functional teats
- Number of teat pairs anterior navel
- Rated udder health (score 1-5)
- Presence and number of shoulder lesions
- Rated body condition score (score 1-4)
- Rated leg health (score 1-5)
- Rated hoof health (score 1-5)
- Number of parameters noted on sow card.

Observations and measurements of different parameters concerning the climate and environment in the farrowing unit were also collected. In order to obtain unbiased recordings, measurements were performed in three pre-determined and scattered locations of the unit. All measurements were performed inside pens at the animal level. Measures were reported directly to the producers for feedback. The standardized protocol is shown in Appendix II.

Climate/environmental parameters recorded in the farrowing unit were:

- Number of farrowing pens
- Number of sows and litters
- Age of the piglets
- Temperature (measured with IR-Thermometer)
- Relative humidity (RH) (measured with psychrometer)
- NH_3-level (measured with Kitagawa pump and detector tubes)
- Noise level (measured with audio meter)
- Light intensity (measured with lux meter)
- Rated dust level (score 1-5)
- Number of fans
- Number of air inlets per pen.

6.1.2.3. Key figures and production data collection

During herd visits, Swedish producers were asked if they would agree to send a web-backup of their herd-monitoring program with key figures and production data. All Swedish producers used PigWin Sugg as their herd-monitoring program and agreed to send a web-backup by e-mail. The web-backup was sent after weaning of the batch where observations and measurements had been performed. Thus, data of the number of weaned piglets, for sows included in the study, could be obtained as well as production reports for the past year. Danish producers were asked if they would agree to send a production report for the past year instead of a web-backup, due to the fact that the software needed in order to receive web-backups from Agrosoft or SvineIT, were not available. All Danish producers agreed to send production reports by e-mail.

6.1.3. STATISTICAL ANALYSIS

Descriptive statistics (*i.e.* means and frequencies) for herd-, sow-, litter- and farrowing unit data was calculated using the MEANS- and FREQ-procedures in SAS© 9.2 (2002-2008). The purpose was to describe successful Swedish and Danish herds in terms of sow material, management, housing, feed etc. Thus, it was possible to compare herds in terms of what they had or had not in common or what management factors the majority of herds used. Swedish and Danish herds were separated in the analysis in order to note differences between the countries. In order to calculate associations between management factors and sow productivity, sow data was tested in variance models using the GLM-procedure in SAS © 9.2 (2002-2008). A matrix over performed variance tests is shown in Table 5. The effect of herd and parity number was included in all models tested.

Since all data was from the same period of time no effect of time was included in the model. Effects of management on sow productivity parameters in Swedish and Danish sows was tested separately as well as for all sows included in the study. Statistical models were constructed to analyze factors influencing number of piglets born alive (NBA), number of piglets born dead (NBD), number of weaned piglets per sow (NW), homogeneity of litter and litter rating. Data on the number of piglets weaned per sow, litter homogeneity and litter rating was only available for Swedish sows. Thus, it was only possible to test the different sow- and litter parameters on the above mentioned sow productivity measures on Swedish sows.

Table 5. Matrix showing performed statistical tests in proc glm analyses, factors included in statistical models

	No. of sows	Classified (no.groups) or continuous	NBA	NBD	NW	Homogeneity of litter	Litter rating
			S+DK	S+DK	S	S	S
Herd	209	Class (11)	X	X	X	X	X
Parity number	202	Class (6)	X	X	X	X	X
Pen hygiene	179	Class (5)			X		
No. water nipples sow	209	Class (2)	X	X	X		
No. water nipples piglets	209	Class (2)			X		
Water flow sow nipple	176	Class (5)	X	X	X		
Water flow piglet nipple	176	Class (5)			X		
Litter homogeneity	179	Continuous			X		
Litter rating	179	Continuous			X		
Empty/feed in trough	176	Class (2)			X	X	X
Surface temp creep area floor	178	Continuous			X		
Surface temp sow area floor	178	Continuous	X	X	X		
No. functional teats	193	Class	X	X	X	X	X
No. teat pairs in front of navel	167	Class	X	X	X	X	X
Rated udder health	146	Class (5)			X	X	X
Presence of shoulder lesions	147	Class (3)	X	X	X		
Body condition score	147	Class (4)	X	X	X	X	X
Leg health	147	Class (5)	X	X	X		
Hoof health	146	Class (5)	X	X	X		

NBA= Number born alive; NBD=Number born dead; NW= Number weaned
S=Test only possible for Swedish sows; DK= Test only possible for Danish sows;
S+DK=Test possible for all sows

After trying each effect only with herd and parity in the model all significant parameters were included in a combined model per analyzed trait. None of the sow- or management parameters tested (see Table 5) had a significant impact on NBA or NBD. In the end, three statistical models were used.

Model 1: NW = Herd + Parity number + Litter rating + Number of functional teats + Rated udder health
Model 2: Litter homogeneity = Herd + Parity number + Rated udder health
Model 3: Litter rating = Herd + Parity number + Body condition score + Rated udder health

In order to calculate whether different sow parameters differed between countries, sow data was tested in variance analyses models using the GLM-procedure in SAS © 9.2 (2002-2008). The difference between countries for sow parameters were not tested using mixed models, since the herds were not randomly selected. Sow parameters tested for differences between countries were the total number of piglets born, the number of piglets born alive, the number of stillborn piglets, the number of functional teats, the number of teat pairs in front of the navel, the rated udder health (score 1-5), the number of shoulder lesions, the body condition score (score 1-4), the rated leg health (score 1-5) and the rated hoof health (score 1-5). In these analyses the model included herd (nested within country), country and parity number (see Model 4). No effect of time period was included in the model since all records were from the same period.

Model 4: Trait[8] = Herd (country) + Country + Parity number

Since only eleven herds were included in the study (*i.e.* the observations were too few) key figures and production data (one record per herd) could not be tested at herd level. Production data was instead compiled into figures for comparison between herds and countries.

7. RESULTS

7.1 Sweden

7.1.1. GENERAL HERD RESULTS

The majority of the eight herds were either integrated (three of eight) or external integrated (three of eight). No farrowing interval was more common than the other, as two of the herds had farrowings every third week, two of the herds had a 4(45) farrowing system and two of the herds had a 7(78) farrowing system. The least common farrowing systems were farrowings every second week (one herd) and every 2.5-week (one herd). Descriptive statistics for general herd parameters is shown in Table 6. The average number of delivered piglets per herd and year was 5869 and the number of sows in production was on average 228. The sows were on average divided into 5.9 groups with 39 sows in each group. When producers were asked for how long they had conducted the current production, the average answer was for nine years. The producers were generally more positive than negative in terms of how they perceived their production at the time of the visit (*i.e.* 3.9 out of 5) and profitability (*i.e.* 3.1 out of 5). All producers were generally satisfied with their herd veterinary and they all gave them the highest possible perceived score (*i.e.* 5 out of 5). Six of the producers also had some kind of herd advisor in addition to their veterinary. The producers were generally positive in terms of how they perceived the herd advisor (*i.e.* 4.6 out of 5).

Table 6. Descriptive statistics for general herd parameters

Parameter	N	Mean	Min	Max	Unit
Delivered piglets/year	8	5869	3000	13000	pcs
No. sows in production	8	228	120	495	pcs
No. sow groups	8	5.9	3.0	11.0	pcs
No. sows/group	8	39.0	18.0	55.0	pcs
Yrs in current production	8	9.0	1.5	13.5	years
Perception of production	8	3.9	3.5	4.0	1-5
Perception of profitability	8	3.1	2.0	4.0	1-5
Perception of advisor	5	4.6	4.0	5.0	1-5
Perception of veterinary	7	5.0	5.0	5.0	1-5

[8] Traits tested according to the principle of Model 4: The total number of piglets born, the number of piglets born alive, the number of stillborn piglets, the number of functional teats, the number of teat pairs in front of the navel, the rated udder health, the number of shoulder lesions, the body condition score, the rated leg health and the rated hoof health.

7.1.2. HOUSING

7.1.2.1. Service- and gestation unit

The majority of herds had separate units for service and gestation (five of eight herds). The most common way of housing dry sows was in groups on deep-litter bedding with feeding stalls (six of 12 units) and most herds used long straw as litter (six of nine answers). The most common manure handling system was by removing deep-litter using a bobcat or hydraulic jack (five of 13 answers) or removal by drained floors, manure scrapes and transversal culverts (five of 13 answers). All herds in the study had mechanical ventilation with negative pressure in the units for dry sows. Seven of the eight producers stated that they were generally satisfied with the ventilation system and six of the eight producers stated that they were generally satisfied with the manure handling system used. The majority of herds did not have any additional night-lights in the units for dry sows (five of seven answers) and six of the herds did not change shoes or clothes between the units. Descriptive statistics for housing in the service- and gestation unit is shown in Table 7. The average number of units designated for dry sows were 1.8 and the age of the units were on average 13 years. There was on average 4.8 sick pens designated for dry sows in the entire herd. The lights were on average lit for 17.1 hours/day during service and for 10 hours/day during gestation.

Table 7. Descriptive statistics for housing in the service- and gestation unit

Parameter	N	Mean	Min	Max	Unit
No. gestation units	8	1.8	1.0	3.0	pcs
Age of unit	9	13.0	1.5	31.5	years
No. relief pens	6	4.8	0	10.0	pcs
Light time service	5	17.1	13.5	24.0	h
Light time gestation	7	10.0	1.0	16.0	h

7.1.2.2. Farrowing unit

The majority of the herds (six of nine farrowing units) housed lactating sows in farrowing pens and moved the piglets to a growers unit after weaning. Two herds had farrowing to growers units and one herd had farrowing in pens and then moved the sows and piglets to a loose-housed group system (*i.e.* "Family-system"). The creep area was generally located in connection to the working isle. All farrowing units were mechanically ventilated with negative pressure and all producers stated that they were generally satisfied with the ventilation system. The most common manure handling system was removal by drained floors, manure scrapes and transversal culverts (six of nine units). Five of the eight producers stated that they were generally satisfied with the manure handling system. The most common litter used for the sow was chopped straw (five of nine answers) and in the creep area chopped straw (six of 13 answers) or fine cutter shavings (five of 13 answers). All herds used additional heating lamps and had heated floors in the creep area. Seven of the eight herds had insulated floors and additional night-lights in the units. Six of the herds did not change shoes or clothes between units. Descriptive statistics for housing in the farrowing unit is shown in Table 8. The average number of farrowing units was 2.6 and the age of the units were on average 13 years. The lights were on average lit for 12.8 hours during the farrowing week and for 10.8 hours during the rest of the nursing period. The units were on kept empty for on average 5.4 days between batches.

Table 8. Descriptive statistics for housing in the farrowing unit

Parameter	N	Mean	Min	Max	Unit
No. farrowing units	8	2.6	2.0	4.0	pcs
Age of unit	9	13.0	1.5	31.5	years
Light time farrowing week	8	12.8	5.5	24.0	h
Light time nursing period	8	10.8	5.5	15.0	h
Empty time between batches	7	5.4	2.5	15.0	days

A number of environmental parameters were also measured in one farrowing unit per herd during. Descriptive statistics for measured farrowing unit parameters is shown in Table 9. The piglets were on average 3.9 weeks of age during the herd visits. The outdoor temperature varied between 8°C and 15°C, since the herds were scattered over a large part of the country and since the visits were also performed from September to November. The average measured indoor unit temperature was 20.8°C and the average temperature according to ventilation systems was 19.8°C. The average measured relative humidity (RH) was 52 %, but there were problems with the equipment. Measured ammonia (NH_3) levels were on average 5.4 ppm. The measured noise level was on average 63.6 dBA and the measured light was on average 125.9 lux. The rated dust level was generally moderate (*i.e.* on average 3.3 out of 5). There was on average two fans per unit and 0.72 air inlets per pen. The sows had access to one or two water nipples, generating an average of 1.4 nipples per sow. The rated water flow in sow nipples was on average 3.8 out of five. The piglets also had access to one or two water nipples, generating an average of 1.1 nipples per litter. The rated water flow in piglet nipples was lower than that for sow nipples (on average 2.8 out of 5). There was large variation between the number of parameters noted on the sow card, since some producers did not use any sow cards and some noted events frequently. The average number of parameters noted was 7.9.

Table 9. Descriptive statistics for measured farrowing unit parameters

Parameter	N	Mean	Min	Max	Unit
Farrowing week	8	37.9	33.0	43	week
Piglet age	8	3.9	2.0	5	weeks
Temperature outside	3	10.8	8.0	15.9	°C
Temperature unit	24	20.8	19.3	23.3	°C
Temperature ventilation	7	19.8	18.0	21.5	°C
Relative humidity unit	21	52.0	22.0	74.0	%
NH_3 unit	8	5.4	2.0	10.0	ppm
Noise level	24	63.6	56.0	69.0	dBA
Light level	24	125.9	52.0	197.0	lux
Rated dust level	24	3.3	2.0	4.0	1-5
No. of fans	8	2.0	1.0	3.0	pcs
No. air inlets/pen	6	0.72	0.29	1.0	pcs
No. sow nipples/pen	179	1.4	1.0	2.0	pcs
No. piglet nipples/pen	179	1.1	1.0	2.0	pcs
Rated sow nipple flow	176	3.8	0	5.0	1-5
Rated piglet nipple flow	176	2.8	0	5.0	1-5
No. parameters/sow card	8	7.9	0	14.0	pcs

7.1.3. FEED AND WATER

The majority (seven of eight) of herds had more than one feed mixture for sows, *i.e.* one feed for dry sows and one feed mixture for lactating sows. Some producers had three different feed mixtures, *i.e.* one feed for sows in the service unit, one feed for gestating sows and one feed for lactating sows. There were also some producers who fed sows in the service unit and sows in the farrowing unit a feed mixture designated for lactating sows. Most herds (six of eight) used complete feed for dry as well as lactating sows and five of eight herds used dry feed for both dry and lactating sows. The majority of producers stated that they adjusted the feed ration on a daily basis and five herds also used some kind of feed additive. Feed additives were in most cases used as an energy additive for too lean or first parity sows during lactation but some producers included feed additives into the daily feed ration for all lactating sows during. The majority (four of the five herds that produced own replacement gilts) did not have a separate feed mixture for replacement gilts. Replacement gilts were often fed a normal finisher diet until they were moved into the service unit, where they were normally fed a feed mixture designated for dry sows. When providing piglets with creep feed it was most common to serve a complete feed mixture and to serve this with iron peat and milk replacer powder (four of eight answers). Descriptive statistics for feed parameters are shown in Table 10. Piglets were on average 6.5 days of age when creep feed was first provided. All producers fed sows in the service unit (newly weaned sows, sows in estrus and newly served sows) twice daily. The average number of feedings per day for gestating sows was 1.6. The number of feedings per day for lactating sows varied between two and four (on average three feedings daily). When producers were asked if they changed the feed ration around the day of parturition 50 % (four herds) stated that they lowered the ration and 50 % (four herds) stated that they did not change anything. It took on average 11.2 days after farrowing until lactating sows reached their maximal feed ration and the stated variation between herds was large (7-14 days). The perceived presence of feed refusal was generally low (on average 2.1 out of 5). The most common way of handling sows that refused to eat was to provide another feed mixture or a feed additive (five of 11 answers). Sows were on average fed 61.1 MJ ME after weaning, 33.4 MJ ME during mid-gestation, 30.9 MJ ME during late gestation, 29.2 MJ ME at farrowing and 112.8 MJ ME after reaching maximal ration during lactation.

Table 10. Descriptive statistics for feed parameters

Parameter	N	Mean	Min	Max	Unit
No. feedings/day service	8	2.0	2.0	2.0	pcs
No. feedings/day gestation	8	1.6	1.0	2.0	pcs
No. feedings/day lactation	8	3.0	2.0	4.0	pcs
MJ ME/day after weaning	8	61.1	27.7	90.0	MJ ME
MJ ME/day mid gestation	7	33.4	27.7	40.0	MJ ME
MJ ME/day late gestation	7	30.9	27.7	35.0	MJ ME
MJ ME/day start lactation	8	29.2	18.9	39.6	MJ ME
MJ ME/day max lactation*	7	112.8	77.7	*ad lib*	MJ ME
Time postpartum max ration	8	11.2	7.0	14.0	days
Perception of feed refusal	8	2.1	1.0	4.0	1-5
Age of piglets at feeding start	8	6.5	3.5	10.0	days
No. feed samples/year	6	1.5	0	3.0	pcs

*One farm *ad lib*, not included in calculation of the average.

The majority (seven of eight) of producers stated that they had routines for checking the sows' body condition. All producers stated that body condition score control was performed by visual estimation and no one used sonar or palpation to measure the back fat thickness. However, some producers stated that the body condition scoring was performed by the advisor and in those cases it was not questioned what methods were used.

The average number of feed samples performed per year was 1.5, ranging from zero to three. It was uncommon that producers performed quality samples of litter and water. More than 80 % (six of seven herds) tested the straw hygiene less than once every year and more than 60 % (five of eight herds) tested the water quality less than once every year. When producers were asked if they had accumulations of anything in particular in the water that they provided their pigs, the most common answer was iron (three of eight answers).

7.1.4. MANAGEMENT

7.1.4.1. Service- and gestation unit

The majority of producers separated the farrowing group into smaller groups after weaning (six of eight herds). Most herds (six of ten answers) separated sows according to age and size in order to gather first- or second parity sows in one separate group during estrus and service. Two herds also separated according to body condition. The most common weekdays for sows to return to estrus after weaning were on Mondays (four of nine answers) and Tuesdays (three of nine answers).

Thus, estrus normally occurred in the beginning of the week. The majority of producers (seven of eight) experienced that their sows showed normal estrus symptoms and behavior. Descriptive statistics for reproductive management parameters are shown in Table 11. The average number of estrus checks per sow and day was 1.6. The majority of services were performed on Tuesdays (five of 15 answers) or Mondays (four of 15 answers). The average number of inseminations per sow and estrus was 2.5. Gilts were normally served by performing inseminations (three of six answers), rather than by natural mating (two of six answers), or a combination of AI and natural mating (one answer). However, all herds used natural mating by a boar occasionally. The average number of boars per herd was 2.1. When performing natural mating, it was most common to bring the sow into the boar pen rather than to bring the boar into the sow group (four of seven answers). If excluding natural mating as reason for keeping boars the most common boar use was for estrus synchronization and for inducing the standing reflex in sows during estrus and insemination (six of eight answers). The most common place for insemination was in a separate insemination stalls or insemination pens (three of nine answers). Other places used for inseminations were feeding stalls (two of nine answers), the loose-housed system (two of nine answers) and the boar pen (two of nine answers). The majority of herds performed one pregnancy test per sow and pregnancy (five of eight herds) at on average gestation day 28.4 and the rest of the herds performed two pregnancy tests. The second pregnancy test was on average performed on gestation day 51. Most herds (six of eight herds) used an ultrasonic meter to detect pregnancy. One herd used an ultrasonic scanner and one used the boar as a pregnancy tester. The producers did generally not perceive problems with sows returning to estrus after service (*i.e.* 2.1 out of 5) and none of the producers experienced problems with miscarriages.

Table 11. Descriptive statistics for reproductive management parameters

Parameter	N	Mean	Min	Max	Unit
Estrus checks/day	8	1.6	1.0	2.5	pcs
No. AI/sow/estrus	8	2.5	2.0	2.7	pcs
No. boars	8	2.1	1.0	4.0	pcs
Pregnancy test 1	8	28.4	28.0	30.0	gest. day
Pregnancy test 2	2	51.0	42.0	60.0	gest. day
Perception of returns-to-estrus after service	8	2.1	1.0	4.0	1-5

Descriptive statistics for culling and recruitment parameters is shown in Table 12. The yearly herd recruitment was on average 41 %. Sows were on average culled at parity 4.7 and at latest culled at on average parity 7.8. The most common cause for culling was age (five of 20 answers). It was more common to produce own replacement gilts (five of eight herds) than to buy replacement gilts from another producer. When producing replacement gilts the number of teats (four of 18 answers) and the hoof quality (four of 18 answers) were considered the most important traits for selection. Producers were generally satisfied with their own recruitment as the perception was on average 4.6 of five. Producers who purchased replacement gilts were generally also satisfied as the perception was on average 4.0 out of five. Gilts were on average served for the first time during estrus number 2.2.

