Management routines influencing piglet survival in loose-housed sow herds

Ellen Marie Rosvold*‡, Camilla Kielland*, Marko Ocepek*, Tore Framstad*, Bente Fredriksen**, Ina Andersen-Ranberg†, Geir Næss‡, Inger Lise Andersen*

** Norwegian University of Life Sciences, Department of Animal and Aquacultural Sciences, PO Box 5003, 1432 Ås, Norway*

*** Norwegian Meat and Poultry Research Centre (Animalia), PO Box 396, 0513 Oslo, Norway*

† Topigs Norsvin, PO Box 504, 2304 Hamar, Norway

‡Nord University, PO Box 2501, 7729 Steinkjer, Norway

Corresponding author: Ellen Marie Rosvold. E-mail: ellen.m.rosvold@nord.no

Abstract

Piglet mortality is still a significant welfare and ethical matter in pig production, as well as an economical challenge for the farmer. Most of the mortality occurs early after farrowing, and previous studies have shown that the farm`s management routines, especially around farrowing, are important factors to reduce it. When sows are loose-housed at farrowing and in the following lactation period, it puts higher demands on management input from the farmer to keep piglet mortality low. The objective of this study was to assess the importance of different management routines around the time of farrowing, and other farm qualities for piglet survival in loose-housed herds. To study risk factors for herd piglet mortality, a cross-sectional field survey was carried out in Norway in the year 2013, and included 52 commercial herds with hybrid LY sows (Norwegian Landrace x Swedish Yorkshire). The farms were visited once, and the farmers answered a questionnaire about their management practices. The outcome was the average herd pre-weaning mortality in the years of 2012-2013. To include as many management factors as possible into the multivariable linear regression model, we generated a new variable based on 4 management routines: 3 routines at farrowing (presence at 80-100% of the farrowings, drying newborn piglets, and practice split suckling), and one concerning farmer´s contact with the sows. This variable was called "Management type" (M), and were divided into 4 categories with increasing effort; M1 herds without any of the 4 mentioned routines, M2 had contact with sows >2 times per day, M3 performed the 3 routines at farrowing, and M4 combined the high sow contact and the 3 routines. The predicted values of mean herd piglet mortality for M1, M2, M3 and M4 were 20.1%, 17.0%, 16.2% and 13.3% respectively. The farmer`s increased management effort was associated with lower piglet mortality ($P<0.05$). The farmer`s effort at critical times together with systematic and important routines, and having frequent contact with the sows, makes a huge difference for piglet survival. The farmers are credited for this work by having lower piglet mortality as a result.

Keywords: Piglet mortality, Management, Farrowing, Loose housed sows, Field survey

Highlights:

- Piglet mortality is multifactorial as many factor together leads to reduction.
- Presence at farrowing, drying newborn piglets and split suckling are routines associated with lower piglet mortality.
- Frequent contact with sows is associated with lower piglet mortality.

1. Introduction

High piglet mortality is still an ethical and economical challenge in pig production. As much as 50-80% of the piglet mortality is caused by crushing and starvation (English and Morrison, 1984; Dyck and Swiestra, 1987; Marchant et al., 2000), and this mainly occurs within the first two or three days after farrowing (Dyck and Swiestra, 1987; Cronin et al., 2000; Marchant et al., 2000; Andersen et al., 2005; Westin et al., 2015). A field survey from Norwegian farms reported that the mortality of live born piglets ranged from 5 to 24%, and management was suggested to be an important factor (Andersen et al., 2007). In a review by Kirkden et al. (2013), it was concluded that piglet mortality can be reduced by a range of management routines, especially around farrowing. One important procedure is the supervision of farrowing by trained staff, and also attending sows a couple of days postpartum, which can reduce piglet mortality (Holyoake et al., 1995; White et al., 1996). While being present, the farmer could more easily detect animals that are in need of assistance, and for instance save piglets from near-crushing incidents. Some management routines, such as drying and placing piglets under a heat source immediately after birth can all reduce mortality (White et al., 1996; Christison et al., 1997; Andersen et al., 2009).