All herds vaccinated their gilts against Parvovirus, seven of the eight herds vaccinated gilts against piglet diarrhea caused by *Escherichia coli* (*E. coli)* and *Clostridium Perfringens* (*Cl. Perfringens*) and seven of the eight herds vaccinated gilts against Erysipelas. All herds vaccinated their sows against Parvovirus and piglet diarrhea caused by *E.coli* and *Cl. Perfringens* in every cycle. Six of the eight herds vaccinated sows against Erysipelas.

Table 12. Descriptive statistics for culling and recruitment parameters

Parameter	N	Mean	Min	Max	Unit
Yearly recruitment	8	41.0	22.5	52.0	%
Average parity at removal	8	4.7	1.5	6.0	no
Max parity at removal	5	7.8	7.5	8.0	no
Estrus no. first service	5	2.2	1.0	3.0	no
Perception own recruitment	5	4.6	4.0	5.0	1-5
Perception purchased animals	3	4.0	3.0	5.0	1-5

7.1.4.2. Farrowing unit

Descriptive statistics for management in the farrowing unit is shown in Table 13. Sows were on average moved into the farrowing unit 7.1 days before farrowing. However, there was a large variation between herds (*i.e.* varied between 2.5-18 days). Half (four of eight) of the herds normally had farrowings that started on Wednesdays and the average number of farrowing days was 4.8. Thus, most herds had farrowings in the end of the week and during weekends. The producers were generally satisfied with the number of piglets born alive (*i.e.* perception 4.6 out of 5). They were also generally satisfied with the piglet growth (*i.e.* perception 4.3 out of 5) and did not consider the pre weaning mortality a large problem (*i.e.* perception 2.4 out of 5). All producers stated that the majority of piglet deaths occurred within one to three days after birth. Some producers (three herds) also mentioned a peak in mortality during the second or third week. The majority of producers perceived that the most common cause of death was crushing by the sow (four of eight answers). Some (two producers) also stated that a combination of factors (*i.e.* weak born piglets, starvation and crushing) was the most common cause of death. Some of the producers (six of 13 answers) considered the litter sizes as the underlying cause of pre weaning mortality while others (five of 13 answers) considered the sow as the underlying cause. The milk production of the sow and the piglets themselves were also mentioned.

Table 13. Descriptive statistics for management in farrowing unit

Parameter	N	Mean	Min	Max	Unit
Days pre partum moving in	8	7.1	2.5	18.0	days
No. farrowing days	6	4.8	4.0	7.0	days
Perception of NBA	8	4.6	4.0	5.0	1-5
Perception of growth	8	4.3	3.0	5.0	1-5
Perception of PWM	8	2.4	1.0	4.0	1-5
Perception of NW	8	4.3	4.0	5.0	1-5

NBA= Number born alive; PWM= Pre weaning mortality; NW= Number weaned.

In order to teach the piglets to find the creep area, some producers locked the piglets into the creep area for a while shortly after birth and colostrum ingestion. However, the majority of producers (five of six answers) stated that they did not lock the piglets into the creep area after birth. All eight herds grinded piglet teeth in litters where it was considered necessary, cross fostered litters and used analgesics in connection to castration. No producer required any specific education of their employees and all stated that interest was of more importance. All herds had a nursing period of five weeks and the majority weaned on a Thursday (six of ten answers).

7.1.5. THE MOST RECENT BATCH WEANED AS AN EXAMPLE

During the herd visits, producers were asked questions concerning the most recent batch weaned in order to avoid answers corresponding to normal or desired management. Thus, producers were able to share what happened during one particular batch. Descriptive statistics for the most recent batch weaned is shown in Table 14, 15 and 16.

The majority of producers experienced no ventilation problems during the nursing period, as seven of eight producers gave the highest possible perceived score (*i.e.* 5 out of 5). The average perception of the ventilation was 4.75. The majority perceived normal temperatures in the farrowing unit during farrowing (five of eight herds) and around weaning (six of eight herds). Most producers also considered the RH during farrowing normal (seven of eight herds) and all producers perceived normal RH around weaning. All producers perceived good air quality in the unit during farrowing and around weaning (*i.e.* perception 5 out of 5). Most producers (five of eight) did not notice any draught in the unit (*i.e.* perceived lowest possible score). Most of the producers (seven of eight) perceived highest possible score in terms of noise level, *i.e.* as very quiet. The majority of the producers (six of eight) washed the unit before the sows were moved into the unit and four of eight producers also disinfected the unit between batches. Hence, two of the eight producers did neither wash nor disinfect the unit before the most recent batch weaned. All producers that did wash the unit thought that the last washing represented a normal washing. The average empty time between batches was 5.4 days. The pen hygiene was generally considered good (perceived hygiene problems on average 1.3 out of 5). The majority of herds (five of eight) tested and adjusted all the water nipples before moving the sows into the unit and ensuring water intake around farrowing was generally considered important.

Descriptive statistics concerning feed and feeding in the most recent batch weaned is shown in Table 14. All producers stated that the sows had been given the same feed mixtures as normally and that no feed problems arose during the nursing period. The feeding routines around farrowing were also followed according to all producers. It took on average 11.8 days after parturition until sows were fed the maximal ration. In case of feed refusal, four producers stated that the sow was provided with another feed or feed additives and two producers stated that they adjusted the ration. However, the perception of feed refusal was generally low (average 1.8 out of 5) and the average number of sows given special feeding attention during lactation was 10.8. All producers used the same creep feed as normally and seven of eight herds had access to creep feed during the whole nursing period (*i.e.* they were never out of feed). Piglets were on average offered creep feed from day 6.4 of life. The body condition of the sows was generally checked on a daily basis (five of ten answers). The perceived body condition score of all sows in the group were on average 2.9 at time of farrowing, 2.8 at three weeks post farrowing and 2.5 at weaning.

Table 14. Descriptive statistics for feed and feeding in the most recent batch weaned

Parameter	N	Mean	Min	Max	Unit
No. days postpartum at max ration	8	11.8	8.5	14.0	days
Perception of feed refusal	8	1.8	1.0	5.0	1-5
No. sows with special feeding attention	4	10.8	0	24.0	pcs
Age piglets at feeding start	8	6.4	3.5	10.0	days
BCS at farrowing	8	2.9	2.0	3.0	1-4
BCS at 3w postpartum	8	2.8	2.0	3.0	1-4
BCS at weaning	8	2.5	1.0	3.0	1-4

BCS= Body condition score.

Descriptive statistics concerning farrowing parameters in the most recent batch weaned is shown in Table 15. Most farrowings started on a Thursday (three of eight batches) or on a Wednesday (two of eight batches) and the average number of farrowing days was 5.1. It was not common that sows farrowed before moving into the farrowing unit (on average 0.29 sows). The average number of employees working in the unit during farrowing was 1.6. The majority of herds (five of eight) had the same employee/employees working in the unit throughout the whole farrowing week, including weekends. The majority of herds (seven of eight) also had one person responsible for the batch. When producers were asked if they provided additional supervision during the farrowing week, seven answered that they checked the sows additionally in the evening. The average time spent in the unit during the farrowing week was 8.4 hours per day, in comparison to on average 3.1 hours per day during the rest of the nursing period. The most common way of establishing that a sow had started to farrow was by noticing her nest building behavior (six of 17 answers). The most common way of establishing that a sow had finished farrowing was by noticing afterbirth (seven of nine answers). When it was noticed that a sow had started to farrow, six producers stated that they provided additional litter and five producers stated that they made sure that the pen was clean and dry. Three producers stated that the additional litter was provided in connection to the rear of the sow. The perceived incidence of farrowing difficulties were moderate (*i.e.* 2 out of 5), but in case of farrowing difficulties it was most often considered that the age of the sow was the underlying cause (two of four answers). The most common way of handling farrowing difficulties was by injecting oxytocin in order to stimulate uterus contractions (six of 15 answers), to provide obstetric assistance (five of 15 answers) or to exercise the sows (three of 15 answers). It was uncommon that sows died during the nursing period (on average 0.13 sows).

All producers stated that the general sow health around farrowing was good. Producers were generally satisfied with the number of piglets born alive (4.3 out of 5) and the birth weights (4.1 out of 5) and did generally consider the number born dead (3.1 out of 5) and the number born weak (2.3 out of 5) moderate problems. The most common way of deciding if a dead piglet was stillborn or not, was by checking if the fetal membranes were left on the piglet (four of eight answers). No piglets were reported as born with abnormalities. The majority of herds (six of eight did not check the rectal temperature of all sows during or after farrowing. Most herds stated that they checked the rectal temperature of a sow if necessary, *i.e.* if she did not eat or seemed to be ill. Most producers (five of eight) also stated that they did not count the number of functional teats around farrowing. Many producers however stated, that they counted teats occasionally, particularly on older sows but it was common to expect a certain minimal number of teats as they never selected or purchased replacement gilts with fewer functional teats than for example 14. Some producers had also registered the number of functional teats per sow in PigWin so that it was easy to see on the sow card how many piglets she was able to nurse. It was also common that producers said that they checked the sow card for the number of weaned piglets during earlier parities in order to check how many piglets she had managed before.

Table 15. Descriptive statistics for farrowing parameters in the most recent batch weaned

Parameter	N	Mean	Min	Max	Unit
No. farrowing days	8	5.1	3.0	9.0	days
No. sows farrowed before moving in	7	0.29	0	2.0	pcs
No. employees in unit during farrowing	8	1.6	1.0	2.0	pcs
Time in unit/day during farrowing	7	8.4	3.5	18.0	h
Time in unit/day during nursing period	7	3.1	0.5	8.0	h
Perception of farrowing difficulties	7	2.0	1.0	4.0	1-5
No. sows died during farrowing/nursing	8	0.13	0	1.0	pcs
Perception of NBA	8	4.3	3.0	5.0	1-5
Perception of birth weight	8	4.1	3.0	5.0	1-5
Perception of NBD	7	3.1	2.0	4.0	1-5
Perception of NBW	8	2.3	1.0	3.0	1-5

NBA= Number born alive; NBD= Number born dead; NBW= Number born weak.

Descriptive statistics for management during the nursing period in the most recent batch weaned is shown in Table 16. All producers perceived that all piglets were able to ingest colostrum during the first hours after birth (*i.e.* perception 5 out of 5). The most common way of controlling this was by establishing that piglets seemed to be healthy and alert (six of nine answers). If a sow was subjected to agalactia it was most common to inject her with oxytocin (seven of 11 answers). Piglet diarrhea was not considered a big problem (perception on average 2.1 out of 5) and neither was piglets becoming weak (perception on average 2 out of 5). Although most producers stated that they normally did not lock the piglets into the creep area, most producers who stated that they did do something in order to teach the piglets to find the creep area stated that they locked the piglets into the creep area (six of ten answers).

All producers performed teeth grinding in litters where it was considered necessary. The most common way of providing additional iron was by providing one iron injection and iron peat (six of eight herds). The average piglet age at time of castration was 4.1 days. Six of seven herds used a castration bench and a scalpel to perform surgical castration. All producers gave analgesics in connection to castration. Almost all of the producers provided iron injections (seven of eight herds) and vaccinated against three-week diarrhea (*i.e.* Baycox) (six of eight herds) at the time of castration. The majority of producers (five of six) that vaccinated their piglets against three-week diarrhea considered the vaccination successful. Thus, diarrhea at three weeks of age was not considered as a problem (perception on average 1.4 out of 5). No hernias were discovered and all producers stated that the piglets had grown as expected at time of castration (perception 5 out of 5). The perceived litter homogeneity was 4.8 out of five and on average 1.1 piglets per litter had on average died at time of castration. The perceived amount of piglet treatments at time of castration was considered low (2.6 out of 5).

Most herds used chopped straw as litter for the sow (five of nine answers) and chopped straw (six of 13 answers) or fine cutter shavings (five of 13 answers) as litter in the creep area. It was uncommon that producers used additional protection rails, other than the ones provided by the normal pen design, in order to prevent crushing. Most herds (five of six) stated that they did not use any additional protection rails.

All producers cross fostered litters during the batch. The majority of producers (five of eight) stated that cross fostering was registered in some way. It was most common to foster piglets at 24-48 hours after birth (six of 16 answers) or at 5-24 hours after birth (five of 16 answers). A litter that was cross fostered was normally one where the number of functional teats was lower than the number of piglets in the litter (seven of 21 answers) or a litter where the number of piglets was smaller than the other litters in the batch (seven of 21 answers). In most cases, both small and large piglets were subjected to cross fostering (five of 11 answers). Piglets were fostered to first parity sows, multiparous sows and nursing sows or to a sow with a small litter. Five of the eight herds did not use nursing sows during the last batch weaned. However, it was quite common that herds used nursing sows if/when the opportunity was given, for example when there was access to lactating sows that was going to be culled. Only one herd used split suckling. Most of the herds (five of eight) provided milk replacer to piglets when considered necessary. The majority of the herds (six of eight) also provided electrolytes to piglets when considered necessary. The reason for providing electrolytes was generally due to diarrhea (four of nine answers) or due to weakness or agalactia in the sow (four of nine answers). Only one herd used potato meal for any cause and only three herds used “Pig Pusher”, “Piglet saver” or any other energy boost if piglets were born weak. All producers considered the sow health around three weeks postpartum well and stated that the piglets had grown as expected at three weeks of age (perception 5 out of 5). On average 1.5 piglets per litter had died at three weeks after parturition. The perceived amount of piglet treatments was considered moderate (2.5 out of 5) at three weeks of age. The majority of herds (seven of eight) vaccinated their piglets against Postweaning multisystemic wasting syndrome (PMWS). The number of weaned piglets per litter was on average 11.5 and the weaning weight, the weaning size, the weaning health of piglets and the weaning health of sows were all considered good (perception 4.9 out of 5).

Table 16. Descriptive statistics for management during nursing period in the most recent batch

Parameter	N	Mean	Min	Max	Unit
Producer perception of piglet diarrhea	8	2.1	1.0	4.0	1-5
Producer perception of no. became weak	8	2.0	1.0	3.0	1-5
Age at castration	8	4.1	3.5	5.0	days
Producer perception of litter homogeneity	8	4.8	3.0	5.0	1-5
No. dead per litter at castration	7	1.1	0.5	1.5	pcs
Producer perception of treatments castration	8	2.6	1.0	3.0	1-5
Producer perception of 3w diarrhea	7	1.4	1.0	4.0	1-5
No. dead per litter at 3w	8	1.5	1.0	2.5	pcs
Producer perception of treatments at 3w	8	2.5	1.0	3.0	1-5
Producer perception of hygiene problems	8	1.3	1.0	3.0	1-5
No. weaned/sow	8	11.5	10.9	12.0	pcs
Producer perception of weaning weight	8	4.9	4.0	5.0	1-5
Producer perception of weaning size	8	4.9	4.0	5.0	1-5
Producer perception of weaning health piglet	8	4.9	4.0	5.0	1-5
Producer perception of weaning health sows	8	4.9	4.0	5.0	1-5

7.1.6. SWEDISH SOWS

Descriptive statistics for Swedish sows is shown in Table 17. The average parity number was 3.5, ranging from parity one to nine. The sows had on average 14.9 piglets born in total, 13.7 piglets born alive, 1.2 piglets born dead and 11.6 piglets at the time of visit. The average number of weaned piglets was 11.7. The majority of litters were cross fostered (69.1 % of litters) and the number of piglets added or subtracted to a litter varied between -5 and +8. The rated litter homogeneity was on average 4.1 out of five and the rated litter score was on average 4.2 out of five. The difference between planned and actual farrowing date was on average 1.9 days, ranging from minus one to plus 19 days.

The majority of sows had not been subjected to MMA during farrowing or shortly thereafter (75 % of sows). However 25 % of the sows had thus suffered from MMA in the current parity. It is noteworthy though that the number of observations of this parameter was smaller than for other parameters (N=88). Most sows had received some kind of medical treatment (*i.e.* antibiotics, analgesics or oxytocin) during the nursing period (56.8 % of sows). The average number of functional teats per sow was 14.4, ranging from 12 to 18. The average number of teat pairs in front of the navel was 3.9, ranging from two to six. The rated udder health was generally high and averaged 4.3 out of five.

The majority of sows did not have any shoulder lesions (75.5 % of the sows), but 15.8 % of the sows had shoulder lesions on one side and 8.6 % of the sows had shoulder lesions on both sides. The average number of shoulder lesions was thus 0.33. The pen hygiene was generally satisfying as it was rated to on average 4.6 out of five. Most pens were not equipped with additional protection rails (99.4 % of pens). The average surface temperature on the floor of the creep area was 26.9°C and the average surface temperature on the floor of the sow lying area was 23.7°C. The majority of sows had feed left in their feed through at the time of observation (65.9 % of sows). The average body condition score was 2.8, a score close to the recommended score three. The rated leg health and hoof health were generally high as the average numbers were both 4.7 out of five.

Table 17. Descriptive statistics for Swedish sows

Parameter	N	Mean	Min	Max	Unit
Parity no.	178	3.5	1.0	9.0	no
Total number born	178	14.9	3.0	23.0	pcs
Number born alive	178	13.7	3.0	22.0	pcs
Number born dead	178	1.2	0	7.0	pcs
No. piglets at visit	179	11.6	7.0	15.0	pcs
Weaned piglets	178	11.7	7.0	15.0	pcs
No. piglets ± to litters	78	0.35	-5.0	8.0	pcs
Rated litter homogeneity	179	4.1	2.0	5.0	1-5
Rated litter score	179	4.2	2.0	5.0	1-5
Difference planned/real farrowing date	128	1.9	-1.0	19.0	days
No. functional teats	163	14.4	12.0	18.0	pcs
No. teat pair in front of navel	137	3.9	2.0	6.0	pcs
Rated udder health	138	4.3	1.0	5.0	1-5
No. of shoulder lesions	139	0.33	0	2.0	pcs
Body condition score	139	2.8	1.0	4.0	1-4
Rated leg health	139	4.7	1.0	5.0	1-5
Rated hoof health	138	4.7	1.0	5.0	1-5
Rated pen hygiene	179	4.6	2.0	5.0	1-5
Surface temperature floor creep area	178	26.9	21.0	32.7	°C
Surface temperature floor sow lying area	178	23.7	19.1	28.4	°C

7.1.6.1. Factors with significant impact on production results

None of the investigated management- or sow factors had any significant impact on the number of piglets born alive or dead. However, some factors had significant impacts (P<0.05) on the number of piglets weaned, the litter homogeneity and the litter rating. The number of weaned piglets was significantly influenced by herd (P<0.05), the number of functional teats (P<0.01), the rated udder health (P<0.01) and the litter rating score (P<0.05). Parity number had no significant impact on the number of weaned piglets per litter. Factors with significant effect on the number of weaned piglets are shown in Table 18. Herd number two, three and eight weaned the most piglets in the observed batches. The number of weaned piglets was highest for sows with at least 15 functional teats, for sows with a rated udder health of ≤3 (*i.e.* the lowest scores) or 5 (*i.e.* the highest possible score) and for litters rated to have litter score four or five.

Table 18. Significant results concerning the number of weaned piglets

Herd	Mean NW	No. functional teats	Mean NW	Rated udder health (1-5)	Mean NW	Litter rating (1-5)	Mean NW
1	11.1[bc]	≤13	10.7[a]	≤3	11.9[a]	≤3	11.1[a]
2	12.1[a]	14	11.3[b]	4	10.9[b]	4	11.7[b]
3	12.0[ab]	15	11.9[c]	5	11.5[a]	5	12.0[b]
4	11.2[ac]	≥16	11.8[bc]				
5	11.4[ac]						
6	11.0[c]						
7	10.9[c]						
8	11.7[ac]						

NW= Number weaned

The homogeneity of the litter was significantly influenced by the rated udder health of the sow (P<0.05). Neither herd nor parity number had any significant impact on the litter homogeneity. Significant results concerning the litter homogeneity are shown in Table 19. The litter homogeneity was greatest for sows rated to have the second highest or highest possible score for udder health.

Table 19. Significant results concerning the litter homogeneity

Rated udder health score (1-5)	Litter homogeneity score (1-5)
≤3	3.8[a]
4	4.2[b]
5	4.2[b]

The litter rating score was significantly influenced by herd (P<0.01), the body condition score of the sow (P<0.001) and the rated udder health (P<0.01). Parity number had no significant impact on the litter rating score. Significant results concerning the litter rating score are shown in Table 20. Sows with body condition scores equal to or higher than two and sows rated to have the second highest or highest possible score for udder health, had litters with the highest possible score (*i.e.* the best litter appearance). Sows with body condition score one had litters with lower litter rating scores than sows with body condition score two or higher (*i.e.* too lean sows have worse litters than normal or obese sows).