Rearing piglets in loose housing systems demands sows with good maternal abilities (Wechsler and Hegglin, 1997; Andersen et al., 2005; Johnson et al., 2007). But as litter size has increased over the years, and sows have a limited biological capacity related to number of functional teats and maternal investment, these larger litters demands more management input from the farmer to keep piglet mortality low (English, 1993). For instance, one experiment demonstrated that litters with more than 12 piglets, on average one piglet had no teat during a nursing bout in the first couple of days after farrowing, a factor that could lead to starvation (Rosvold, 2006). Management options when litters are large are for instance cross-fostering, split-suckling and nurse sow systems (Baxter et al., 2013). A good relationship between humans and animals is another factor important for welfare, health and production. For instance, in a study by Andersen et al. (2006), sows with low confidence that were positively handled the last two weeks prior farrowing, had increased confidence score, shorter farrowing duration, and also tended to give birth to fewer mummified or immature stillborn piglets compared to control sows. Ravel et al. (1996) found in their farm survey that the stockperson factors constitutes 26-27% of the variance in pre-weaning mortality.

The pre-weaning mortality of live born piglets on herd level is frequently used when evaluating a farms` production result from one year to another. This is a number that most pig farmers are familiar with, and refers to high survival rate among the piglets. A field survey was carried out to obtain information about pig farms, their management, especially around farrowing, and their production results. In this study we will investigate pre-weaning mortality of live born piglets (%) on herd level (HPM). All farm information are factors on herd level. The objective of this survey was to identify and assess the importance of systematic management routines around the time of farrowing for piglet survival in loose-housed sow herds.

2. Materials and methods

2.1 Farm selection and study population

This field survey was planned to include 60 commercial sow herds, with 20 farms representing each out of three major pig production regions in Norway (East, West and Middle). Inclusion criteria were breed (LY; sows of Norwegian Landrace x Swedish Yorkshire) and a consistent practice of keeping the sows loose during farrowing. The farms also had to keep regular recordings of production results to Ingris (The National Efficiency Control Database, administrated by Animalia (Norwegian Meat and Poultry Research Centre) and Norsvin (Norwegian Pig Breeding Association)). Information from Ingris concerning the numbers of litters born per year in each herd, gave us a possibility to select herds with a variety in size. Farmers were initially invited to participate in the study by letter in February 2013, followed by phone call for a second invitation. Fifty-two herds that complied with the inclusion criteria accepted to participate in the field survey. Before the onset of the study, the selected farmers were well prepared and we explained the importance of assessing the causes of death while they were present during farrowing.

2.2 Collecting of farm data

During spring and summer 2013, one of two trained researchers visited the farms once. The visit was carried out during the lactation period, with a compulsory tour in the pig house. Farmers answered questions about management practice and routines before, during and immediately after farrowing. Questions, categories and responses are presented in the results, including Table 2-4. The farms` production results for 2012 and 2013 were extracted from Ingris, and are presented in Table 5 and Figure 1. In 2013, there were 281 commercial herds in Ingris with registrations on LY sows and piglets, and the herds in the field survey (52) constitute 18.5% of these herds.

2.3 Data analysis

Data handling and statistical analyses were performed in Stata (Stata SE/11, Stata Corp., College Station, TX, USA) and SPSS (IMB SPSS Statistics Version 22, SPSS Inc. Chicago, USA).

For multiple choice questions distribution of the answers were calculated. Questions with answers given as continuous variables were reported by mean, standard error (S.E.) and range. The outcome were the average HPM in the years 2012 and 2013, and the average of two years was chosen to even out potential bad or good years. A multivariable linear regression model was used to evaluate which and how explanatory herd level factors were associated with HPM.

Descriptive statistics to assess the assumptions were made using a multivariable regression model, where evaluated using various techniques. Linearity between the continuous outcome and dichotomous variables was investigated with graphs using a "logit" function in Stata, creating a lowess line between the two variables. In addition, probability plots, best linear fit, and R2 were used to explore how continuous explanatory variables explained the variation in HPM.

Several management factors were recorded during the farm visit, i.e. split suckling, drying piglets (for more details see Table 2-4). The challenge regarding the various managements registered, was that some farms had similar management routines, but several farms had their own unique routines. The regression analysis made many 2x2 tables, and we needed enough numbers in each box to give sensible estimates. Therefore, we had to cluster the farms into groups with similar management systems. After identifying management variables from the univariate analyses during the model building process, a new variable were generated using the Stata command "egen concat", concatenate routines, categorizing farms based on four routines (concatenate commands are normally used to join two or more text strings into one string). This variable was called "Management type" (M), and was based on four management routines. Three of the management routines were conducted at farrowing (being present at 80-100% of the farrowings, drying and massaging newborn piglets, and performing split suckling), and the fourth routine was contact with the sows >2 times per day (Table 1). Contact was defined as touching, talking to and/or being present near the sow in the farrowing pen. This new variable had four categories; M1 herds did not perform any of the four management routines displayed in Table 1. These herds had all unique combinations of the management routines from Table 2-4, and could not be grouped. M2 herds had contact with sows >2 times per day, M3 herds performed the three mentioned routines at farrowing, and M4 herds combined contact and the routines. Management types were ordinal categories, and M1 meant low management effort, with increasing effort by M2, M3 and M4. The latter therefore meant high management effort.