Table 20. Significant results concerning the litter rating score

Body condition score (1-4)	Litter rating score (1-5)	Rated udder health score (1-5)	Litter rating score (1-5)
1	2.7[a]	≤3	3.3[a]
2	4.1[b]	4	3.8[b]
3	4.0[b]	5	3.7[b]
4	3.6[b]		

7.1.7. PRODUCTION RESULTS/KEY FIGURES

The sow productivity concerning different key figures, for each Swedish herd visited, is shown in Figure 1 to 12 in Appendix III. The average sow productivity for all Swedish herds as well as the average sow productivity for the 25 % most successful herds is also shown in the figures for comparison. The red line, shown in some of the figures, is the boundary recommended by Knox (2005a) and Gill (2007) in order to achieve 30 weaned piglets per sow and year.

The average weaning to service interval in the visited Swedish herds is shown in Figure 1. All herds except herd five and eight had a weaning to service interval shorter than both the average Swedish herds as the 25 % most successful Swedish herds.

The average farrowing rate in the visited Swedish herds is shown in Figure 2. All herds had a farrowing rate exceeding the average Swedish herds. However, herd five and six had a lower farrowing rate than the average for the 25 % most successful herds. All herds, except herd six had a farrowing rate exceeding 85 % and herd two, three, four, seven and eight (five of eight herds) had a farrowing rate equal to or exceeding 90 %. The average percentage of returns to estrus after service is shown in Figure 3. None of the herds had a higher percentage of sows returning to estrus after service than the average Swedish herds. Four of the herds (*i.e.* herd two, four, seven and eight) had the same or higher percentage of returning sows than the 25 % most successful Swedish herds.

The average number of piglets born alive in the visited Swedish herds is shown in Figure 4. All herds except herd four had a higher number of piglets born alive than the Swedish average herds. Herd one, three and seven had more piglets born alive than the 25 % most successful Swedish herds. Only herd three had a number of live born piglets exceeding 14. The average number of piglets born dead in the visited Swedish herds is shown in Figure 5. Herd number one, six and seven had fewer stillborn piglets than the average Swedish herd. Only herd six and seven had fewer stillborn piglets than the average 25 % most successful Swedish herds.

The average pre weaning mortality in the visited Swedish herds is shown in Figure 6. All herds had a lower pre weaning mortality than the Swedish average. Herd number one, three and seven had a pre weaning mortality higher than the average of the 25 % most successful Swedish herds. None of the herds visited had a pre weaning mortality lower than 10 %. The average length of the nursing period in the visited Swedish herds is shown in Figure 7. Herd number one, seven and eight had a nursing period longer than both the Swedish average and the average of the 25 % most successful Swedish herds. The average number of weaned piglets per litter in the visited Swedish herds is shown in Figure 8. All herds visited had a higher number of weaned piglets per litter than the Swedish average and only herd four and seven had fewer piglets weaned per litter than the 25 % most successful Swedish herds. The average estimated weaning weight of piglets in the visited Swedish herds is shown in Figure 9. The weaning weights ranged between nine and ten kg. Herd one and eight had the highest weaning weights and herd seven had the lowest weaning weights.

The average number of litters per sow and year in the visited Swedish herds is shown in Figure 10. Only herd one had sows producing fewer litters per year than the average Swedish herd. Herd one, five, six and eight had sows producing fewer litters per year than the 25 % most successful herds. The average number of non-productive days per litter in the visited Swedish herds is shown in Figure 11. Only herd one had a larger number of non-productive days per litter than the average Swedish herds. Herd number one, five, six and eight had a larger number of non-productive days than the 25 % most successful Swedish herds.

The average number of weaned piglets per sow and year in the visited Swedish herds is shown in Figure 12. All herds produced more piglets per sow and year than the average Swedish herd but only herd two and three exceeded the 25 % most successful Swedish herds.

7.2. Denmark

7.2.1. GENERAL HERD RESULTS

All three herds were integrated, even though all producers stated that the different branches of the production were more or less scattered geographically (*i.e.* multisite production). Two of the herds had farrowings every second week and one herd had farrowings every week. All producers were generally satisfied with the herd veterinary and hired an additional advisor from the same company (*i.e.* Øvet). Descriptive statistics for general herd parameters is shown in Table 21. The average number of delivered piglets per herd and year was 15 333 and the number of sows in production was on average 500. The sows were on average divided into 15 groups with 36.7 sows in each group. When producers were asked for how long they had conducted the current production, the average answer was for eight years.

Table 21. Descriptive statistics for general herd parameters

Parameter	N	Mean	Min	Max	Unit
Delivered piglets/year	3	15333.3	12500.0	17000.0	pcs
No. sows in production	3	500.0	400.0	550.0	pcs
No. sow groups	3	15.0	11.0	23.0	pcs
No. sows/group	3	36.7	24.0	50.0	pcs
Yrs in current production	2	8.0	6.0	10.0	years

7.2.2. HOUSING

7.2.2.1. Service- and gestation unit

There were several different systems used for housing dry sows but all herds had separate units for service and gestation. All producers kept their sows in individual stalls after weaning, during estrus and service and until around four weeks after service. The sows were then moved to the gestation unit. All herds had an Electronic Sow Feeding system (ESF-system) in the gestation unit, where sows where loose-housed in larger groups. A herd with access to four transponders generally divided the sows into four groups so that each group consisted of all sows in one batch. Thus, all herds visited had finished the preparations and adapted to the EU-directive incorporated from January 2013. The largest part of the floor in the ESF-system consisted of slatted floors but there was always access to resting areas with solid concrete floor. Gestating sows were generally not provided with bedding material, but they had access to straw provided in an automatic litter supplier. Two of the herds visited kept some gestating sows on deep-litter with feeding stalls during gestation (*i.e.* "Englandsgrisen"). All three herds also had access to a number of pens, where gilts or sows were either kept individually or in groups of two to four animals. These pens generally had a combined lying- and manure area and a feeding area with troughs. The herds also had access to a larger pen with a training area for teaching replacement gilts how to use the ESF-system. Sows housed in individual stalls did generally not have access to litter but sows housed in pens or loose on deep-litter had access to litter. In units where litter was provided, chopped straw was the most common material (two of five answers). The most common manure handling system was removal by bobcat or a hydraulic jack (two of four answers) or by slatted floors and vacuum systems (two of four answers). All herds had mechanical ventilation with negative pressure in as well the service- as the gestation unit. None of the herds changed shoes or clothes between the units. Descriptive statistics for housing in the service- and gestation unit is shown in Table 22. The average number of units designated for dry sows were 2.3. One producer stated that the lights were on average lit for 18 hours during service and for 10 hours during gestation.

Table 22. Descriptive statistics for housing in service- and gestation unit

Parameter	N	Mean	Min	Max	Unit
No. gestation units	3	2.3	2.0	3.0	pcs
Light time service	1	18.0	18.0	18.0	h
Light time gestation	1	10.0	10.0	10.0	h

7.2.2.2. Farrowing unit

All three herds housed their sows in farrowing crates during farrowing and lactation and moved the piglets to a growers unit after weaning. The creep area was in none of the herds located in connection to the working isle. All farrowing units were mechanically ventilated with negative pressure. The most common manure handling system (two of three herds) was to have slatted floors and a screw that pressed the manure against a transversal culvert. The three herds used additional heating lamps, had heated floors and a roof in the creep area. Two of the herds also used a third wall occasionally during the first days of life. Descriptive statistics for housing in the farrowing unit is shown in Table 23. The average number of farrowing units was 3.8. One producer stated that the lights were on average lit for nine hours per day during the farrowing week and for 15 hours per day during the rest of the nursing period. The units were empty for on average 2.3 days between batches. None of the herds changed shoes or clothes between the units but all producers stated that they cleaned and disinfected the farrowing unit between batches. There was one water nipple designated for the sow and one water nipple designated for the piglets in each pen. There was on average 7.3 parameters noted on the sow card, ranging between zero and 13.

Table 23. Descriptive statistics for housing in farrowing unit

Parameter	N	Mean	Min	Max	Unit
No. farrowing units	3	3.8	2.0	6.0	pcs
Light time farrowing week	1	9.0	9.0	9.0	h
Light time nursing period	1	15.0	15.0	15.0	h
Empty time between batches	3	2.3	1.0	5.0	days
No. parameters/sow card	3	7.3	0	13	pcs
No. sow nipples/pen	30	1.0	1.0	1.0	pcs
No. piglet nipples/pen	30	1.0	1.0	1.0	pcs

7.2.3. FEED AND WATER

All producers had at least two feed mixture for sows, *i.e.* one feed for dry sows and one feed for lactating sows. Both dry and lactating sows were most commonly fed a feed mixture consisting of cereals, soybean meal and premix (two of three herds). One farm provided a complete feed mixture. All herds used dry feed for as well dry as lactating sows. The most common act in order to avoid MMA was to decrease the feed ration from around two days before the expected farrowing date (two out of three herds). One of the producers completely removed all feed on the expected farrowing day. Descriptive statistics for feed parameters are shown in Table 24. During the time of farrowing sows were on average fed 28.8 MJ ME. All producers stated that the feed ration was increased gradually during the whole nursing period, including the last weeks of lactation. Thus, the average number of days after farrowing when sows reached their maximal feed ration was 25.7, ranging from 14 to 35 days postpartum. Sows were on average fed 114 MJ ME after reaching their maximal ration during lactation. In case of feed refusal one producer stated that the feed ration was adjusted and decreased fairly. All producers provided the piglets with dry creep feed, which was offered without iron peat or milk replacer powder. It was most common to provide the creep feed directly on the floor (two of three herds). Piglets were on average 12.5 days of age when creep feed was first provided.

Table 24. Descriptive statistics for feed parameters

Parameter	N	Mean	Min	Max	Unit
MJ ME/day start lactation*	2	28.8	26.4	31.2	MJ ME
MJ ME/day max lactation*	2	114.0	108.0	120.0	MJ ME
Time postpartum at max ration	3	25.7	14.0	35.0	days
Age of piglets at feeding start	3	12.5	10.0	17.5	days

*1 FEso=12 MJ ME (Lindahl, 2013)

All producers stated that they had routines and regularly checked the body condition score of the sows and they all stated that this check was performed using visual estimation. Two of the producers stated that they checked the body condition of the sows on a daily basis. One of the producers checked the body condition score of the sows at the time of moving the sows from the service unit into the gestation unit. Depending on the body condition score, sows were located on one out of three different feed curves throughout the whole gestation.

7.2.4. MANAGEMENT

7.2.4.1. Service- and gestation unit

None of the producers separated the farrowing group into smaller groups after weaning, since the sows were housed individually in stalls during estrus and service. When moving the sows from the service unit into the loose-housed gestation unit the sows were generally housed in one group. The most common weekdays for sows to return to estrus after weaning were on Mondays (two of five answers) and Tuesdays (two of five answers). Thus, estrus normally occurred in the beginning of the week. Descriptive statistics for service- and gestation management parameters are shown in Table 25. One herd only performed one estrus check per sow and day. The majority of services were performed on Mondays (two of five answers). The average number of inseminations per sow and estrus was 1.9. Gilts were always served by performing inseminations (100 % of answers), rather than by natural mating or a combination of AI and natural mating. However, all herds had access to boars. The average number of boars per herd was 5.7. The most common cause for keeping boars was for estrus synchronization and for inducing the standing reflex in sows during estrus and insemination (100 % of answers). During insemination the boar was generally allowed to walk the working isle in front of the stalls and to have snout contact with around five sows at the time. Sows were always inseminated in stalls. Two of the herds performed two pregnancy tests per sow and pregnancy at on average gestation day 26.7 and 56, and one herd performed one pregnancy test. All herds used a scanner to detect pregnancy.

The annual replacement rate was on average 50 %. Sows were on average culled at parity 3.7 and at latest culled at on average parity eight. The most common cause for culling was leg problems (three of six answers), and age (two of six answers). Two of the producers stated that leg problems and age was the most common causes for culling. One producer stated that leg- and hoof problems were the most common causes for culling. All producers purchased replacement gilts and were generally satisfied with purchased animals. All herds served their gilts for the first time during the second visible estrus.

All producers vaccinated their gilts and sows against Erysipelas, Parvovirus and piglet diarrhea caused by *E. coli* and *Cl. Perfringens*. All herds trimmed sow hooves when considered necessary. One of the producers had even built a hoof-trimming box himself, in which he always trimmed five sows per group at the time of moving them from the service unit into the gestation unit.

Table 25. Descriptive statistics for management in service- and gestation unit

Parameter	N	Mean	Min	Max	Unit
Annual replacement rate	3	50.0	47.5	51.4	%
Average parity at removal	1	3.7	3.7	3.7	no
Max parity at removal	1	8.0	8.0	8.0	no
Estrus checks/day	1	1.0	1.0	1.0	pcs
No. AI/sow/estrus	2	1.9	1.5	2.3	pcs
Estrus no. first service	2	2.0	2.0	2.0	no
No. boars	3	5.7	4.0	8.0	pcs
Pregnancy test 1	3	26.7	26.0	28.0	day
Pregnancy test 2	1	56.0	56.0	56.0	day

7.2.4.2. Farrowing unit

Descriptive statistics for management in the farrowing unit is shown in Table 26. Sows were on average moved into the farrowing unit 4.3 days before the planned farrowing date. Two of the herds normally had farrowings that started on Thursdays and one of the herds had farrowings that started on Fridays. The mean number of farrowing days per batch was 4.5. Thus, most herds had farrowings in the end of the week and also during weekends. The perception of the number of piglets born alive was generally high (4.3 out of 5) and the perception of pre weaning mortality was generally moderate (2.7 out of 5). All producers stated that the largest part of the pre weaning mortality occurred during the first one to four days of life. One producer stated that the most common cause for death was crushing by the sow and one producer stated that the most common cause for death was starvation (however, in combination with crushing). Two of the producers did not register the cause of death in any way whereas one producer did register the number of dead piglets and the causes of mortality. All producers stated that one person normally handled the farrowings during the farrowing week. One of the producers always provided additional supervision at 22.00 in the evening during the farrowing week. It was difficult to establish exactly what management that was provided directly after the notification of a farrowing start. However, one producer stated that he noted the time of the farrowing start and then continuously kept an eye on the progression. Notes about the progression were put on the sow card, for example if afterbirth had been observed. It was also generally accepted amongst the producers that it was important to provide obstetric assistance if necessary. One producer stated that the most common underlying cause of farrowing difficulties was the age of the sow. One producer checked the rectal temperature of all sows after farrowing and noted it on the sow card, while the other two producers did not. The same producer also counted the number of functional teats and also noted the size of the teats (small, medium or large in order to enable cross fostering) at the farrowing day. The other two producers did not count the number of functional teats during farrowing.

All three herds cross fostered litters and stated that they normally would move piglets to first parity sows, older sows and nursing sows and to small litters. The choice of which litters to cross foster depended on the size of the actual litter (one of four answers), on the number of functional teats of the biological sow (one of four answers), on the size of the other litters in the batch (one of four answers) and on the homogeneity of the litters (one of four answers). Thereby as well small as large piglets were fostered. It was most common (three of four answers) to cross foster litters between 5-24 hours after birth. However, it was generally noted that it was possible to cross foster litters between two sows that had farrowed the same day but in case of cross fostering to a nursing sow it was important to make sure that the piglets had ingested colostrum. All herds used nursing sows and two of three herds stated that younger sows were preferred as nursing sows. It was most common to save a few farrowing crates in the unit empty so that nursing sows could later on be moved into the farrowing unit with the most recent farrowing (two out of three herds). One of the producers stated that only large and viable piglets were moved to nursing sows. None of the herds used split suckling.

All producers supplied the piglets with iron supplement by providing iron injections in connection to castration. Castration was generally performed on the fourth day of life. All herds used analgesics in connection to castration and grinded the teeth of the piglets. One of the producers also vaccinated the piglets against the diarrhea occurring during the third week of life (*i.e.* Baycox). Generally, the producers experienced low incidence of piglet diarrhea.

The majority of producers (two of three) did not provide the sow with litter during the nursing period. All herds used very fine cutter shavings as litter in the creep area. Two out of three herds used milk replacer if considered necessary and electrolytes in case of piglet diarrhea. One herd only provided an additional bowl of water in case of diarrhea. One of the herds did vaccinate piglets against PMWS. The perception of the number of weaned piglets was generally high (4.3 out of 5) and the weaning age was on average 4.3 weeks, since two of the producers weaned at five weeks of age and one producer at four weeks of age. One herd weaned on Wednesdays, one on Thursdays and one on Saturdays.

Table 26. Descriptive statistics for management in farrowing unit

Parameter	N	Mean	Min	Max	Unit
Days before farrowing moving in	2	4.3	3.5	5.0	days
No. farrowing days	2	4.5	4.0	5.0	days
Perception of number born alive	3	4.3	4.0	5.0	1-5
Perception of pre weaning mortality	3	2.7	1.0	4.0	1-5
Perception of number weaned	3	4.3	4.0	5.0	1-5
Weaning age	3	4.3	4.0	5.0	weeks

7.2.5. DANISH SOWS

Descriptive statistics for Danish sows is shown in Table 27. The average parity number was 3.4, ranging from one to seven. The sows had on average 18.9 piglets born in total, 17.1 piglets born alive and 1.8 piglets born dead. The average number of functional teats per sow was 14.3, ranging from 12 to 16. The size distribution of the teats, which was recorded in one herd, was even between the size small (31.3 %), medium (31.3 %) and large (37.5 %). The average number of teat pairs in front of the navel was 3.6, ranging from three to four. The rated udder health was generally high and averaged 4.3 out of five. Noteworthy is also that no shoulder lesions were noted during the herd visits.

The pen hygiene was not necessary to rate, since sows were stalled on slatted floors. No pens were equipped with additional protection rails, since all sows were crated. The average body condition score was 3.3, a score close to the recommended score three. The rated leg health and hoof health were generally high as the average numbers were 4.6 and 4.9 out of five respectively. The sows had on average been used as nursing sows for 0.5 times, ranging from zero to three times.

Table 27. Descriptive statistics for Danish sows

Parameter	N	Mean	Min	Max	Unit
Parity number	24	3.4	1.0	7.0	no
Total number born	23	18.9	13.0	26.0	pcs
Number born alive	23	17.1	11.0	26.0	pcs
Number born dead	23	1.8	0	6.0	pcs
No. functional teats	30	14.3	12.0	16.0	pcs
No. teat pairs in front of navel	30	3.6	3.0	4.0	pcs
Rated udder health	8	4.3	3.0	5.0	1-5
Body condition score	8	3.3	3.0	4.0	1-4
No. shoulder lesions	8	0	0	0	pcs
Rated leg health	8	4.6	2.0	5.0	1-5
Rated hoof health	8	4.9	4.0	5.0	1-5
No. times as nursing sow	17	0.5	0	3.0	times

7.2.5.1. Factors with significant impact on production results

Due to technical difficulties, it was not possible to collect data of the number of piglets weaned and due to shortage of time it was not possible to collect data of litter homogeneity and litter rating score in Danish herds. Thus, data of the number of piglets born alive and dead were the only parameters possible to test statistically. None of the management- or sow factors tested had any significant impact on the number of piglets born alive or dead.

7.2.6. PRODUCTION RESULTS/KEY FIGURES

The sow productivity concerning different key figures, for each Danish herd visited, is shown in Figure 1 to 12 in Appendix III. The average sow productivity of all Danish herds as well as the average sow productivity of the 25 % most successful herds is also shown in the figures for comparison. The red line, shown in some of the figures, indicates the boundary recommended by Knox (2005a) and Gill (2007) in order to achieve 30 weaned piglets per sow and year.

The average weaning to service interval in the visited Danish herds is shown in Figure 1. Only herd nine had a weaning to service interval lower than the Danish average and the 25 % most successful Danish herds.

The average farrowing rate in the visited Danish herds is shown in Figure 2. Herd nine and 11 had a farrowing rate exceeding the average Danish farrowing rate, but only herd nine had a farrowing rate exceeding the 25 % most successful herds and 90 %. The average percentage of returns to estrus after service is shown in Figure 3. Herd nine and 11 had fewer returns to estrus after service than both the Danish average and the 25 % most successful herds, while herd nine had more returners than the average.

The average number of piglets born alive in the visited Danish herds is shown in Figure 4. All herds visited had a higher number of piglets born alive than average Danish herds but only herd 11 had a higher number than the 25 % most successful. All herds had a number of live born piglets exceeding 14. The average number of piglets born dead in the visited Danish herds is shown in Figure 5. All herds had a higher number of stillborn piglets than the average Danish herd and the 25 % most successful herds.