When building the final model, a forward stepwise technique was used, exploring variables with a P-value <0.20 from the univariable analysis, according to the method described by Dohoo et al. (2009). Distortion and confounding could be observed as each variable was included. Biologically plausible first-order interactions of the predictor variables were evaluated and included if the interaction was significant. Normal probability plots was evaluated, and Shapiro-Wilks statistic used to test for normal distribution of these residuals. When exploring influencing values and leverage points, no values were deleted from the analysis due to high influence if the value was within reasonable boundaries. If variables were highly correlated with each other (|ρ|>0.8) (Dohoo et al., 2009), only one of these variables was included. The model was tested for heteroscedasticity using Breusch-Pagan / Cook-Weisberg test. The variating inflating factors also explored to evaluate the final model. For each variable included, the model was evaluated and the best model chosen. The best model was the model with the lowest mean square error. In all analyses, statistical significance was considered with a P-value <0.05 and borderline significance with a P-value <0.10.

3. Results

3.1. Descriptive statistics of farms

Of the 52 farmers, 30 (57.7%) were men and 9 (17.3%) women. Twenty-three (44.2%) of the farms had more than one person working, and 13 (25.3%) farms had both men and women involved in the daily routines. Twenty (38.5%) farms were situated in the East, 13 (25.0%) in the West and 19 (36.5%) in the Middle of Norway. When dividing farmers in age groups, 5 (9.6%) were between 20-30 years old, 34 (65,4%) were between 30-50 years old and 13 (25.0%) were more than 50 years old. Three (5.8%) farmers had no education above primary school, 40 (76.9%) had finished high school, and 9 (17.3%) had been to university. When asked about pig farming experience, 4 (7.7%) farmers had less than 5 years of experience, 6 (11.5%) had 5-10 years, 16 (30.8%) had 10-20 years, and 26 (50.0%) had more than 20 years of experience.

The farms had different systems of batch farrowing. Four (7.7%) farmers had the system of farrowing every 2.5-3rd week, 8 (15.4%) every 5.5 weeks, 34 (65.4%) every 7th week, 3 (5.8%) every 11th week and 3 (5.7%) had farrowing every 22-26th week. Mean number of sows in one farrowing batch was 26.3 ± 1.9 (10-65), and the sows spent on average 9.5 ± 0.7 (2-21) days in the farrowing pen before farrowing. The number of litters born at the farms (mean ± S.E.) during 2012 and 2013 was 178.6 ± 13.0 (ranging from 57.5-498.0).

At the farm visit, type and amount of nest-building material, as well as timing of distribution to sows prior to farrowing were reported. Long stemmed straw was given by 24 (46.2%) farmers, 4 (7.7%) farmers gave chopped straw, 19 (36.5%) gave wood-shavings, 4 (7.7%) gave long-stemmed straw and wood-shavings in combination, and only one (1.9%) farmer gave hay as nest-building material. The mean amount of nest-building material given was 2.6 ± 0.5 kg (ranging from 0.1-20.0), distributed on average 28.7 ± 2.8 hours (ranging from 3.0-96.0) before farrowing. Also, feeding of roughage during gestation and lactation were reported. Five (9.6%) farmers did not provide roughage (hay, silage and straw) at all to their pregnant sows, 17 (32.7%) farmers fed < 200 g roughage daily, 22 (42.3%) fed 200-500 g, and 8 (15.4%) farmers fed their pregnant sows roughage ad libitum. When the sows were in lactation, 15 (28.8%) farmers did not provide roughage at all, 18 (34.6%) fed < 200 g roughage daily, 16 (30.8%) fed 200-500 g, and 3 (5.8%) farmers fed their lactating sows roughage ad libitum.

Characterizations of management and routines around farrowing can be found in Table 2. At farrowing, 24 (46.2%) of the farmers moved newborn piglets both to the udder and to the creep area. There were also combinations of the routines dried/massaged followed by moving piglets to udder and/or creep area. Number of farmers that dried/massaged and moved piglets to the udder was 6 (11.5%), number of farmers who dried/massaged and moved piglets to creep area was also 6 (11.5%), and dried/massaged piglets and moved to both places was 16 (30.8%). Management routines during the first 48 hours had also some combinations identified. Twelve (23.1%) farmers moved piglets both to the udder and to the creep area. Only one farmer (1.9%) massaged and laid the piglets to the creep area, and another two farmers (3.8%) massaged and moved to both places. All farmers conducted cross-fostering, but to what extent it was done and which criteria that were used varied considerably (Table 3).

The farmers were asked if good relationship with the sows was important on a scale from 1 (not important) to 10 (very important), and 32 farmers (61.5 %) scored it to 10. How often farmers had contact with their sows in general, and the farmer`s opinion about ease of handling were reported and shown in Table 4.

3.2 Factors associated with HPM

The results from the investigated 52 farms are presented in Table 5 and Figure 1, and demonstrates some similarities to the national averages in Ingris (Table 5). However, in the 52 survey farms, mean values of number of live born, stillborn and HPM were higher compared to Ingris.

All the factors concerning farm demographics, management and routines described in section 3.1 were explored in relation to HPM. Significant factors associated with HPM were batch system, number of sows per batch, management type as described in Table 1 (i.e. the routines of being present at 80-100% of the farrowings, drying and massaging newborn piglets, conduct split suckling, and having contact with the sows >2 times per day), and time of cross-fostering. Table 6 shows the details of these factors.

From the predicted model in Table 6, one can compare predicted HPM between farms with different size (number of sows in each batch) and management type. As the intercept were an average of baseline, a farm with system and management like the categories in baselines would have 20.1% as predicted HPM. Farms with higher management effort than M1 (baseline) would have a lower value of predicted HPM. The respective predicted HPM values of M2 (having contact with the sows >2 times/day), M3 (having three management routines at farrowing; being present at 80-100% of the farrowings, drying and massaging newborn piglets, and performing split suckling) and M4 (combination of contact and the three farrowing routines), were 17.0%, 16.2% and 13.3% (Figure 2). Cross-fostering conducted at 13-24 hours after farrowing had predicted value of HPM of 20.1% (baseline). Having no systematic routine would make a higher predicted HPM, 24.2% (Figure 3).

3.3.1 Diagnostics

No heteroscedasticity was detected. Variation inflating factors was low both in total and at each variable included in the regression analysis. Normality plots of standardized residuals did not display potential outliers. No influencing points were identified.

4. Discussion

The main purpose of this field survey was to identify management factors that could be associated with low HPM, and were therefore important to give a higher piglet survival. We found that several management factors together lead to a reduction in HPM in commercial farms. Farmers with high management effort (M4: i.e. presence at 80-100% of the farrowings, drying and massaging newborn piglets, split suckling and contact with the sows > 2 per day) were credited for this work by having 6.8 percentage-points lower HPM than the baseline herds (M1 versus M4). One of the reasons for several factors acting together were also that farmers that achieve good results appear to have a more systematic way of managing their farm and their routines, and a good system is important when many sows farrow in batches at the same time even though farmers may focus on slightly different factors. Systematic routines also become predictable routines for the animals themselves, and will most likely give positive effects on the human-animal relationship as well. We also found a high variation from the farm with the lowest losses to the farm with the highest, and this range was in accordance with a previous survey in Norway (Andersen et al., 2007).

As predicted, a high degree of presence during farrowing was one of the factors identified as important to reduce HPM. Other studies have shown that piglet mortality due to stillbirths, crushing by the sow, low viability and starvation were reduced when farrowing was attended (Holyoake et al., 1995; White et al., 1996). However, it is not only about being present, but also having systematic routines that are done while attending the farrowing. For instance, while present, the farmer could more easily detect sows that are in need of birth assistance, remove mucus from the nose and mouth, remove the placental envelopes around newborn piglets to prevent suffocation, dry the piglet and tie the umbilical cord (Holyoake et al., 1995; White et al., 1996). Also putting the piglets under a heat source or at the udder to suckle colostrum could be routines done while present at farrowing, as well as having the possibility to save piglets that are near crushed or savaged by their mother sow.