The average pre weaning mortality in the visited Danish herds is shown in Figure 6. Only herd 11 had a pre weaning mortality lower than the average mortality. None of the herds had a lower pre weaning mortality than the 25 % most successful herds, nor had any a mortality rate lower than 10%. The average length of the nursing period in the visited Danish herds is shown in Figure 7. Herd nine and ten had a longer nursing period than both the average Danish herds and the 25 % most successful. Herd 11 had a nursing period shorter than the average Danish herds but a longer period than the 25 % most successful. The average number of weaned piglets per litter in the visited Danish herds is shown in Figure 8. All herds weaned an equal number or a higher number of piglets per litter than the average Danish herds. However, only herd nine weaned an equal number of piglets per litter as the 25 % most successful. None of the herds exceeded the 25 % most successful. The estimated average weaning weight of piglets in the visited Danish herds is shown in Figure 9. All herds visited had weaning weights exceeding both the average Danish weaning weight and the 25 % most successful herds. The weaning weights ranged between 7.5 and 8.5 kg.

The average number of litters per sow and year in the visited Danish herds is shown in Figure 10. Only herd 11 had sows that produced more litters per sow and year than the average Danish sows. None of the herds had sows producing more litters per sow and year than the 25 % most successful herds. The average number of non-productive days per litter in the visited Danish herds is shown in Figure 11. Only herd nine had fewer non-productive days than the average Danish herds and the 25 % most successful Danish herds.

The average number of weaned piglets per sow and year in visited Danish herds is shown in Figure 12. Herd nine and 11 weaned more piglets per sow and year than the average Danish herds, while herd ten weaned fewer piglets per sow and year. None of the herds visited weaned more piglets per sow and year than the 25 % most successful Danish herds. Only herd nine weaned more than 30 piglets per sow and year.

7.3. Differences between Sweden and Denmark

7.3.1. SOWS

Significant results concerning differences between Sweden and Denmark are shown in Table 28. Significant differences were found between the countries for the total number of piglets born ($P<0.01$) and the number of piglets born alive ($P<0.01$). Danish sows gave birth to significantly more piglets, both in total and alive. Significant differences were found between the countries for the rated udder health ($P<0.01$), the rated leg health ($P<0.01$) and the rated hoof health ($P<0.01$). Swedish sows had significantly higher rated udder-, leg- and hoof health. There was a significant difference between the rated body condition score between Swedish and Danish sows ($P<0.05$). Danish sows had a significantly higher (better) body condition score, located around the preferred number three. No significant differences between the countries were found for parity number, the number of stillborn piglets, the number of functional teats, the number of teat pairs in front of the navel and the number of shoulder lesions.

Table 28. Significant results concerning differences between Sweden and Denmark

Parameter	Swedish mean	Danish mean	Significance
Parity number	3.5	3.5	n.s.
Total number born	14.9	18.9	*
Number born alive	13.7	17.1	*
Number born dead	1.22	1.75	n.s.
No. functional teats	14.3	14.3	n.s.
No. teat pairs in front of navel	3.9	3.7	n.s.
Rated udder health (1-5)	4.2	3.6	*
No. shoulder lesions	0.32	0	n.s.
Body condition score (1-4)	2.8	3.3	*
Rated leg health (1-5)	4.8	4.5	*
Rated hoof health (1-5)	4.7	4.4	*

*Statistically significant difference between countries, $P<0.05$
n.s. No statistically significant difference between countries

It was also tested whether the body condition score had any effect on the number of shoulder lesions for all sows (*i.e.* both Swedish and Danish sows). Herd and parity number was included in the model. Herd and body condition score had no significant impact on the presence of shoulder lesions. However, parity number significantly influenced the presence of shoulder lesions ($P<0.05$). Sows of parity three, six and four had highest prevalence of shoulder lesions.

8. DISCUSSION

8.1. Methodology discussion

Eight successful Swedish herds is a very small sample of herds in general and the results cannot stand for all Swedish herds. Three Danish successful herds is an even smaller sample and the results cannot stand for all Danish herds in general. However, the results from this study may still indicate what successful producers do or does not do and what separates herds in the both countries from each other. The herds were also selected on different premises, since the Swedish herds were collected from the official list of most successful producers during 2011, whereas the Danish herds were selected on the number of weaned piglets per sow and year (*i.e.* should exceed 30) but not in comparison to other successful Danish herds. If the herds had been randomly selected, it would have been possible to perform statistical analysis using mixed models, which was not possible in the present study.

The interview questionnaires consisted of many questions (*i.e.* many variables) and were performed in few herds (*i.e.* few observations), which disabled statistical analysis within herd level. Therefore the interviews were only used in order to describe herds and herd management. The collection of farrowing unit data consisted of few observations (*i.e.* one observation per parameter and Swedish herd), which also made it impossible to perform statistical analysis on herd level. Therefore, data collected for farrowing units was only used in order to describe the units.

The collection of sow and litter data however involved fewer variables and more observations per variable than the other data sets. Thus, it was possible to perform statistical analysis for these parameters. However, some parameters were screened out due to few observations. If the number of observations had been larger the degree of explanation due to the statistical models might have been higher and other differences might have shown up. All performed estimations and ratings were performed by the same person (I) in order to avoid bias and it was fairly easy to avoid bias when valuating sows. However, it was hard not to be affected by the age and general appearance of other litters within batches when valuating piglets and this might have affected the results. Nonetheless, statistically significant impacts on the number of piglets weaned and differences between the countries were found.

The collection of production data from the herd-monitoring program was different for Sweden and Denmark. Since the software needed to receive data from Denmark was not available, it was not possible to collect data of the number of weaned piglets per sow and litter, which disabled all statistical analysis connected to the number of piglets weaned on Danish sows. Thus, it was hard to compare Sweden and Denmark in terms of the scope of this study. However, production data was extracted from the production reports instead, which made it possible to perform comparisons (however not statistically due to few observations) between herds.

8.2. Hypothesis and result discussion

The first hypothesis of this study was that management factors could affect the number of weaned piglets per sow and year. In the study, a significant impact of herd within country (*i.e.* between Swedish herds) on the number of piglets weaned was found. There was also variation in the number of weaned piglets per litter and per sow and year between herds within countries (*i.e.* both within Swedish herds and within Danish herds), according to the production results extracted from herd-monitoring programs. This variation is thus probably, to a large extent, due to management as it has been reported that the number of weaned piglets per sow and year is highly affected by management, such as timing and number of services (Kemp & Soede, 1996; King et al., 1998; Young et al., 2010), attending farrowings (White et al., 1996; Tuchscherer et al., 2000;

Gill, 2007), housing (Friendship et al., 1986; Blackshaw et al., 1994; Marchant et al., 2000), using cross fostering (Bowman et al., 1996; Straw et al., 1998; KilBride et al., 2012) or nursing sows (Knox, 2005a; Mattsson, 2013).

The present study showed that the number of functional teats significantly influenced the number of piglets weaned. This can be expected since the number of functional teats is important for the number of piglets that the sow is able to nurse (Straw et al., 1998; Andersen et al., 2007). The number of functional teats is a trait that is primarily controlled by producers by the selection of F1-gilts. However, sow management is also important to keep the original number of functional teats intact throughout the lifetime of the sow. The rated udder health and the rated litter score did also significantly influence the number of weaned piglets. Udder health and litter appearance are typical factors that can be affected through management. The rated litter homogeneity and litter score were also significantly influenced by the udder health of the sow and the body condition score also significantly influenced the rated litter score. The body condition of the sow is (*i.e.* the body condition score) is highly affected by feeding management.

The high knowledge and control over feeding related parameters could be one cause to the productive and reproductive success of the herds visited as adequate feeding has been reported to be important for sow productivity (Koketsu et al., 1997a; Knox, 2005a; Gill, 2007). All herds either fed complete feed (*i.e.* purchased feed mixtures that should be of high quality) or were producers with large interest and knowledge in feeding. Almost all herds used dry feed. Sows in both countries were generally moved into the farrowing unit as early as possible, which is favorable, since the risk of sows farrowing in the gestation unit decreases and the change of feed is not performed in too close connection to farrowing. Large efforts were put on the feed intake of sows, including daily feed ration adjustment and the use of feed additives for first parity and too lean sows.

An interesting difference between Sweden and Denmark was that Swedish sows generally reached their maximal feed ration at between one and two weeks post farrowing, whereas Danish sows did not reach the maximal ration until the last week of lactation. Danish producers stated that this was due to the fact that the feed intake capability was greatest in the end of the nursing period and that this was an opportunity not to miss. Indeed, there was a significant difference in body condition score between Swedish and Danish sows in the study. Danish sows in visited herds had significantly higher body condition scores than Swedish sows and no shoulder lesions were observed during the Danish herd visits. This indicates that Danish sows were fed more accurately. However, there was no significant difference in the number of shoulder lesions between countries (indicating that the presence of shoulder lesions was low for Swedish sows too), nor had the body condition score any significant influence on the presence of shoulder lesions. Thus, there is a possibility that genetics affect the presence of shoulder lesions. Danish studies have shown that the heritability for presence of shoulder lesions is around 0.15 (Nielsen & Nørgaard, 2012). However, presence of shoulder lesions is not included in the Danish breeding evaluation (Nielsen & Nørgaard, 2012).

The second hypothesis of this study was that there are differences in the reproductive management between Sweden and Denmark that cause differences in the number of piglets born alive and the number of litters per sow and year. It was found in the study that there was a significant difference in the number of piglets born alive between Sweden and Denmark and that the Danish herds visited had significantly more piglets born alive than the Swedish herds visited. The same conclusion is apparent when analyzing production results of visited herds over time. All Danish herds visited exceeded 14 piglets born alive, something which only one Swedish herd managed to do. Since the variation between visited Danish herds is large for most other production parameters, it is probable that the high number of piglets born in all herds is primarily due to breeding. The fact that the general Danish average also exceeded 14 piglets born alive, supports that this is primarily a product of genetic selection. However, no Danish herd would manage as many live born piglets if the reproductive management would be poor. In this study, no significant associations were found between sow- and management related factors and the number of piglets born alive or dead.

According to production results extracted from the herd-monitoring programs, there was a large variation between herds, as well within country as between countries, concerning the number of litters per sow and year. Due to the large variation it is probable that management is the factor separating herds. The number of litters per sow and year is also affected by several other parameters, such as the weaning to service interval, the farrowing rate, the percentage of sows returning to estrus after service, the length of the nursing period and the number of non-productive days (Aumaitre et al., 1976; King et al., 1998; Gill, 2007). According to production results extracted from the herd-monitoring programs, large variations existed for these parameters too. However, the variation in length of the nursing period was smaller than for other parameters, since the minimal length is controlled by legislation (98/58/EC; 2008/120/EC; SJVFS 2010:15). Improving reproductive parameters, mentioned above, by management represents possible opportunities to increase the number of litters per sow and year (Knox, 2005a; Gill, 2007).

The herds in the study generally had sows returning to estrus after weaning in the beginning of the week and thus service was also performed in the beginning of the week. This could be one of the reasons to reproductive success, since the motivation and energy of employees might be higher in the beginning of the week (Love & Wilson, 1990). The herds generally also checked sows for estrus more than once a day and served sows more than twice. These are management factors that have been proven important for successful reproduction (Flowers & Alhusen, 1992; Belstra et al., 2004; Knox, 2005b). However, a noted difference was that Danish producers stated that 100 % of the sows and gilts were served by performing AI, whereas in Sweden it was more common to sometimes use natural mating or a combination of AI and natural mating (even though AI was the most common service strategy). This is in disagreement with earlier studies, which have found that natural mating results in higher farrowing rates than AI (Dewey et al., 1995; Tummaruk et al., 2000).

Another interesting aspect was that all Danish herds used ultrasound scanners for pregnancy testing, whereas almost all Swedish herds used an ultrasonic meter. Research has shown that the accuracy when using an ultrasonic scanner is much higher (100 % accuracy) than when using an ultrasonic meter (70.5 % accuracy) (Taverne et al., 1985). Thus, the use of an ultrasonic scanner could decrease the number of non-productive days. Danish herds also performed fewer estrus checks, fewer services but more pregnancy tests. Thus, it seems that performing two pregnancy tests could also be beneficial for farrowing rates and reproductive success. To focus effort and money in the early stage (*i.e.* at first service) rather than in the later stage (*i.e.* when returning to estrus after service) must be more cost-effective and efficient for herd management.

The third hypothesis of this study was that there are management differences between Sweden and Denmark that cause differences in pre weaning mortality. During the study, it was not possible to analyze the pre weaning mortality within litters. This was due to a) that data was not collected for all sows within each batch and b) due to that not all herds noted the number of cross fostered piglets on the sow card or in the herd-monitoring program. According to production results extracted from the herd-monitoring programs, there was a large variation between herds, as well within country as between countries. Thus, it is probable that management is the factor separating herds. The Danish breeding program has, since 2004, included litter size at day five (*i.e.* the LG5 breeding goal) and this has successfully decreased piglet mortality at the same time as the number of live born piglets has increased (Christiansen, 2010; Klingenberg Jørgensen, 2011; Vinther, 2012). To achieve such a development is admirable, as the most frequently reported outcome is that mortality increases when litter sizes increase (Johnson et al., 1999; Grandinson et al., 2002; Bidanel, 2011). The average pre weaning mortality in Sweden increased between 2010 and 2011 (Svenska Pig, 2012a). However, piglet mortality is not included in the Swedish breeding evaluation. The only fertility trait, concerning piglets, included in the Swedish Yorkshire breeding program is the number of live born piglets (Nordic Genetics, 2012). The Norwegian Landrace, which contributes to 50 % of the genes in Swedish piglet producing sows, has the trait piglet mortality included in its breeding goal since 2010. However, since there are 26 traits included in the breeding goal (Norsvin, 2011), it is unlikely that the weight of the piglet mortality trait is substantial. Still, the pre weaning mortality for Danish herds visited, were according to production results not amongst the lowest. The four visited herds with the lowest pre weaning mortality were all Swedish. Since there is no piglet survival trait included in the Swedish breeding evaluation (Nordic Genetics, 2012), except for the Norwegian Landrace (where the weight is low) (Norsvin, 2012), this must mainly be due to differences in management.

According to production results for Sweden and Denmark nationally, the average pre weaning mortality and the average of the 25 % most successful herds indicates substantially higher pre weaning mortality in Sweden. Thus, it can be concluded that the pre weaning mortality is affected by both the genetic selection for increased survival (*i.e.* the LG5-breeding goal) and management. There were significant differences between the countries concerning udder health, leg health and hoof health. Swedish herds visited had on average higher scores for all these traits. Sow health has been reported to be important for sow productivity (Merks et al., 2000; Knox2005a; Gill, 2007). Furthermore, in the Swedish herds visited, udder health had a significant impact on the number of piglets weaned. Thus, this could be one of the causes to the lower pre weaning mortality. Sows with a rated udder health ≤3 or 5 had the highest number of piglets weaned. Thus, error during rating might have occurred. However, very few animals had a rated udder health lower than three, as only two sows had a rated udder health of score one and only three sows had a rated udder health of score two (*i.e.* the general udder health in visited Swedish herds was good and the variation small). It is probable that the leg and hoof health are more important traits for piglet survival of sows housed under Swedish conditions (*i.e.* loose-housed during lactation) than for sows hosed according to Danish conditions (*i.e.* crated during lactation), as leg problems have been reported to increase incidences of crushing in farrowing pens (Lensink et al., 2009).

Measurements of Swedish farrowing units showed that temperatures, light levels and dust levels were generally at a satisfying level. Ammonia- and noise levels were generally lower than levels set by animal welfare legislation (SJVFS 2010:15). The water flow in nipples was generally also satisfying. Thus, the air quality and housing conditions were considered high, which might partly be the cause of success in production. The relative humidity was on average 52 %, which is a highly doubtable measure and must be considered to be incorrect due to measurement error.

All herds had farrowings late in the week and during weekends, but one factor of success was probably that most herds had one employee responsible for the batch and that worked throughout the farrowing week. Some management factors frequently used and that was probably connected to success were cross fostering (Bowman et al., 1996; Straw et al., 1998; KilBride et al., 2012), the grinding of teeth when considered necessary, the use of milk replacer and electrolytes (*i.e.* employees tried to make a difference when noticing that piglets did not seem to thrive) (Knox, 2005b), the high hygiene in the pens (Bowman et al., 1996) and the generally healthy sows and piglets (Merks et al., 2000; Knox, 2005a; Gill, 2007). The use of split suckling was uncommon.

During the herd visits, it was not possible to pin point one or several management factors, used in the farrowing unit, that differed between the countries. The only obvious factor that seemed to differ was the use of nursing sows. In Denmark, the use of nursing sows is extensive (Knox, 2005a; Mattsson, 2013) and all Danish producers stated that they used on average five nursing sows per farrowing batch. Although this study has not been able to prove that this is one management factor that affects pre weaning mortality or the number of weaned piglets, it is believed that this, together with the breeding goal for survival, are the most likely causes to the generally lower pre weaning mortality in Denmark. According to Knox (2005a) the use of nursing sows decreases the pre weaning mortality. Some Swedish producers stated that they used nursing sows, even though it is not possible to use it in the traditional Danish manner due to legislation, but many also stated that they found it hard to find a satisfying methodology around this. Two of the four Swedish producers with the lowest mortality stated that they occasionally used nursing sows, and one of these producers used nursing sows almost like the Danish producers. However, no piglet was weaned prior to 28 days of life. One of these producers only used nursing sows after weaning in order to improve growth.

However, it is also important to add to the discussion that the number of piglets born was a lot higher in the Danish herds. Since, larger litters are frequently reported to increase the pre weaning mortality (Hartsock & Graves, 1976; Tuchscherer et al., 2000, Vasdal et al., 2011), it is also hard to compare countries with such different prerequisites. Thus, if the Swedish herds in the study had had as many live born piglets as the Danish herds in the study, perhaps they would have had a higher mortality.

There was no significant difference between Sweden and Denmark concerning the number of stillborn piglets. This is interesting, since it has been frequently reported that larger litters increase the incidence of stillbirths (Marchant et al., 2000; Hanenberg et al., 2001; Oliviero et al., 2010), and since there was a significant difference in the total number of piglets born and the number of piglets born alive.

The fact that the Swedish breeding evaluation has included the litter weight at three weeks of age for the Swedish Yorkshire dam-line has lead to that Swedish piglets often weigh around nine to ten kg at weaning, whereas Danish piglets weigh around seven to eight kg at weaning. However, this is probably primarily due to the different lengths of the nursing period, as Swedish piglets generally have an additional week to grow before weaning (98/58/EC; 2008/120/EC; SJVFS 2010:15). In the study, the Danish producers also started to provide creep feed on average later than Swedish producers did.

The fourth hypothesis of this study was that legislation differences between the countries cause difference in the number of litters per sow and year due to different lactation lengths. Only one of the visited Danish herds had a shorter lactation length than Swedish herds (*i.e.* herd 11), since the other two Danish herds also used a five-week nursing period. Herd 11 also produced more litters per sow and year than the other two Danish herds (*i.e.* herd nine and ten). Thus, the length of the nursing period and the number of litters per sow and year are related to each other and it is possible to conclude that lactation length affects the number of litters per sow and year (Aumaitre et al., 1976; King et al., 1998). However, according to data extracted from the herd-monitoring programs, other reproductive parameters also affect the number of litters per sow and year (Knox, 2005a; Gill, 2007). Herd nine, had the longest lactation length but the shortest weaning to service interval and the fewest non-productive days and were thus clearly superior to the other Danish (and Swedish) herds, regarding the number of weaned piglets per sow and year. Swedish herds number two, three and four produced more litters per sow and year than all Danish herds, regardless of the length of the nursing period, which indicates that lactation length is not the most important factor for the number of litters per sow and year. However, if implying a lactation length of five weeks and having reproductive issues or poor reproductive management (*i.e.* a prolonged weaning to service interval and many non-productive days per litter) one cannot expect to achieve a high number of litters per sow and year (see Danish herd number ten). Swedish average herds thus have great opportunities to increase the number of litters per sow and year, despite the five week lactation length, but should focus on a short weaning to service intervals, a high farrowing rate, few returns to estrus after service and few non-productive days (Vesseur et al., 1994; Kemp & Soede, 1996; Knox, 2005a).