In our study, it was the combination of being present at 80-100% of the farrowings, drying newborn piglets, and practice split suckling in addition to being in contact with the sows more than two times per day resulted in the lowest HPM. However, in order to decide whether all this extra effort pays off for the farmer, we would have to calculate the benefit in terms of how many extra piglets are saved per hour extra effort made in the farm compared to the baseline herds. Although experiments on drying and placing the piglets under the heat lamp have resulted in a much higher piglet survival in controlled experiments conducted on one particular farm (e.g. Andersen et al., 2009), these data were difficult to reproduce when studying a large number of farms differing in so many ways, i.e. stockmanship, feeding, management and physical environment. Furthermore, we were not able to control how many litters that actually were subjected to the specific routines that they claim to have. In our study, we had no knowledge of how many piglets that were dried or placed in the creep within a litter, as our data are on herd level, not on piglet or sow level. This is also why we decided to focus on a combination of factors that separately had been documented as successful in earlier studies, and the present data shows quite clearly that an increased number of routines in combination produces a steady decline in HPM. This is also an important message to give to the farmers that want to improve their production results.

Split suckling was also one of the routines in combination with others that resulted in lower HPM in this survey. This routine of having the larger piglets in a litter enclosed for approximately an hour so that the smaller piglets could have full access to the udder, should allow all the piglets access to colostrum, and therefore acquire passive immunity (Baxter et al., 2013). However, Donovan and Dritz (2000) found no effect of split suckling on mortality or serum immunoglobulin concentrations, but found a reduced heterogeneity of weight gain in larger litters (≥ 9 piglets). Considering the large work load put on the farmer, this routine could better be viewed as a last strategy to save piglets in extremely large litters rather than a common everyday routine.

The frequency of the farmer`s contact with the sows had an effect on HPM. As suggested in the review by Kirkden et al. (2013), improved human-animal relationship, by reducing negative behaviours and increasing positive behaviours, could reduce the sow`s fear level. Positive contact or handling means that the animals` behavioural response is positive when being approached, touched and/or talked to by humans (Andersen et al., 2006). In our field study, contact could be neutral or positive as it was defined as touching, talking to or being in close proximity of the sow in the pen. By being more present in a predictive way, the sows habituates to the stockperson, may perhaps also develop some positive expectations to this presence, thereby reducing the level of fear. An increased confidence and calmness in the presence of humans may benefit the overall maternal behaviour of the sows (e.g. Lensink et al., 2009a; Lensink et al., 2009b; Marchant Forde, 2002) and most likely increase the ease of handling whenever this is necessary, for instance during birth assistance. By being more present, the farmer is also likely to discover problems with individual sows earlier and for instance act earlier in near crushing events or when sows are having birth problems.

Number of sows per batch had influence on HPM, as 20 or more sows in a batch were associated with lower HPM. This effect could be caused by higher professionality, more systematically routines, and higher level of focus on what was happening in the pig house. Also, in the model, a batch system with frequent farrowing (2.5-3 weeks) tended to be associated with lower HPM.

All farmers conducted cross-fostering to a certain degree, and with variations in routines. As the number of newborn piglets in a litter often exceed the number of functional and accessible teats, cross-fostering has been a method with aim to secure milk to the piglets. A recommended fostering strategy is to leave the weaker and smaller piglets with the mother and foster off the strong ones, but also to foster off weaker piglets to a newly farrowed sow who has a smaller litter. It is also recommended that fostering of piglets should occur as early as possible after farrowing, provided that they have an adequate intake of colostrum before taken from the mother (English, 1993). In an experiment by Heim et al. (2012), cross-fostering was performed within 24 hours after farrowing, and the results indicated that the adopted piglets had neither reduced survival rate nor growth. Another experiment, with piglets cross-fostered within 48 hours, concluded that cross-fostered piglets had lower survival rates than those not cross-fostered (Neal and Irvin, 1991). In our study, most of the farmers cross-fostered within the first 24 hours after farrowing, and within a 12 hours "time-window", but when farmers had no systematic routine of this (i.e. conducted cross-fostering for a longer time period than 12 hours and with variation of timing after farrowing), it was associated with higher HPM.

Conclusions

Piglet mortality in commercial pig herds are affected by several management factors, and some of these may, if combined in a systematic way, increase piglet survival. Based on our results, we can recommend that farmers are more present during farrowings, have a systematic and frequent contact with the sows, dry newborn piglets whenever some need special attention and conduct split-suckling in large litters.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Figure captions

Table 1: Definition of four different management routines, number (n) and percentage (%) of farmers grouped within different types of management.

Table 2: Percentage of 52 farms that conducted the different management routines at farrowing and within the first 48 hours after farrowing.

Table 3: Distribution of different routines and criteria of cross fostering at the 52 farms.

Table 4: Distribution of farmer/ sow relationship and farmer`s opinion of the sows at 52 farms.

Table 5: Production results of study herds (n=52) extracted from Ingris (The National Efficiency Control Database) (n=290 in 2012 and 281 in 2013).

Table 6: Factors significantly associated with pre-weaning herd piglet mortality (HPM %). Multivariable adjusted estimated coefficients from a linear regression model. Number of observations (n), estimates (β), standard error (SE), *P*- value and the 95% confidence intervals (CI).

Figure 1: Frequency of Herd live born piglet mortality (HPM) in the study herds (n=52).

Figure 2: Distribution of predicted values of herd piglet mortality (HPM) from different management types (M) in the regression model, % (mean ± S.E). Management effort increases from M1 to M2 (contact with sows >2 times per day), to M3 (presence at 80-100% of the farrowings, drying newborn piglets, and practice split suckling) and to M4 (combined M2 and M3). M1 herds were baseline without any of the four previously mentioned routines.

Figure 3: Distribution of predicted values of herd piglet mortality (HPM), % (mean ± S.E), with different routines of cross-fostering timing in the regression model (Differences between predicted HPM are indicated by letters: a and b: P = 0,01, ab: NS).

Table 1. Definition of four different management routines, number (n) and percentage (%) of farmers grouped within different types of management.

Management type (M)	n	%	Present at 80-100 % of the farrowings	Drying and massaging	Split suckling	Contact with sows >2 times per day
M1	28	53.8	-	-	-	-
M2	11	21.2	-	-	-	+
M3	9	17.3	+	+	+	-
M4	4	7.7	+	+	+	+

Table 2. Percentage of 52 farms that conducted the different management routines at farrowing and within the first 48 hours after farrowing.

	Farrowing n (%)	First 48 h n (%)
Farmers presence;	[1]	[2]
80-100%	22 (42.3)	12 (23.1)
60-80%	12 (23.1)	14 (26.9)
40-60%	14 (26.9)	16 (30.8)
20-40%	3 (5.8)	5 (9.6)
0-20%	1 (1.9)	5 (9.6)
Piglets are		
dried/massaged	28 (53.8)	4 (7.7)
moved to the udder	36 (69.2)	15 (28.8)
moved to the creep	35 (67.3)	25 (48.1)
Split suckling	29 (55.8)	-
Additional milk[3]	28 (53.8)	-
Piglets closed inside creep at feeding	-	28 (53.8)
Sow exercise[4]	-	16 (30.8)
Tooth grinding	-	42 (80.8)
Other routines[5]	23 (44.2)	15 (28.8)

[1]Farmers` presence in % of all farrowings in a typical batch.
[2]Farmers` presence in % of the time the first 48 hours after farrowing.
[3]Milk replacer
[4]Sows are taken out from the farrowing pen for a short walk in the farrowing unit.
[5]Routines done regularly by farmer but not asked for specifically in the survey.

Table 3: Distribution of different routines and criteria of cross fostering at the 52 farms.

Cross fostering	n (%)
Proportions of litters where cross-fostering is performed	
80-100%	4 (7.7)
60-80%	7 (13.5)
40-60%	18 (34.6)
20-40%	17 (32.7)
00-20%	6 (11.5)
Criteria for cross fostering	
Even out number of piglets between litters	23 (44.2)
Homogeneity in piglet size within litter	4 (7.7)
According to number of functional teats	8 (15.4)
Two of the criteria[1]	11 (21.0)
Three of the criteria[1]	5 (9.6)
Other criteria[1]	1 (1.9)
Which piglets are cross-fostered	
The biggest	25 (48.1)
The smallest	2 (3.8)
The medium	2 (3.8)
No preference	2 (3.8)
The biggest + smallest[1]	15 (28.8)
Biggest + other[1]	2 (3.8)
Biggest + medium[1]	2 (3.8)
Biggest + smallest + medium[1]	2 (2.8)
Timing of cross fostering after farrowing	
First 12 hours	7 (13.5)
13-24 hours	21 (40.4)
25-36 hours	15 (28.8)
<12-24 hours[1]	2 (3.8)
13-36 hours[1]	4 (7.7)
<12-36 hours[1]	2 (3.8)
<12- > 48 hours[1]	1 (1.9)

[1]Farmers with more than one routine or other routine(s) than the existent answer categories.