The fifth hypothesis of this study was that legislation differences between the countries cause difference in total pre weaning mortality due to management of nursing sows. Since this has been discussed above it will not be treated further. However, the question is how the extensive use of nursing sows affects the sow longevity, considering the prolonged nursing period and the risk of sows returning to estrus during lactation. The Swedish sows in the study were culled later than the Danish sows in the study. However, no literature concerning the longevity of sows that have been used as nursing sows for several times has been found in order to support this. According to Mattsson (2013) Swedish sows that were used as nursing sows, and were thereby lactating for eight weeks in total, showed tendencies to have lower farrowing rates than sows that had been lactating for five weeks. The use of nursing sows also implies that the nursing periods, reported in the herd-monitoring programs, only states for how long the sow has been lactating and not for how long the piglets have been nursing. Thus, it is hard to compare lactation lengths between countries. Another interesting aspect in the present study was that the most common causes for culling was different than normally reported in the literature (*i.e.* reproductive problems) (Jalvingh et al., 1992; Koketsu et al., 1997a; Engblom et al., 2007). In the present study, the most common causes for culling was old age in Sweden and leg problems or old age in Denmark. Age has been reported to be the second most common cause for culling (Engblom et al., 2007) and leg problems the fourth most common cause for culling (Engblom et al., 2007; Knox, 2005a). Another distinct difference between Sweden and Denmark was that Swedish producers often produced their own replacement gilts while all Danish producers purchased replacement gilts.

The sixth hypothesis of this study was that legislation differences between the countries do not cause difference in total pre weaning mortality due to different housing systems. Due to the fact that some of the Swedish herds visited had lower pre weaning mortality than all Danish herds, according to production results extracted from the herd-monitoring programs, the use of farrowing crates cannot guarantee a lower pre weaning mortality. That the use of farrowing crates does not necessarily imply a decreased pre weaning mortality has been reported in the literature (Cronin et al., 2000; Weber et al., 2007; KilBride et al., 2012). However, the number of piglets born alive was significantly higher for Danish herds and larger litters are frequently reported to increase pre weaning mortality (Hartsock & Graves, 1976; Tuchscherer et al., 2000; Vasdal et al., 2011). Thus, no conclusions can be made about the different housing systems and its impact on mortality.

The seventh hypothesis of this study was that there are genetic differences between the sows in successful Swedish and Danish herds causing differences in the number of weaned piglets per litter and per sow and year. According to production results, extracted from the herd monitoring programs, the visited Danish herds were superior to Swedish in terms of weaned piglets per litter and per sow and year. Only one Swedish herd visited was approaching the Danish production level in terms of weaned per sow and year. In the study it was found that the number of functional teats, the udder health and the litter appearance significantly affected the number of weaned piglets. These are all factors affected by the genes of the sow, even if management also affects the outcome. Thus, the genes of the sow can affect the number of weaned piglets. However, one should add to the discussion that Danish herds did not seem to correct the number of weaned piglets according to the use of nursing sows. This means that the total number of weaned piglets within one batch was counted and then divided with the number of sows that farrowed within that batch (*i.e.* they did not take the added nursing sows into account to the results), which makes it hard to compare the number of weaned piglets between countries.

There were large variations between all herds in most production parameters except in the number born alive (as discussed above), where Danish herds were clearly superior (probably due to breeding as discussed above). Due to this, it is probable that the high number of piglets born alive is the main cause to the high numbers of piglets weaned in Denmark. This has also been stated in the literature (Gill, 2007). Today, breeding companies control the genetic selection of different pig breeds nationally (Nielsen & Nørgaard, 2012; Nordic Genetics, 2012; Norsvin, 2012). Thus, at this very moment the genetic material within country can be considered fairly equal, even if producers are able to modify the genetic material by selection of F1-gilts. Since, the high number of piglets born alive in Denmark is probably due to selection and since the number of piglets weaned may predominantly be due to the high number of piglets born alive, it may be possible to conclude that there are genetic differences between Swedish and Danish sows and that this partly causes differences in the number of weaned piglets per litter and per sow and year.

The eighth hypothesis of this study was that Swedish piglet producers have the potential to increase the number of piglets born alive, decrease piglet mortality and increase the number of litters per sow and year by improving management. Summarizing, everything discussed above it can be concluded that Swedish average producers have the potential to wean more piglets per sow and year by improved management. Primarily, this could be achieved by improving piglet survival (Tuchscherer et al., 2000; Grandinson et al., 2002; Andersen et al., 2007), decreasing the weaning to service interval, increasing the farrowing rate, decreasing the percentage of sows returning to estrus after service and decreasing the number of non-productive days (Vesseur et al., 1994; Kemp & Soede, 1996; Knox, 2005a). The number of piglets born alive can also be increased by for example attended farrowings (White et al., 1996; Tuchscherer et al., 2000; Knox, 2005b) but the highest gain of the number born alive and improved piglet survival could be achieved by including a LG5-breeding goal into the Swedish breeding evaluation.

8.3. Discussion of future implications

During 2012 the breeding company responsible for the Swedish Yorkshire and Hampshire breeds (*i.e.* Nordic Genetics) announced that the breeding for the Swedish Yorkshire would be expended due to low profitability (Brink, 2012; Jordbruksaktuellt, 2012). In the future, the majority of the genetic material used in Sweden will thus be Danish Yorkshire and Danish Landrace in dam-lines and Swedish Hampshire or Danish Duroc in the sire-lines and the import of genetic material will start during 2013 (Jordbruksaktuellt, 2012). The consequences of this decision have been discussed during 2012. A decreased biosecurity has been brought up as concern in terms of Salmonella, Porcine Reproductive and Respiratory Syndrome (PRRS) and Meticillinresistent *Staphylococcus aureus* (MRSA), diseases and pathogens that Swedish pigs are free from today (Wallberg, 2012). The suitability of European genetic material has also been brought up as concern. The differences in housing systems (*i.e.* farrowing crates vs. farrowing pens), in allowed interventions (*i.e.* tail docking and the use of hormones to induce estrus) and in allowed weaning age, between Sweden and the rest of Europe, have raised concerns about how for example Danish sows would perform (*i.e.* maternal traits etc.) according to Swedish conditions (Rydhmer et al., 2012).

All concerns mentioned above will certainly involve challenges for Swedish producers, but may also imply possible improvement. Import of Danish genetic material would mean import of genetic material, which is bred for more piglets born alive, for higher piglet survival (*i.e.* the LG5-breeding goal) and against shoulder lesions. However, since the sire-line (*i.e.* Hampshire or Duroc) contributes to 50 % of the genes in the piglet, the LG5-breeding goal should also be included in the breeding evaluation of those breeds. Nonetheless, the number of piglets born in total and alive will most probably increase in the future and this is something that Swedish piglet producers will have to be able to handle, preferably without increasing the pre weaning mortality additionally, but also something that they can look forward to. The issue of what management factors currently used in Denmark, and that could also be used in Sweden will be more important than ever. Perhaps, some legislation might have to slightly ease in order to allow Swedish producers to use, for example, nursing sows more extensively in order to not increase piglet mortality additionally. The question of how much piglet mortality that is acceptable before it is considered too much or a serious welfare issue for the piglets is more up to date than ever. Furthermore, since Danish sows had significantly fewer shoulder lesions than Swedish sows, the presence might be decreased in the future.

The producers interviewed were generally positive and open-minded and they seldom stated that they considered something problematic. As an example, all Danish herds visited had finished the preparations and adjusted to the new EU-directive incorporated from January 2013 and all gestating sows were thus loose-housed from four weeks post service and until seven days prior to farrowing. A positive mind can for example decrease the pre weaning mortality (Gill, 2007). Danish herds were both larger and more uniform, in terms of management and housing, than Swedish herds. All Swedish herds visited were very good at something and mostly something distinguished each herd from other herds. For example, one herd visited had excellent and extremely large piglets, another herd had excellent udder health and nice udders with many unharmed teats, another herd had excellent air quality with very little dust and ammonia and another herd had completely silent units. It was often the first impression noticed when entering the unit that was the strength of the herd and during measurement it often turned out to be true. It can thus be stated that one does not have to be best at everything in order to be part of the most successful herds. However, one must be quite good at most things, not bad at most things and an expert on something.

Knox (2005a) stated that: “Since farms can apparently approach the objective of 30 PSY (*i.e.* piglets per sow and year) by different routes, the essential elements may involve what they share in common rather than what they do differently”. Thus it would be interesting with further studies investigating the influence of some management parameters but with a larger number of observations than possible in this study. A larger number of observations could increase the degree of explanation in the models and would probably find other differences. It would be interesting with a study investigating the longevity of sows that has been used as nursing sows for one or several times in relation to sows that has never been used as nursing sows. How this affects the general herd results and profitability when considering the whole production.

9. IMPLICATIONS FOR SWEDISH PRODUCERS

The most important factors for improving the number of weaned piglets per sow and year are:

- To improve piglet survival
- To decrease the weaning to service interval
- To increase the farrowing rate
- To decrease the percentage of sows returning to estrus after service
- To decrease the number of non-productive days.

A change from Swedish Yorkshire x Norwegian Landrace sows into Danish Yorkshire x Landrace sows in commercial Swedish herds will probably:

- Increase litter sizes
- Decrease pre weaning mortality
- Increase the number of weaned piglets per sow and year due to higher number of piglets born alive
- Decrease weaning weights of piglets
- Decrease the presence of shoulder lesions.

Management factors used in Denmark and that could improve productivity of Swedish sows are:

- To continuously increase the feed ration throughout lactation (*i.e.* during the last weeks of the nursing period) in order to increase body condition scores of sows, since high body condition scores had significant impact on a high litter appearance
- To use ultrasonic scanners as pregnancy testers instead of ultrasonic meters and to perform two pregnancy tests per sow and pregnancy, in order to decrease the number of non-productive days and thus increase the number of litters per sow and year
- To find a way to use nursing sows more extensively than today, suitable to Swedish conditions and possibilities, in order to improve piglet survival.

10. CONCLUSIONS

- Management factors affect the number of weaned piglets per sow and year. The number of weaned piglets per litter is significantly influenced by herd, the number of functional teats per sow, the udder health and the litter appearance. The litter homogeneity is significantly influenced by the udder health. The litter appearance is significantly influenced by the body condition score of the sow and the udder health.
- The number of piglets born alive is primarily affected by breeding goals. The total number of piglets born and the number of piglets born alive is significantly higher in Denmark than in Sweden.
- The number of litters per sow and year is affected by management. The weaning to service interval, farrowing rate, percentage of sows returning to estrus after service and number of non-productive days are more important for the outcome than the lactation length.
- Pre weaning mortality is affected by management but also genetics. The LG5-breeding goal is an important cause of the lower pre weaning mortality in Denmark compared to Sweden. It was not possible during this study to conclude exactly what management factors that could improve piglet survival. However, the use of nursing sows is believed to be the most important one. The udder-, leg- and hoof health was significantly higher in Swedish sows. The body condition score was significantly higher (better) in Danish sows and no shoulder lesions were observed in Danish herds.
- Using farrowing crates is not a guarantee to lower pre weaning mortality, since some Swedish herds in the study had lower pre weaning mortality than the Danish herds. However, since the number of piglets born alive was significantly higher for Danish herds, no certain conclusions can be made.
- Swedish average producers have the potential to wean more piglets per sow and year, primarily by improving piglet survival, decreasing the weaning to service interval, increasing the farrowing rate, decreasing the percentage of sows returning to estrus after service and decreasing the number of non-productive days. The number of piglets born alive as well as piglet survival could also be improved by including a piglet survival-breeding goal into the Swedish breeding evaluation (*i.e.* for Hampshire since Danish Yorkshire is likely to be used in the future).

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12. APPENDICES

Appendix I: Interview questionnaire
Appendix II: Protocol
Appendix III: Key figures for visited herds

Appendix I

INTERVJUUNDERLAG

Besättning: ………………………………………………………………………………………...
Besöksdatum: ………………………
Intervjuad:…………………………………………………………………….. Anställd □ Ägare □ Mailadress: …………………………
Typ av produktion:…………………………………. Antal levererade grisar per år: Smågrisar:……….Slaktsvin:…………………..
Smågrisleverans: ……………………….. Slakteri:……………………………
Besättningsveterinär:………………………………..
Rådgivare: …………………………………..
Hur länge har ni haft dagens produktion?...

Frågor med svar enligt en femgradig skala 1-5 där 1 är "dåligt" och 5 är "bra" alternativt det påstående som i frågan kommer först t.ex. torrt (1)/fuktigt (5)

GRUNDLÄGGANDE		AVDELNING A	AVDELNING B	Kommentarer A	Kommentarer B
1	Antal suggor i produktion	stycken			
2	Omgångssystem				
3	Antal suggrupper	stycken			
4	Antal suggor/grupp	stycken	stycken		
5	Hur upplever du att er produktion fungerar idag?	1 2 3 4 5	1 2 3 4 5		
6	Är grisproduktionen lönsam?	1 2 3 4 5	1 2 3 4 5		
7	Har ni någon rådgivning?	JA NEJ			
8	Hur upplever ni er rådgivning?	1 2 3 4 5			
9	Fungerar det bra med besättningsveterinären?	1 2 3 4 5			
10	Byter ni skor/kläder mellan avdelningarna?	Skor Kläder Skotvätt Stalosantråg Mellan smågr/sl.sv Nej	Skor Kläder Skotvätt Stalosantråg Mellan smågr/sl.sv Nej		
11	Har ni egen rekrytering eller köps djur in?	Egen Inköp dräktiga	Egen Inköp dräktiga		

		Inköp gyltor Både och	Inköp gyltor Både och		
12	Hur går den egna rekryteringen till?				
13	Hur väljs gyltämnen ut?	Antal spenar Storlek Benställning Klövar Annat	Antal spenar Storlek Benställning Klövar Annat		
14	Upplever ni att treraskorsningar klarar sig bättre än tvåraskorsningar fram till avvänjning?	JA NEJ	JA NEJ		*Livsduglighet, överlevnad, tillväxt etc.*
15	Är ni nöjda med den egna rekryteringen?	1 2 3 4 5			
16	Är ni nöjda med inköpta djur?	1 2 3 4 5			
17	Vad har ni för utslagsprocent/år?				
18	Vad upplever ni är den vanligaste orsaken till utslagning?	Fertilitet Omlöp Svårt att se brunst Sjukdom Skada Få antal födda Få antal avvanda Ålder Annat	Fertilitet Omlöp Svårt att se brunst Sjukdom Skada Få antal födda Få antal avvanda Ålder Annat		
19	Vid vilket kullnummer slås suggorna ut i snitt?				
20	Vid vilket kullnummer slår ni ut suggorna som max?				
21	Verkar ni klövar?	Vid grisning Vid brunst Annan tidpunkt Nej	Vid grisning Vid brunst Annan tidpunkt Nej		

Appendix I

SINSUGGAVDELNING		AVDELNING A	AVDELNING B	Kommentarer A	Kommentarer B
1	Antal sinavdelningar	**stycken**	**stycken**		
2	Finns separata avdelningar för betäckning och dräktighet?	**JA** **NEJ**	**JA** **NEJ**		
3	Hur länge har avdelningarna varit i bruk?	**Sedan**	**Sedan**		
4	Vilket inhysningssystem finns i avdelningarna?	**Djupströ m ätbås** **Djupströ u ätbås** **3-rummare** **2-rummare** **Tvärtråg** **ESF**	**Djupströ m ätbås** **Djupströ u ätbås** **3-rummare** **2-rummare** **Tvärtråg** **ESF**		
5	Vilket strö används i avdelningen?	**Långhalm** **Hackad halm** **Torv** **Spån**	**Långhalm** **Hackad halm** **Torv** **Spån**		
6	Vilket ventilationssystem finns i avdelningen?	**Undertryck** **Övertryck** **Neutraltryck** **Naturlig**	**Undertryck** **Övertryck** **Neutraltryck** **Naturlig**		
7	Fungerar ventilationen smärtfritt?	**JA** **NEJ**	**JA** **NEJ**		
8	Vilket utgödslingssystem finns i avdelningen?				
9	Fungerar utgödslingen smärtfritt?	**JA** **NEJ**	**JA** **NEJ**		
10	Finns tillgång till sjukbox? Hur många?	**JA** **NEJ** **stycken**	**JA** **NEJ** **stycken**		
11	Upplever ni att ni har tillräckligt med sjukboxar?	**JA** **NEJ**	**JA** **NEJ**		
12	Hur många timmar/dygn är avdelningen tänd?	**timmar**	**timmar**		
13	Skiljer sig antalet ljustimmar vid brunst/seminering/	**JA** **NEJ**	**JA** **NEJ**		

	dräktighet? Hur?				
14	Finns nattlampa i avdelningen?	**JA** **NEJ**	**JA** **NEJ**		
15	Vad vaccineras gyltor mot?	**Rödsjuka** **Parvo** **Spädgrisdiarré** **Mycoplasma** **PMWS** **Annat**			
16	Vad vaccineras suggor mot?	**Rödsjuka** **Parvo** **Spädgrisdiarré** **Mycoplasma** **PMWS** **Annat**			
17	Hur grupperas suggorna efter avvänjning?	**Kullnummer** **Storlek** **Hull** **Ej**	**Kullnummer** **Storlek** **Hull** **Ej**		
18	Hur integreras gyltor i nya grupper?				
19	Vilken veckodag kommer suggorna i regel i brunst?				
20	Upplever ni att suggorna uppvisar normalt brunstbeteende?	**JA** **NEJ**			
21	Under vilka veckodagar sker vanligtvis seminering/betäckning?				
22	Hur många gånger semineras varje sugga?				
23	Semineras eller betäcks gyltor?	**Semineras** **Betäcks** **Både och**	**Semineras** **Betäcks** **Både och**		
24	Vid vilken brunst semineras/betäcks gyltor för första gången?				
25	Har ni några galtar?	**JA** **NEJ**			

	Hur många?	**stycken**			
26	Förekommer det att galtarna får betäcka? Vilka?	**JA** **NEJ**			
27	Hur använder ni galtarna i övrigt?	**Brunstsynk** **Seminering** **Arbetsgång** **Galtvagn** **Bädd** **Övrigt**	**Brunstsynk** **Seminering** **Arbetsgång** **Galtvagn** **Bädd** **Övrigt**		
28	Vilka rutiner finns för brunstkontroll? Hur ofta kollas brunst?				
29	Vilka rutiner finns för seminering?				
30	Vilka rutiner finns för betäckning?				
31	Finns skrivna rutiner för brunstkontroll, seminering och betäckning?	**JA** **NEJ**			
32	På vilken dräktighetsdag görs dräktighetskontroll?				
33	Hur utförs dräktighetskontrollen?	**Ultraljud** **Rektalpalpering** **Scanner**			
34	Upplever ni att ni har problem med omlöp?	**1 2 3 4 5**	**1 2 3 4 5**		
35	Vad upplever ni är orsaken till detta?				
36	Upplever ni att ni har problem med kastningar?	**1 2 3 4 5**	**1 2 3 4 5**		
37	Vad upplever ni är orsaken till detta?				