Table 4: Distribution of farmer/ sow relationship and farmer`s opinion of the sows at 52 farms.

Farmer/ sow relationships	n (%)
Contact with the sow	
> 2 times/day	15 (28.8)
2 times/day (at feeding)	29 (55.8)
≤ 7 times/week	8 (15.4)
Farmer`s opinion of handling sows during pregnancy	
80-100% of sows easy to handle	44 (84.6)
60-80% of sows easy to handle	4 (7.7)
40-60% of sows easy to handle	3 (5.8)
20-40% of sows easy to handle	0 (0)
0-20% of sows easy to handle	1 (1.9)
Farmer`s opinion of handling sows at farrowing/lactation	
80-100% of sows easy to handle	42 (80.8)
60-80% of sows easy to handle	7 (13.5)
40-60% of sows easy to handle	1 (1.9)
20-40% of sows easy to handle	2 (3.8)
0-20% of sows easy to handle	0 (0)

Table 5: Production results of study herds (n=52), extracted from Ingris (The National Efficiency Control Database), and national results from Ingris (n=290 in 2012 and 281 in 2013).

		Study herds		National results, Ingris
	Year	Mean ± S.E.	(Min-Max)	Mean
Live born	2012+2013	13.6 ± 0.1	(11.6-15.1)	-
	2012	13.6 ± 0.1	(11.7-15.3)	13.3
	2013	13.6 ± 0.1	(11.2-15.0)	13.2
Stillborn	2012+2013	1.7 ± 0.1	(0.6-2.7)	-
	2012	1.6 ± 0.1	(0.6-2.9)	1.2
	2013	1.7 ± 0.1	(0.5-2.8)	1.2
Weaned	2012+2013	11.3 ± 0.1	(9.3-13.3)	
	2012	11.3 ± 0.1	(9.2-13.4)	11.3
	2013	11.3 ± 0.1	(9.4-13.2)	11.2
Herd piglet mortality (HPM), % [1]	2012+2013	16.9 ± 0.6	(5.5-28.3)	-
	2012	16.9 ± 0.7	(6.4-29.3)	15.0
	2013	16.9 ± 0.7	(4.3-27.6)	15.3

[1] Herd piglet mortality (HPM): ((Live born - weaned)/Live born)*100%.

Table 6: Factors significantly associated with pre-weaning herd piglet mortality (HPM %). Multivariable adjusted estimated coefficients from a linear regression model. Number of observations (n), estimates (β), standard error (SE), *P*- value and the 95% confidence intervals (CI).

Variables	n	β	SE	*P*	[95% Conf.	Interval]
Intercept	52	20.07	1.41	<0.01	17.22	22.91
Batch system[1]						
7 wk	34	0.00	(base)			
2.5-3 wk	4	-4.31	2.22	0.06	-8.81	0.18
5.5 wk	8	1.30	1.70	0.45	-2.15	4.75
11/22-26 wk	6	3.13	1.85	0.10	-0.62	6.88
Number of sows/batch						
<20	17	0.00	(base)			
20	5	-5.33	2.03	0.01	-9.33	-1.12
21-39	21	-3.58	1.27	0.01	-6.16	-1.01
40-65	9	-5.16	1.77	0.01	-8.75	-1.57
Management type[2]						
1 (M1)	28	0.00	(base)			
2 (M2)	11	-3.05	1.40	0.04	-5.88	-0.21
3 (M3)	9	-3.85	1.54	0.02	-6.98	-0.73
4 (M4)	4	-6.77	2.12	<0.01	-11.07	-2.48
Time of cross-fostering						
13-24 h after farrowing	21	0.00	(base)			
< 12 h after farrowing	7	0.8	1.67	0.63	-2.57	4.17
25-36 h after farrowing	15	1.61	1.39	0.25	-1.20	4.42
No systematic routine[3]	9	4.11	1.51	0.01	1.07	7.16
Herd litter size centered around the mean[4]	52	0.73	0.95	0.45	-1.19	2.65

[1]Time interval between farrowings, for instance 7 wk means farrowing every 7^{th} week.
[2]Management type 1-4 are ordinal categories, where management type 1 (M1) means low management effort and management type 4 (M4) means high management effort.
[3]Farmers had a longer "time-window" than 12 hours for cross-fostering, and it was done with variation of timing after farrowing.
[4]2012 and 2013 results on herd level and centered around mean to get a more biological constant, even out results that could be too good or bad that it cannot represent the herd in overall.