GRISNINGSAVDELNING		**AVDELNING A**	**AVDELNING B**	**Kommentarer A**	**Kommentarer B**
1	Antal grisningsavdelningar	**stycken**	**stycken**		
2	Har grisningsavdelningarna olika utförande?	**JA** **NEJ**			
3	Hur länge har avdelningarna varit i bruk?	**Sedan**	**Sedan**		
4	Vilket boxsystem finns i avdelningarna?	**Framåtvänd BB** **Bakåtvänd BB** **Enhetsbox** **FTS** **Djupströ BB** **Djupströ Familj**	**Framåtvänd BB** **Bakåtvänd BB** **Enhetsbox** **FTS** **Djupströ BB** **Djupströ Familj**		
5	Hur är smågrishörnorna utformade?	**Värmelampa** **Värmetak** **Golvvärme** **Tre väggar** **Annat**	**Värmelampa** **Värmetak** **Golvvärme** **Tre väggar** **Annat**		
6	Vilket ventilationssystem finns i avdelningen?	**Undertryck** **Övertryck** **Neutraltryck** **Naturlig**	**Undertryck** **Övertryck** **Neutraltryck** **Naturlig**		
7	Fungerar ventilationen smärtfritt?	**JA** **NEJ**	**JA** **NEJ**		
8	Vilket utgödslingssystem finns i avdelningen?				
9	Fungerar utgödslingen smärtfritt?	**JA** **NEJ**	**JA** **NEJ**		
10	Hur många timmar/dygn är avdelningen tänd?	**timmar**	**timmar**		
11	Skiljer sig antalet ljustimmar något under digivningen? Hur?	**JA** **NEJ**	**JA** **NEJ**		
12	Finns nattlampa i avdelningen?	**JA** **NEJ**	**JA** **NEJ**		
13	Hur långt innan grisning flyttas suggorna in i	**dagar**	**dagar**		

	grisningsavdelningen?				
14	Hur ställs avdelningen i ordning innan insättning?	**Lampor** **Strö hörna** **Strö box** **Suggkort** **Avbäringsrör** **Annat**	**Lampor** **Strö hörna** **Strö box** **Suggkort** **Avbäringsrör** **Annat**		
15	Vilken veckodag börjar grisningen?				
16	Är antalet födda tillfredställande?	**1 2 3 4 5**	**1 2 3 4 5**		
17	Hur uppfattar ni generellt smågrisarnas tillväxt?	**1 2 3 4 5**	**1 2 3 4 5**		
18	Upplever ni att smågrisdödligheten är ett problem?	**1 2 3 4 5**	**1 2 3 4 5**		
19	När upplever ni att ni tappar de flesta smågrisarna?	**Vid Grisning** **De första dagarna** **v1** **v2** **v3** **v4**	**Vid Grisning** **De första dagarna** **v1** **v2** **v3** **v4**		
20	Vilken är den vanligaste dödsorsaken? (rangordna)	**Dödfödd__** **Svält/Ej fått råmjölk__** **Svagfödd__** **Klämd__** **Sjukdom__** **Missbildning__** **Övrigt __**	**Dödfödd__** **Svält/Ej fått råmjölk__** **Svagfödd__** **Klämd__** **Sjukdom__** **Missbildning__** **Övrigt __**		
21	Vad upplever ni är den vanligaste bakomliggande orsaken till dödligheten?	**Kullstorlek** **Mjölkproduktion** **Suggrelaterat** **Smågrisrelaterat**	**Kullstorlek** **Mjölkproduktion** **Suggrelaterat** **Smågrisrelaterat**		
22	Gör ni något för att minska förekomsten av smågrisdödligheten?	**JA** **NEJ**	**JA** **NEJ**		

23	Vad?				
24	Hur registreras smågrisdödligheten?	**Individuell reg.** **Orsak** **Tidpunkt** **Endast ant avv.**	**Individuell reg.** **Orsak** **Tidpunkt** **Endast ant avv.**		
25	Vilken avvänjningsålder har ni?	**dagar** **veckor**	**dagar** **veckor**		
26	Vilken veckodag avvänjer ni?				
27	Är antalet avvanda tillfredsställande?	**1 2 3 4 5**	**1 2 3 4 5**		

FODER OCH VATTEN		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	Vad har ni för foderanläggning?				
2	Har ni enhetsfoder till suggorna eller olika under sintid och ditid?	**Enhet** **Olika**	**Enhet** **Olika**		*Hur lika är recept?*
3	När byter ni foder?				
4	Vad får sinsuggorna för foder?	**Premix** **Konc** **Färdig** **Råvaror** **Recept**	**Premix** **Konc** **Färdig** **Råvaror** **Recept**		
5	Vad får digivande suggor för foder?	**Premix** **Konc** **Färdig** **Råvaror** **Recept**	**Premix** **Konc** **Färdig** **Råvaror** **Recept**		
6	Finns något särskilt energitillskott i digivningsfodret? Vad?	**JA** **NEJ**	**JA** **NEJ**		
7	Får suggorna samma foderblandning från insättning i BB till avvänjning?	**JA** **NEJ**	**JA** **NEJ**		
8	Hur ofta utfodras sinsuggor?	**gånger/dag**	**gånger/dag**		

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9	Vid vilken tid får de foder?	**kl**	**kl**		
10	Hur ofta utfodras digivande suggor?	**gånger/dag**	**gånger/dag**		
11	Vid vilken tid får de foder?	**kl**	**kl**		
12	Får sinsuggor torrfoder eller blötfoder?	**Torrt** **Blött**	**Torrt** **Blött**		
13	Får digivande suggor torrfoder eller blötfoder?	**Torrt** **Blött**	**Torrt** **Blött**		
14	Vilken giva får sinsuggor efter avvänjning?	**MJ** **KG** **LITER**	**MJ** **KG** **LITER**		
15	Vilken giva får sinsuggor under mitten av sintiden?	**MJ** **KG** **LITER**	**MJ** **KG** **LITER**		
16	Vilken giva får sinsuggor i slutet av sintiden?	**MJ** **KG** **LITER**	**MJ** **KG** **LITER**		
17	Vilken grundgiva får digivande suggor?	**MJ** **KG** **LITER**	**MJ** **KG** **LITER**		
18	Vilken maxgiva får digivande suggor?	**MJ** **KG** **LITER**	**MJ** **KG** **LITER**		
19	Hur fort kommer suggorna normalt upp i maxgiva efter grisning?	**dagar**	**dagar**		
20	Vilka utfodringsrutiner finns för övrigt under ditiden?				*Justeras foder dagligen? Även helger? När kollar man foder? Hur mkt höjer/sänker man om suggorna ätit upp/inte ätit upp? Annat?*
21	Vad finns för foderrutiner dagarna innan grisning?	**Minskning__** **Tar bort__** **Annat foder__** **Övrigt___** **Inga förändringar__**	**Minskning__** **Tar bort__** **Annat foder__** **Övrigt___** **Inga förändringar__**		
22	Hur vanligt är det med fodervägran?	**1 2 3 4 5**	**1 2 3 4 5**		

23	Hur hanteras fodervägrande suggor?				
24	Finns det skrivna rutiner för fodervägran?	**JA** **NEJ**	**JA** **NEJ**		
25	Vad får smågrisarna för foder?				
26	När börjar smågrisarna utfodras?	**dagar** **veckan**	**dagar** **veckan**		
27	Hur mycket foder får smågrisarna totalt under diperioden per kull?	**KG** **LITER**	**KG** **LITER**		
28	Hur sker utfodringen av smågrisarna?	**I tråg** **På golvet**	**I tråg** **På golvet**		
29	Finns ett separat foder för rekryteringsdjur?	**JA** **NEJ**	**JA** **NEJ**		
30	Hur ofta tas foderprover?				*Hygien + näringsinnehåll*
31	Hur ofta tas prover på strömaterialet?				*Hygien*
32	Hur ofta tas vattenprover?				*Hygien*
33	Vet ni med er att ni har mycket av något ämne i ert vatten? Vad?	**JA** **NEJ**	**JA** **NEJ**		

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UNDER DIN SENAST AVVANDA OMGÅNG
När var det: AVD A:____________________ AVD B:_________________________

AVDELNINGEN		AVD A	AVD B	Kommentarer A	Kommentarer B
1	Grisning: För varmt/kallt?	**1 2 3 4 5**	**1 2 3 4 5**		
2	Grisning: För fuktigt/torrt?	**1 2 3 4 5**	**1 2 3 4 5**		
3	Grisning: Luftkvalitet?	**1 2 3 4 5**	**1 2 3 4 5**		*NH3, H2S, damm etc.*
4	Avvänjning: För varmt/kallt?	**1 2 3 4 5**	**1 2 3 4 5**		
5	Avvänjning: För fuktigt/torrt?	**1 2 3 4 5**	**1 2 3 4 5**		
6	Avvänjning: Luftkvalitet?	**1 2 3 4 5**	**1 2 3 4 5**		
7	Förekom det drag i avdelningen?	**1 2 3 4 5**	**1 2 3 4 5**		
8	Hur var ljudnivån i avdelningen?	**1 2 3 4 5**	**1 2 3 4 5**		
9	Fungerade ventilationen bra?	**1 2 3 4 5**	**1 2 3 4 5**		
10	Tvättade ni avdelningen innan insättning?	**JA** **NEJ**	**JA** **NEJ**		
11	Desinficerades avdelningen?	**JA** **NEJ**	**JA** **NEJ**		
12	Med vilket preparat?				
13	Hur lång var torktiden?	**dagar**	**dagar**		
14	Var tvätten representativ för en normal omgång?	**JA** **NEJ**	**JA** **NEJ**		
15	Är golvet i BB isolerat?	**JA** **NEJ**	**JA** **NEJ**		
16	Finns golvvärme i BB-boxarna?	**Hela golv__** **Smågrishörnan__** **Nej__**	**Hela golv__** **Smågrishörnan__** **Nej__**		

		Torkning__	**Torkning__**		
17	Upplevde ni problem med att suggorna vände på boxarna?	**1 2 3 4 5**	**1 2 3 4 5**		
18	Testades alla vattennipplar innan insättning?	**JA** **NEJ**	**JA** **NEJ**		

TILLSYN		AVD A	AVD B	Kommentarer A	Kommentarer B
1	Under vilka veckodagar pågick grisningen?				
2	Var det någon som grisade i bädden/innan inflytt?	**JA** **NEJ**	**JA** **NEJ**		
3	Hur många personer jobbade i BB under grisning?	**stycken**	**stycken**		
4	Var det samma personer som jobbade i avdelningen under hela grisningsveckan, inklusive eventuell helg?	**JA** **NEJ**	**JA** **NEJ**		
5	Var det en person som ansvarade för omgången?	**JA** **NEJ**	**JA** **NEJ**		
6	Har samma person huvudansvaret för alla omgångar?	**JA** **NEJ**	**JA** **NEJ**		
7	Har ni särskilda krav på utbildning/erfarenhet hos era anställda?	**JA** **NEJ**	**JA** **NEJ**		
8	Mellan vilka tider jobbar ni med grisarna?				
9	Fick de tillsyn utöver normal arbetstid under grisningsveckan?	**Kvällstid** **Tidig morgon** **Nej**	**Kvällstid** **Tidig morgon** **Nej**		
10	Ungefär hur mycket tid spenderades i grisningsstallet totalt	**timmar**	**timmar**		

	under grisningsveckan per dag?				
11	Ungefär hur mycket tid spenderades i grisningsstallet totalt per dag under övriga digivningsperioden?	**timmar**	**timmar**		
12	Vad gör ni när ni noterat att en sugga börjat grisa?	**Skrapa** **Halma** **Stalosan** **Avbäringsrör** **Räkna spenar** **Tempa** **Suggkort** **Omgångslista** **Juverprotokoll** **Annat**	**Skrapa** **Halma** **Stalosan** **Avbäringsrör** **Räkna spenar** **Tempa** **Suggkort** **Omgångslista** **Juverprotokoll** **Annat**		
13	Förekom det utdragna grisningar?	**1 2 3 4 5**	**1 2 3 4 5**		
14	Vad klassificerades som utdragna grisningar, hur lång tid fick det ta? Om inga andra tecken på komplikationer fanns.				*När gör man något?*
15	Vad var orsaken till de utdragna grisningarna?	**Dålig kondition** **Överviktig** **För trång** **Gylta** **Framfall** **Annat** **Vet inte**	**Dålig kondition** **Överviktig** **För trång** **Gylta** **Framfall** **Annat** **Vet inte**		
16	Hur hanterades detta?	**Motion** **Känna** **Dra ut** **Spruta** **Massage** **Annat** **Inget**	**Motion** **Känna** **Dra ut** **Spruta** **Massage** **Annat** **Inget**		
17	Fanns skrivna rutiner?	**JA** **NEJ**	**JA** **NEJ**		

18	Hur hanterade ni situationen när en grisning inte kom igång alls, och passerade beräknat datum?				

FODER OCH VATTEN		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	Användes samma foderblandningar som normalt?	**JA** **NEJ**	**JA** **NEJ**		
2	Uppstod några foderproblem under sintiden?	**JA** **NEJ**	**JA** **NEJ**		
3	Uppstod några foderproblem under digivningen?	**JA** **NEJ**	**JA** **NEJ**		
4	Hur vanligt var det med fodervägran?	**1 2 3 4 5**	**1 2 3 4 5**		
5	Hur diagnostiserades fodervägran?				
6	Vilka insatser gjordes för att få fodervägrande suggor att äta?	**Annat** **suggfoder** **Smågrisfoder** **Mjölkpulver** **Behandling** **Annat**	**Annat** **suggfoder** **Smågrisfoder** **Mjölkpulver** **Behandling** **Annat**		
7	Hur många suggor fick särskild utfodring under sintiden?	**stycken**	**stycken**		
8	Hur många suggor fick särskild utfodring under digivningen?	**stycken**	**stycken**		
9	Hur fort kom suggorna upp i maxgiva efter grisningen?	**dagar**	**dagar**		
10	Följdes rutiner för utfodring dagarna innan grisning?	**JA** **NEJ**	**JA** **NEJ**		
11	Var dessa rutiner	**JA**	**JA**		

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	nedskrivna?	**NEJ**	**NEJ**		
12	Fick smågrisarna samma foder som normalt?	**JA** **NEJ**	**JA** **NEJ**		
13	När började smågrisarna utfodras?	**dagar** **veckan**	**dagar** **veckan**		
14	Fanns tillgång till smågrisfoder hela tiden?	**JA** **NEJ**	**JA** **NEJ**		

SUGGOR		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	Finns rutiner för att kolla suggornas hull?	**JA** **NEJ**	**JA** **NEJ**		
2	När kontrollerar ni hullet?	**Avvänjning** **Dräktighetstest** **60 dagar** **Insättning BB** **Annan**	**Avvänjning** **Dräktighetstest** **60 dagar** **Insättning BB** **Annan**		
3	Hur kontrolleras hullet?	**Ögonmått** **Palpering** **Ekolod** **Annat**	**Ögonmått** **Palpering** **Ekolod** **Annat**		
4	Vad hade suggorna för hull vid grisning?	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?** **1 2 3 4 5**	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?** **1 2 3 4 5**		
5	Vad hade suggorna för hull då grisarna var runt tre veckor gamla?	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?**	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?**		

		1 2 3 4 5	**1 2 3 4 5**		
6	Vad hade suggorna för hull vid avvänjning?	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?** **1 2 3 4 5**	**Hullstatus** **1 2 3 4** **Allmän hälsostatus** **1 2 3 4 5** **Påverkade det digivningen?** **1 2 3 4 5**		
7	Tempades alla suggor vid grisning?	**JA** **NEJ**	**JA** **NEJ**		
8	Räknades antalet funktionella spenar vid grisning?	**JA** **NEJ**	**JA** **NEJ**		
9	Vad noterades på suggkortet?	**Antal spenar** **Grisningstid** **Suggnr** **Kullnr** **Förväntat grisningsdatum** **Grisningsdatum** **Totalt födda** **Levande födda** **Dödfödda** **Antal grisar** **Järn** **Kastrering** **Svartfoster** **Svagfödda** **Fläkgrisar** **Skakgrisar** **Missbildade** **Behandling sugga** **Behandling smgr** **Temp** **Kullutjämning** **Skiftesdi** **Amma**	**Antal spenar** **Grisningstid** **Suggnr** **Kullnr** **Förväntat grisningsdatum** **Grisningsdatum** **Totalt födda** **Levande födda** **Dödfödda** **Antal grisar** **Järn** **Kastrering** **Svartfoster** **Svagfödda** **Fläkgrisar** **Skakgrisar** **Missbildade** **Behandling sugga** **Behandling smgr** **Temp** **Kullutjämning** **Skiftesdi** **Amma**		

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		Foderintag Annat	**Foderintag Annat**		
10	Hur hanterades kullar som var större än antalet funktionella spenar?	**Kullutjämning Amsuggor Skiftesdigivning**	**Kullutjämning Amsuggor Skiftesdigivning**		
11	Fanns det skrivna rutiner för detta?	**JA NEJ**	**JA NEJ**		
12	Kullutjämnade ni?	**JA NEJ**	**JA NEJ**		
13	När?	**0-5h 5-24h 24-48h 2-3 dagar Över tre dagar**	**0-5h 5-24h 24-48h 2-3 dagar Över tre dagar**		
14	Vilka kullar kullutjämnades?	**Över x antal Beroende på antal spenar Beroende på andra kullstl Suggans hull Annat**	**Över x antal Beroende på antal spenar Beroende på andra kullstl Suggans hull Annat**		
15	Vilka smågrisar flyttades bort?	**Stora/små Svaga/starka Gyltor/galtar Annat**	**Stora/små Svaga/starka Gyltor/galtar Annat**		
16	Till vem flyttade ni?	**Gyltor Amsuggor Gamla suggor Små kullar Där stor dött Annat**	**Gyltor Amsuggor Gamla suggor Små kullar Där stor dött Annat**		
17	Hur registrerades kullutjämning?				
18	Använde ni er av ammsuggor?	**JA NEJ**	**JA NEJ**		
19	När använde ni er av ammsuggor?				
20	Hur togs ammsuggorna in i den nya gruppen?				
21	Hur registrerades och bokfördes amsuggor?				
22	Hur hanterade ni distopp/dålig digivning?				
23	Hade ni några beteendestörningar hos era suggor?	**Äta upp smågrisarna Bita rör Aggressiv Annat Nej**	**Äta upp smågrisarna Bita rör Aggressiv Annat Nej**		
24	Observerade ni bobyggnad innan grisning?	**1 2 3 4 5**	**1 2 3 4 5**		
25	Vilken typ av strö användes?	**Långhalm Hackad halm Torv Spån Halmpellets**	**Långhalm Hackad halm Torv Spån Halmpellets**		
26	Ungefärlig mängd strö som gavs per sugga och dag?	**KG LITER**	**KG LITER**		
27	Strödde ni annorlunda innan grisning?	**JA NEJ**	**JA NEJ**		
28	Hur?	**Bädd Extra mycket Lång halm**	**Bädd Extra mycket Lång halm**		
29	Var det vanligt med aggressioner mellan suggor i anslutande boxar?	**1 2 3 4 5**	**1 2 3 4 5**		
30	Var det någon sugga som dog under grisning/digivning? Antal? Orsak?	**JA NEJ stycken**	**JA NEJ stycken**		

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SMÅGRISAR		AVD A	AVD B	Kommentarer A	Kommentarer B
1	Vilken typ av strö användes i smågrishörnan?	**Lång halm Hackad halm Spån Torv Halmpellets Annat**	**Lång halm Hackad halm Spån Torv Halmpellets Annat**		
2	Gjordes några speciella insatser för att smågrishörnan skulle användas?	**JA NEJ**	**JA NEJ**		*Stänga in Hur länge Hur ofta När Hur släpps ut Liggbeteende Mäta temp Strö*
3	Observerades smågrisarnas liggbeteende?	**JA NEJ**	**JA NEJ**		
4	Var det vanligt förekommande att smågrisarna låg utanför smågrishörnan?	**JA NEJ**	**JA NEJ**		
5	Gjordes insatser därefter? Vad?	**JA NEJ**	**JA NEJ**		
6	Fanns skrivna rutiner för detta?	**JA NEJ**	**JA NEJ**		
7	Arbetade ni något med extra avbäringsrör?	**JA NEJ**	**JA NEJ**		
8	Hur använde ni dem?				
9	Fanns skrivna rutiner för detta?	**JA NEJ**	**JA NEJ**		
10	Hur gav ni järntillskott?	**Oralt Injektion Torv**	**Oralt Injektion Torv**		
11	Använde ni	**JA**	**JA**		

	mjölkersättning?	**NEJ**	**NEJ**		
12	Hur ofta sker det att ni behöver använda mjölkersättning?	**1 2 3 4 5**	**1 2 3 4 5**		
13	Hur ofta utfodrade ni med mjölkersättning/dag?	**gånger**	**gånger**		
14	Hur mycket mjölkersättning gav ni per kull och gång?	**liter**	**liter**		
15	Hur gavs mjölkersättningen?	**Automat Skål**	**Automat Skål**		
16	Fanns det skrivna rutiner för detta?	**JA NEJ**	**JA NEJ**		
17	Använde ni saltbalans?	**JA NEJ**	**JA NEJ**		
18	Hur ofta sker det att ni behöver använda saltbalans?	**1 2 3 4 5**	**1 2 3 4 5**		
19	I vilket syfte använder ni saltbalans?				
20	Hur ofta gav ni saltbalans/dag?	**gånger**	**gånger**		
21	Hur mycket saltbalans gav ni per kull och gång?	**liter**	**liter**		
22	Hur gavs saltbalansen?	**Automat Skål**	**Automat Skål**		
23	Använde ni i något sammanhang potatismjöl?	**JA NEJ**	**JA NEJ**		
24	Hur ofta sker det att ni behöver använda potatismjöl?	**1 2 3 4 5**	**1 2 3 4 5**		
25	I vilket syfte gav ni potatismjöl?				
26	Hur ofta gav ni potatismjöl/dag?	**gånger**	**gånger**		

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27	Hur mycket potatismjöl gav ni per kull och gång?	**msk** **dl**	**msk** **dl**		
28	Hur gavs potatismjölet?	**Juver** **Foder** **I tråg** **På golv** **Sked**	**Juver** **Foder** **I tråg** **På golv** **Sked**		
29	Använde ni "Pig pusher" eller dylikt preparat?	**JA** **NEJ**	**JA** **NEJ**		
30	Hur ofta sker det att ni behöver använda detta?	**1 2 3 4 5**	**1 2 3 4 5**		
31	I vilket syfte gavs detta?				
32	Hur ofta gav ni detta/dag?	**gånger**	**gånger**		
33	Använde ni något annat preparat/ husmorsknep?	**JA** **NEJ**	**JA** **NEJ**		
34	Hur ofta sker det att ni behöver använda detta?	**1 2 3 4 5**	**1 2 3 4 5**		
35	I vilket syfte gavs detta?				
36	Hur ofta gavs detta/dag?	**gånger**	**gånger**		
37	Hur mycket gavs per kull och dag?				
38	Hur gavs detta?				
39	Vad har ni för rutiner kring avlivning av smågrisar? Vilka smågrisar avlivades? Hur länge väntade ni?				
40	Hur avlivades de?				

VID GRISNING		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	Hur konstaterade ni att grisningen var igång?	**Bobygge** **Pissigt** **Orolig** **Mjölk** **Annat**	**Bobygge** **Pissigt** **Orolig** **Mjölk** **Annat**		
2	Hur konstaterade ni att en sugga grisat klart?	**Efterbörd** **Tid** **Antal grisar** **Känna** **Beteende** **Annat**	**Efterbörd** **Tid** **Antal grisar** **Känna** **Beteende** **Annat**		
3	Hur uppfattade ni kullarna?	**Små/Stora kullar** **1 2 3 4 5** **Små/Stora grisar** **1 2 3 4 5** **Många/Få dödfödda** **1 2 3 4 5** **Många/Få svagfödda** **1 2 3 4 5** **Många blev svaga** **1 2 3 4 5**	**Små/Stora kullar** **1 2 3 4 5** **Små/Stora grisar** **1 2 3 4 5** **Många/Få dödfödda** **1 2 3 4 5** **Många/Få svagfödda** **1 2 3 4 5** **Många blev svaga** **1 2 3 4 5**		
4	Fanns det några speciella sjukdomar/skador hos smågrisarna?	**JA** **NEJ**	**JA** **NEJ**		
5	Fick alla di inom ett par timmar efter födseln?	**1 2 3 4 5**	**1 2 3 4 5**		
6	Hur kontrollerade ni att alla fått di?				
7	Hur skiljde man dödfödda smågrisar från de som dött efter födseln?				
8	Förekom det att ni undantagsvis slipade	**JA** **NEJ**	**JA** **NEJ**		

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	tänder?				
9	Observerades suggornas liggbeteende vid grisning?	**JA** **NEJ**	**JA** **NEJ**		
10	Gjordes insatser därefter? Vad?	**JA** **NEJ**	**JA** **NEJ**		

VID KASTRERING		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	Vilken levnadsdag kastrerade ni?	**dagen**	**dagen**		
2	Upplevde ni några komplikationer vid ingreppet?	**Bråck** **Kryptorkism** **Många som dog i samband**	**Bråck** **Kryptorkism** **Många som dog i samband**		
3	Om ni råkade kastrera ett bråck, hur hanterade ni det då?	**Sydde** **Avlivade**	**Sydde** **Avlivade**		
4	Vilka rutiner fanns kring ingreppet?	**Smärtstillande** **Bedövning** **Vagn/Frihand** **Sprit** **Tång/Skalpell**	**Smärtstillande** **Bedövning** **Vagn/Frihand** **Sprit** **Tång/Skalpell**		
5	Utfördes andra moment i samband med kastreringen?	**Järn** **Vaccinering** **3v diarré** **Annat**	**Järn** **Vaccinering** **3v diarré** **Annat**		
6	Upplever ni att vaccinationen mot 3v diarré fungerar?	**JA** **NEJ**	**JA** **NEJ**		
7	Var det jämn fördelning mellan könen?	**1 2 3 4 5**	**1 2 3 4 5**		
8	Var det jämn storleksfördelning?	**1 2 3 4 5**	**1 2 3 4 5**		
9	Hade smågrisarna växt som förväntat?	**1 2 3 4 5**	**1 2 3 4 5**		
10	Hur många smågrisar per kull hade man i genomsnitt tappat vid kastreringen?	**stycken**	**stycken**		
11	Upplevde ni att det fanns problem med spädgrisdiarré?	**1 2 3 4 5**	**1 2 3 4 5**		
12	Upplevde ni att det var mycket smågrisbehandlingar?	**1 2 3 4 5**	**1 2 3 4 5**		
13	Hur ofta byttes kanyler vid behandling?	**Slö** **Varje kull** **Varje individ** **Annat**	**Slö** **Varje kull** **Varje individ** **Annat**		

VID TRE VECKORS ÅLDER		**AVD A**	**AVD B**	**Kommentarer A**	**Kommentarer B**
1	PMWS-vaccinerades grisarna?	**JA** **NEJ**	**JA** **NEJ**		
2	Vilka rutiner fanns för vaccineringen?				
3	Vaccinerades smågrisarna mot något annat?	**JA** **NEJ**	**JA** **NEJ**		
4	Upplevde ni att det fanns problem med 3v diarré?	**1 2 3 4 5**	**1 2 3 4 5**		
5	Hade smågrisarna växt som förväntat?	**1 2 3 4 5**	**1 2 3 4 5**		
6	Hur många smågrisar per kull hade man i genomsnitt tappat vid tre veckor?	**stycken**	**stycken**		
7	Upplevde ni att det var mycket smågrisbehandlingar?	**1 2 3 4 5**	**1 2 3 4 5**		

Appendix I

VID AVVÄNJNING		AVD A	AVD B	Kommentarer A	Kommentarer B
1	Hur många smågrisar avvandes i snitt per sugga?				
2	Var ni nöjda med avvänjningsvikten?	1 2 3 4 5	1 2 3 4 5		
3	Var ni nöjda med grisarnas storlek?	1 2 3 4 5	1 2 3 4 5		
4	Var ni nöjda med grisarnas livskraft/hälsa?	1 2 3 4 5	1 2 3 4 5		
5	Utfördes några åtgärder innan avvänjning för att underlätta avvänjningen? Vad?	JA NEJ	JA NEJ		
6	Hur gick avvänjningen till?				
7	Fanns skrivna rutiner för avvänjning?	JA NEJ	JA NEJ		

HÄLSA

I senast avvanda omgången förekomst av och antal:

Suggor

1. MMA JA ☐ NEJ ☐ ____________
2. Juverinflammation JA ☐ NEJ ☐ ____________
3. Speninflammation JA ☐ NEJ ☐ ____________
4. Spensår JA ☐ NEJ ☐ ____________
5. Dålig mjölkproduktion JA ☐ NEJ ☐ ____________
6. Ledinflammation/klövinflammation/halt JA ☐ NEJ ☐ ____________

7. Livmoderinflammation JA ☐ NEJ ☐ ____________
8. Bogsår JA ☐ NEJ ☐ ____________
9. Andra sår JA ☐ NEJ ☐ ____________
10. Rödsjuka JA ☐ NEJ ☐ ____________
11. Livmoderframfall JA ☐ NEJ ☐ ____________
12. Ändtarmsframfall JA ☐ NEJ ☐ ____________
13. Förstoppning JA ☐ NEJ ☐ ____________
14. Självdöd JA ☐ NEJ ☐ ____________
15. Avlivades JA ☐ NEJ ☐ ____________
16. Övrigt suggor JA ☐ NEJ ☐ ____________

Smågrisar

1. Spädgrisdiarré JA ☐ NEJ ☐ ____________
2. Treveckorsdiarré JA ☐ NEJ ☐ ____________
3. Avvänjningsdiarré JA ☐ NEJ ☐ ____________
4. Ledinflammation JA ☐ NEJ ☐ ____________
5. Klövinflammation/klövtramp JA ☐ NEJ ☐ ____________
6. Trampad/klämd JA ☐ NEJ ☐ ____________
7. Pellar JA ☐ NEJ ☐ ____________

8. Svaga i övrigt JA ☐ NEJ ☐ ______________________________
9. Förlamning JA ☐ NEJ ☐ ______________________________
10. Missbildade sedan födseln, vilka? JA ☐ NEJ ☐ ____________________
11. Skakgrisar JA ☐ NEJ ☐ ______________________________
12. Fläkgrisar JA ☐ NEJ ☐ ______________________________
13. Svartfoster JA ☐ NEJ ☐ ______________________________
14. Dödfödda JA ☐ NEJ ☐ ______________________________
15. Övrigt smågrisar JA ☐ NEJ ☐ ______________________________

SLUTLIGEN

Vilka förändringar, som ni genomfört under de senaste fem åren, tror ni är orsaken till att ni lyckats med produktionsresultaten?

Är det något som ni tycker att jag missat att ta upp?

Material att be om, om möjlighet finns:

- En säkerhetskopia på ert PigWin, efter att den omgången som jag senare ska titta på har avvants och uppgifter om denna omgång förts in i PigWin. På så sätt kan jag få fram all information om de två aktuella omgångarna. Kan skickas till mig via mail. Jag mailar er när det börjar bli dags så kan ni maila tillbaka?
- Om producent ej vill lämna säkerhetskopia så be om produktionsrapporterna från den senast avvanda omgången samt för den omgång som jag senare ska titta på, efter att denna omgång avvants och uppgifter förts in i PigWin.
- Innehållsdeklaration för olika foderblandningar (viktigast med difoder men även sinfoder och smågrisfoder).

AppendixII

STALLPROTOKOLL

Besättning: …………………………………………………………………………………...
Avdelning: ……………………….. Avdelning typ A eller B: ……………………………
Besöksdatum: ………………………
Grisningsvecka: ………………….. Ålder smågrisar: ……………………
Antal suggplatser: ……………….. Antal suggor: ……………………….

AVDELNINGEN	**Punkt 1***	**Punkt 2***	**Punkt 3***	**Ventilation****
Temperatur utomhus				
Temperatur avdelning				
RF utomhus				
RF avdelning				
Ammoniakhalt				
Ljudnivå				
Ljusstyrka				
Upplevd dammhalt	**1 2 3 4 5**	**1 2 3 4 5**	**1 2 3 4 5**	
Hur är fläktar placerade?				
Hur är luftintag placerade?				
Hur är ljusarmatur placerad?				

* Mätpunkter placerade enligt principen: Längst ner på höger sida av avdelningen, i mitten på höger eller vänster sida av avdelningen samt högst upp på vänster sida av avdelningen. Samtliga mätvärden tas inuti grisningsbox, i djurens vistelsezon. Mätpunkter i direkt anslutning till frånluftsfläkt etc. kommer att undvikas. För varje avdelning bifogas separat skiss över valda mätpunkter.
** Värde angivet av ventilationsanläggningen

VAD ANTECKNAS PÅ SUGGKORTEN?

Suggnummer
Kullnummer
Förväntat grisningsdatum
Grisningsdatum
Totalt födda
Levande födda
Dödfödda
Antal grisar
Antal spenar
Tid för grisningsstart
Järn
Kastrerat
Övrigt
Svartfoster
Svagfödda
Fläkta
Skakgrisar
Missbildade
Dödsorsaker
Behandling sugga
Behandling smågris
Rektaltemperatur
Kullutjämning
Skiftesdigivning
Amma
Foderlust

AppendixII

SUGGA NR		**Kommentar**
Kullnummer		
Antal smågrisar		
Totalt födda		
Levande födda		
Dödfödda		
Kullutjämnad eller orörd kull?	**Fått** **Gett** **Fått och gett** **Amma** **Framgår ej**	
Antal till/bortförda smågrisar	+/-	
Grisningsdatum	**Planerat** **Verkligt**	
Grisningssvårigheter?	**JA** **NEJ**	
Har suggan varit/är under behandling?	**JA** **NEJ**	
Dödsorsak smågrisar och antal	**Klämd/trampad** **Svält** **Svag** **Missbildad** **Övrigt** **Okänt** **SUMMA**	
Upplevd boxhygien	**1 2 3 4 5**	*1=Dålig hygien 5=Perfekt hygien*
Vattennipplar	**Antal** **Smågris** **Flöde 1 2 3 4 5**	*1=Mycket litet 5=Väldigt högt*
Extra avbäringsrör? Placering? Rita!	**JA** **NEJ**	
Hur jämn är kullen?	**1 2 3 4 5**	*1=Mycket ojämn 5=Mycket jämn*
Kullbedömning	**1 2 3 4 5**	*1=Dåligt omdöme 5=Bra omdöme*
Är foderträget tomt?	**JA** **NEJ**	
Golvtemperatur smågrishörna		
Golvtemperatur suggans liggyta		
Antal funktionella spenar		
Antal spenpar framför naveln		
Juverhälsa	**1 2 3 4 5**	*1=Mycket dålig hälsa 5=Inga hälsoanmärkningar*
Förekomst av bogsår	**Ena sidan** **Båda sidor** **Nej**	
Hull	**1 2 3 4**	*3=Önskvärt*
Benhälsa	**1 2 3 4 5**	*1=Mycket dålig hälsa 5=Inga hälsoanmärkningar*
Klövhälsa	**1 2 3 4 5**	*1=Mycket dålig hälsa 5=Inga hälsoanmärkningar*

Appendix III

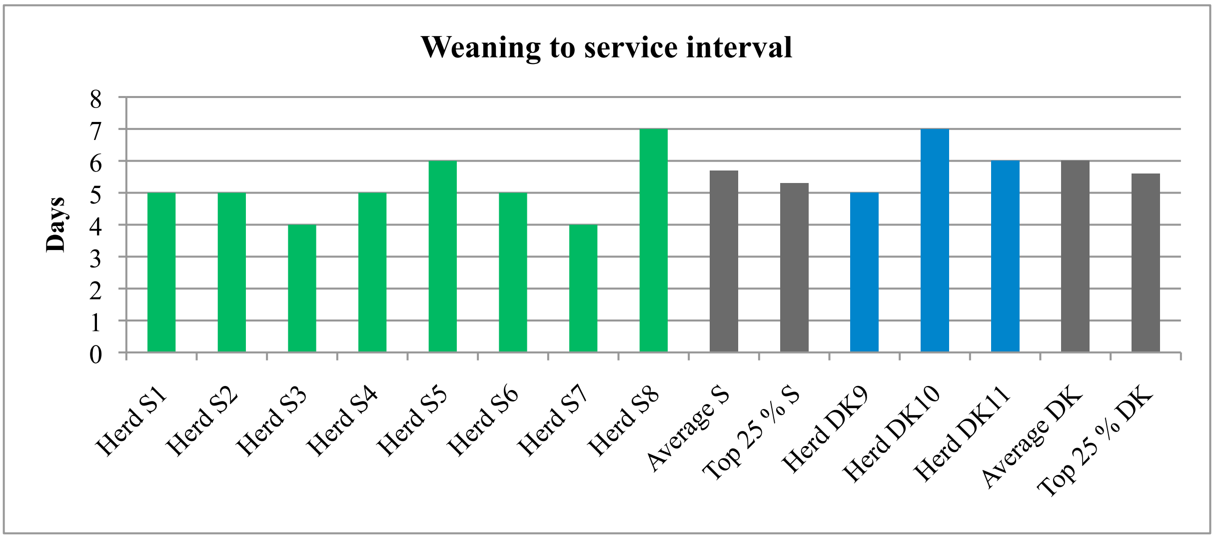

Figure 1. The average weaning to service interval in visited herds in comparison to the average and the 25 % most successful herds.

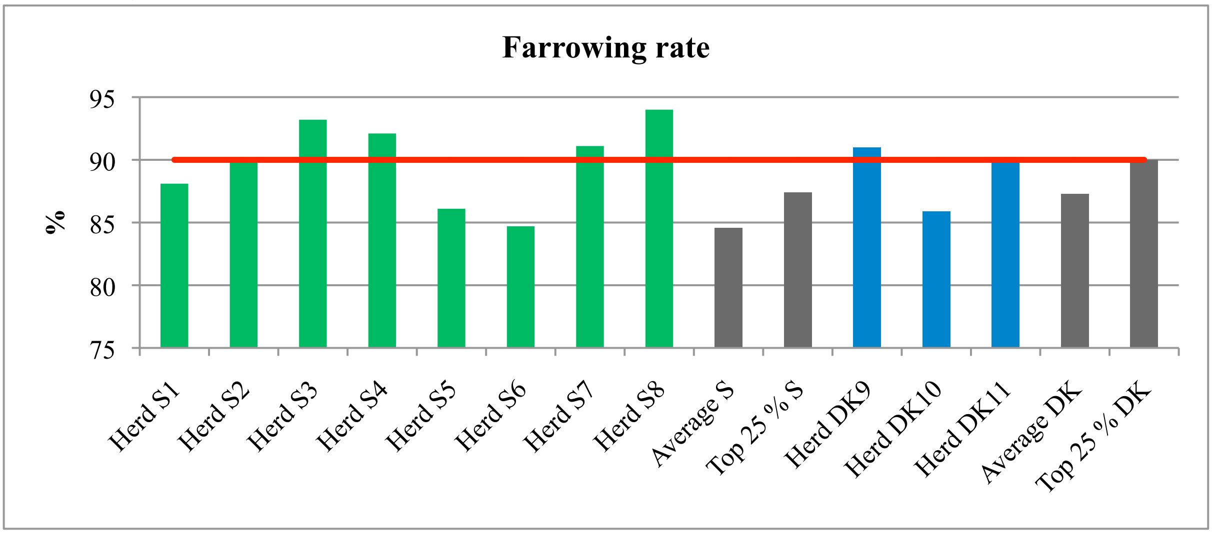

Figure 2. The average farrowing rate in visited herds in comparison to the average and the 25 % most sucessful herds. The red line shows the recommended boundary in order to achieve 30 weaned piglets per sow and year (Knox, 2005a; Gill, 2007).

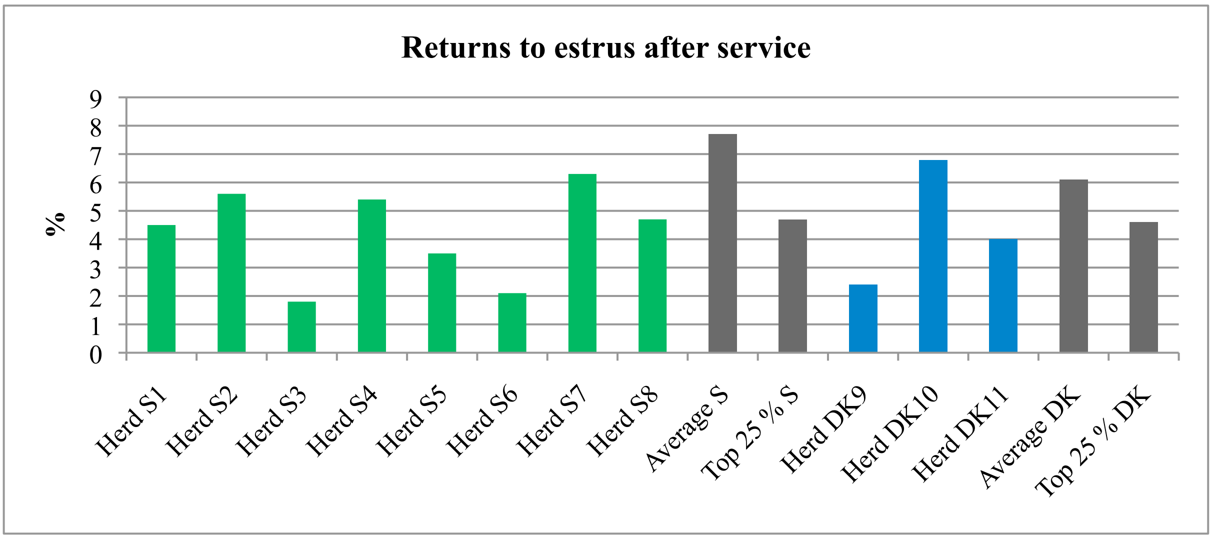

Figure 3. The average percentage of returns to estrus after service in visited herds in comparison to the average and the 25 % most successful herds.

Appendix III

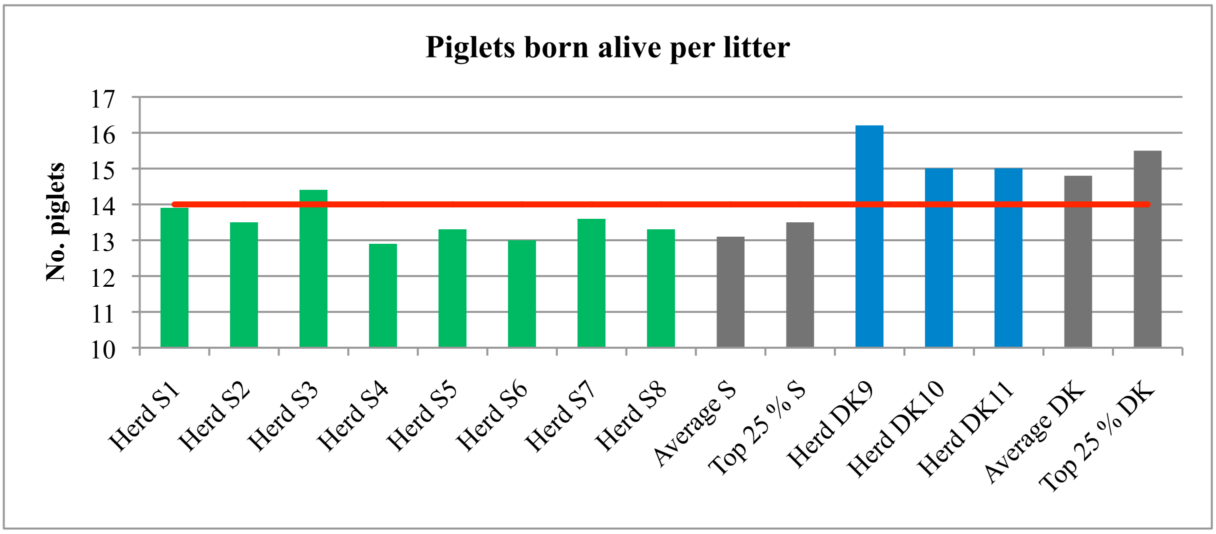

Figure 4. The average number of piglets born alive in visited herds in comparison to the average and the 25 % most successful herds. The red line shows the recommended boundary in order to achieve 30 weaned piglets per sow and year (Knox, 2005a; Gill, 2007).

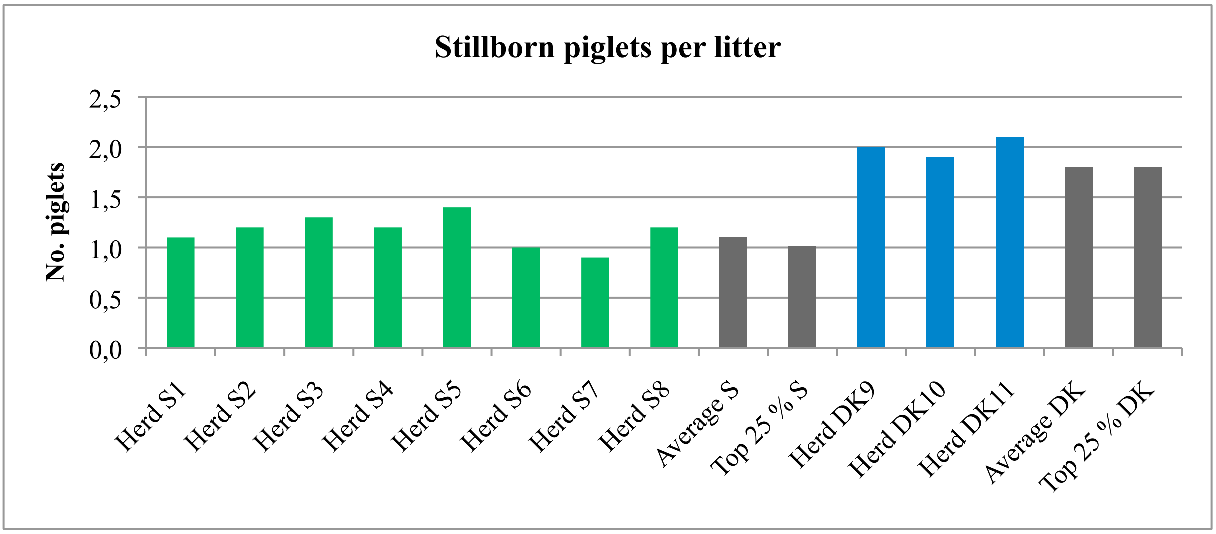

Figure 5. The average number of stillborn piglets in visited herds in comparison to the average and the 25 % most successful herds.

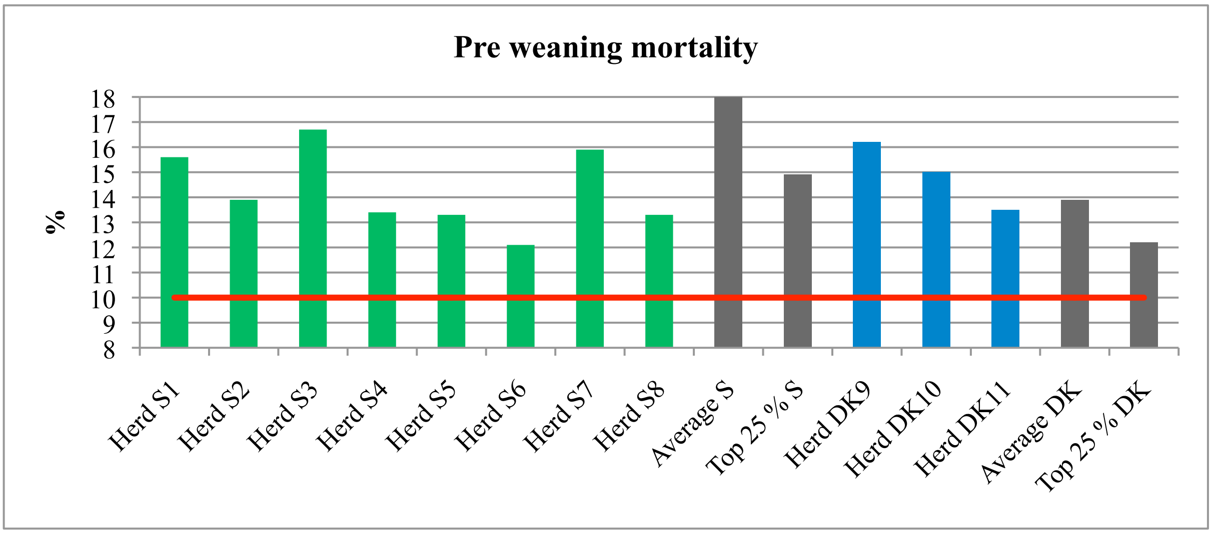

Figure 6. The average pre weaning mortality in visited herds in comparison to the average and the 25 % most successful herds. The red line shows the recommended boundary in order to achieve 30 weaned piglets per sow and year (Knox, 2005a; Gill, 2007).

Appendix III

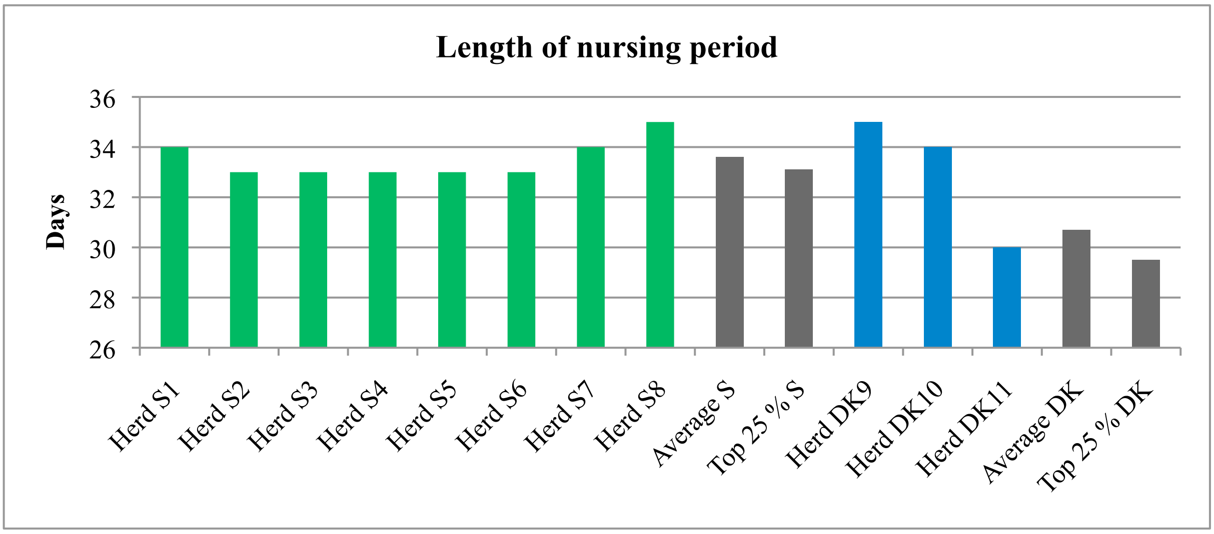

Figure 7. The average length of the nursing period in visited herds in comparison to the average and the 25 % most successful herds.

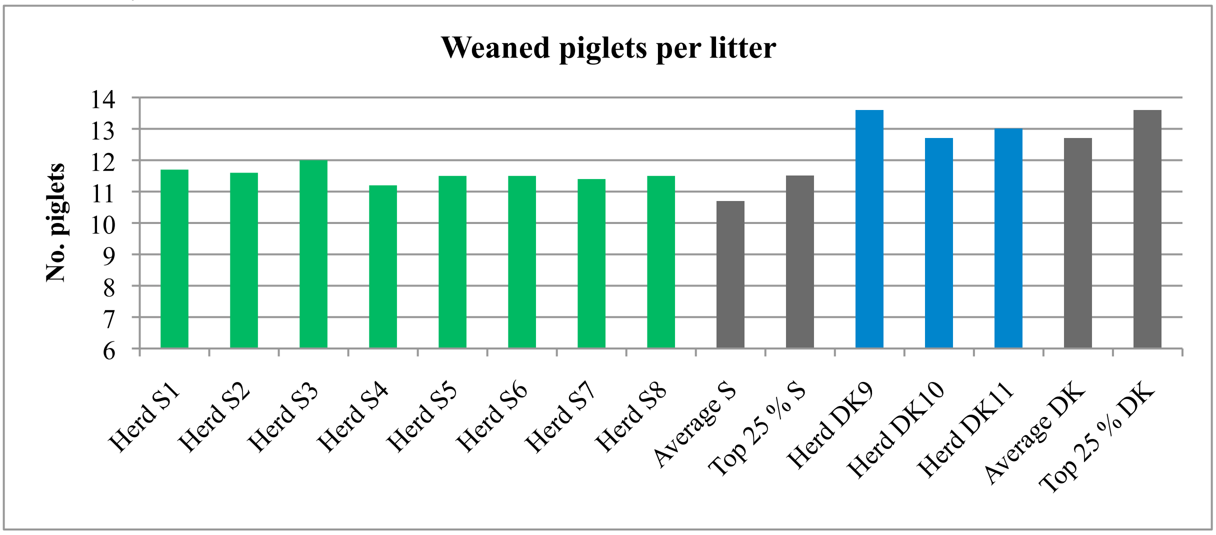

Figure 8. The average number of weaned piglets per litter in visited herds in comparison to the average and the 25 % most successful herds.

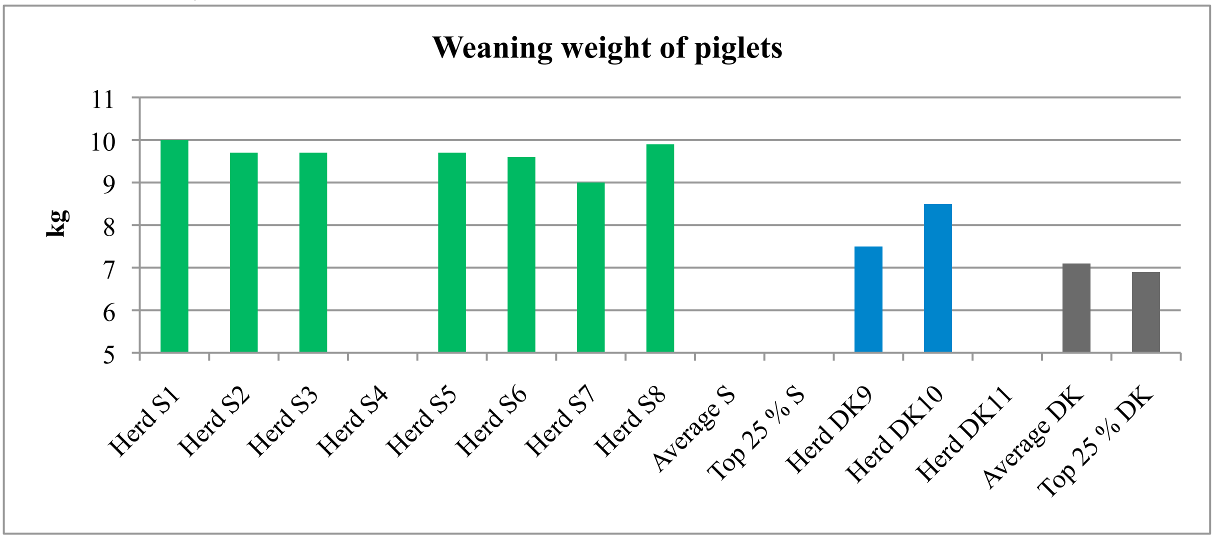

Figure 9. The average weaning weight of piglets in visited herds in comparison to the average and the 25 % most successful herds.

Appendix III

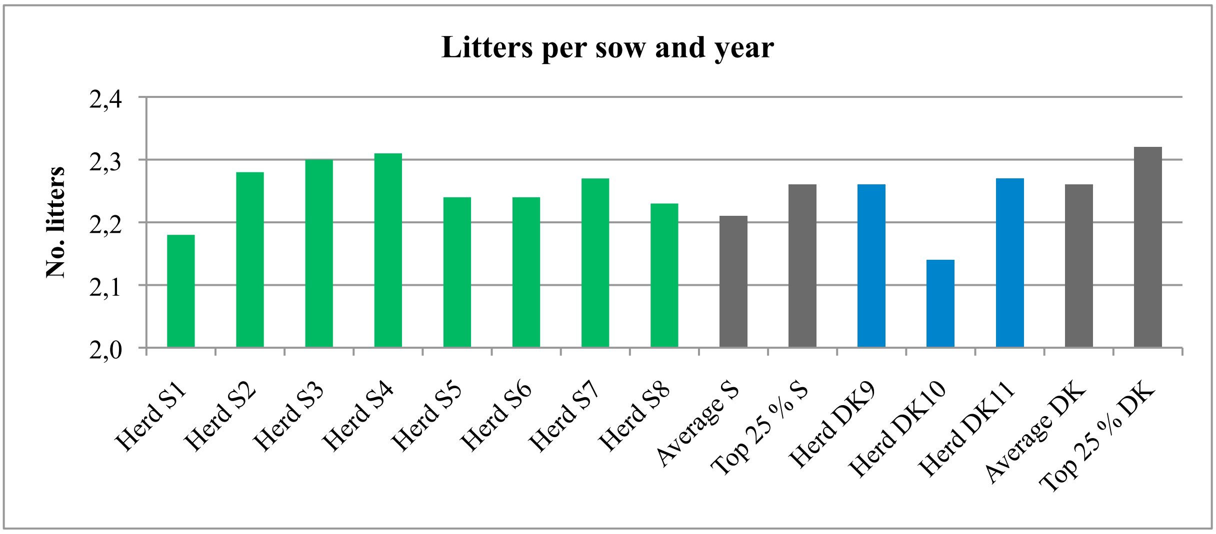

Figure 10. The average number of litters per sow and year in visited herds in comparison to the average and the 25 % most successful herds.

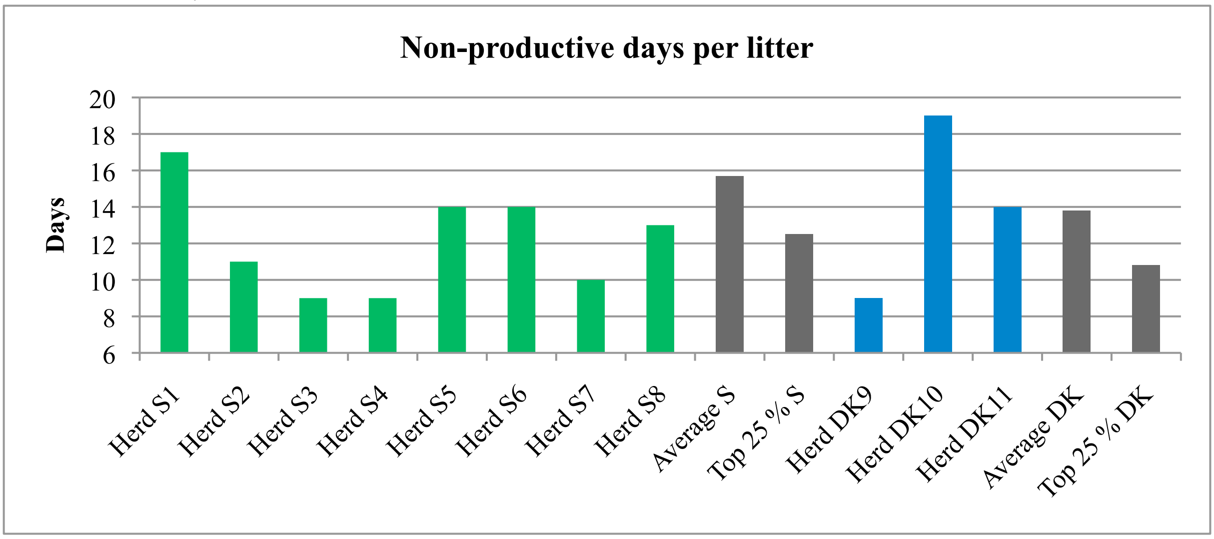

Figure 11. The average number of non-producitve days in visited herds in comparison to the average and the 25 % most successful herds.

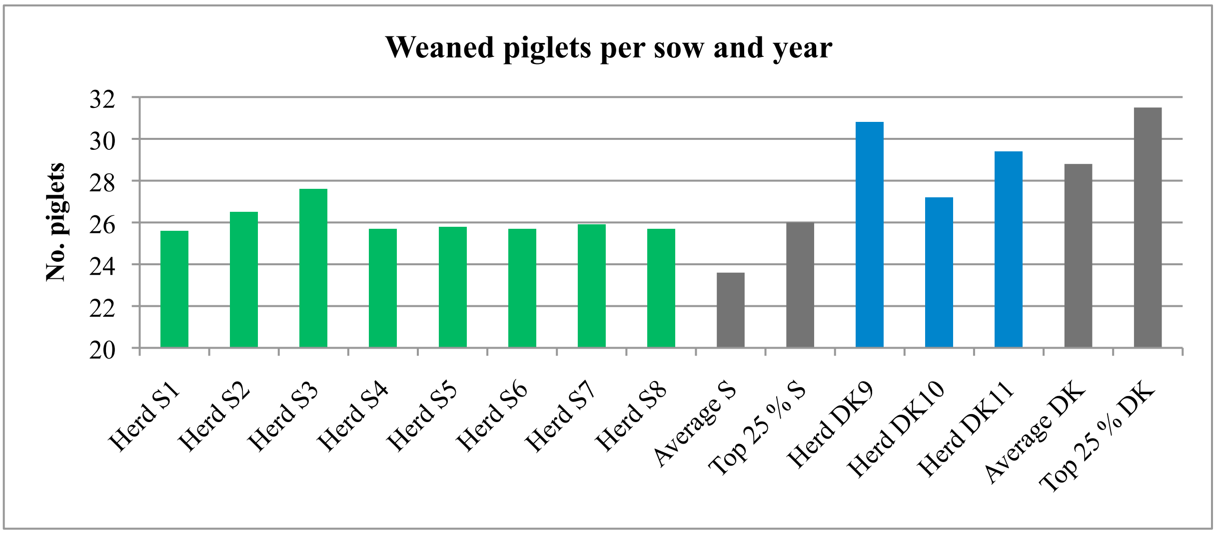

Figure 12. The average number of weaned piglets per sow and year in visited herds in comparison to the average and the 25 % most successful herds.