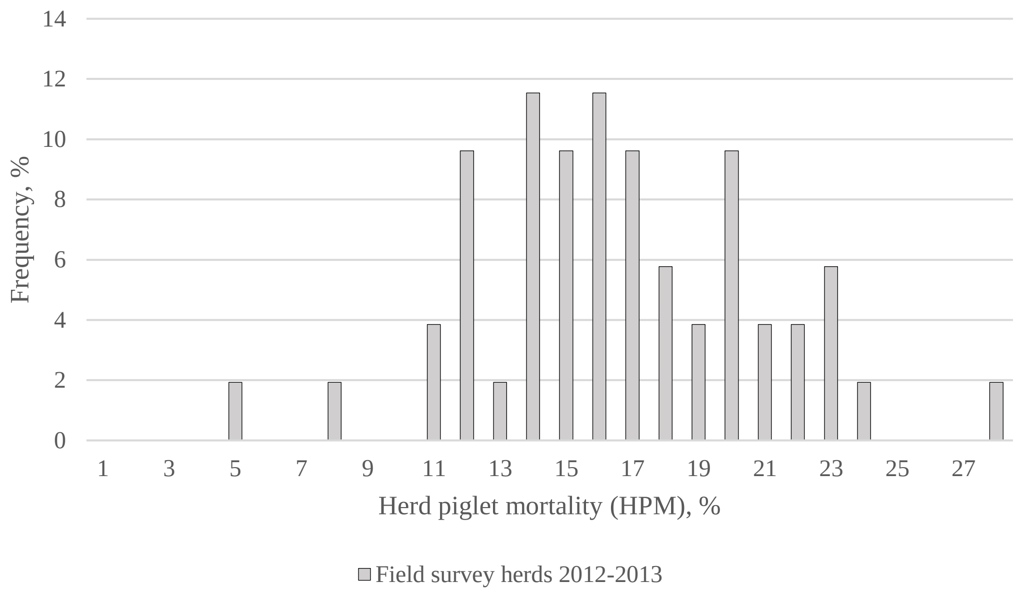

Figure 1. Frequency of Herd live born piglet mortality (HPM) in the study herds (n=52).

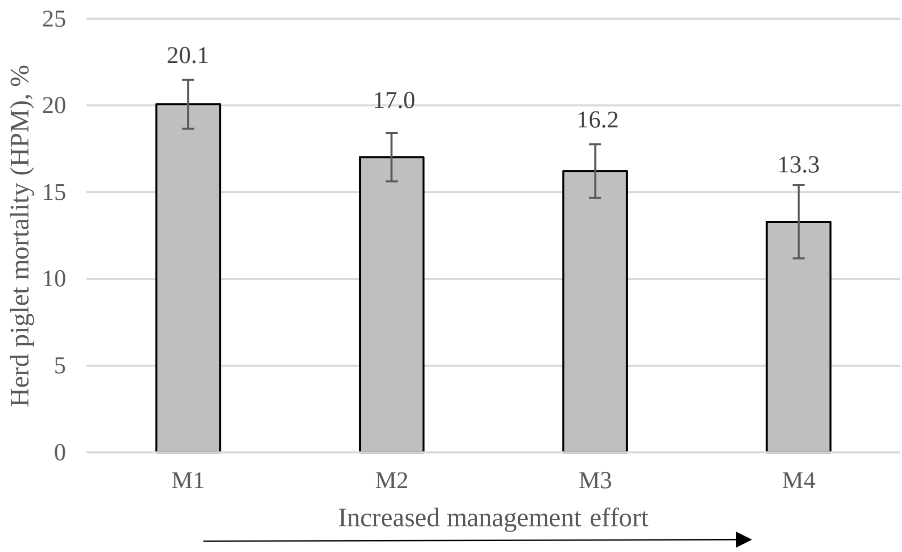

Figure 2. Distribution of predicted values of herd piglet mortality (HPM) from different management types (M) in the regression model, % (mean ± S.E). Management effort increases from M1 to M2 (contact with sows >2 times per day), to M3 (presence at 80-100% of the farrowings, drying newborn piglets, and practice split suckling) and to M4 (combined M2 and M3). M1 herds were baseline without any of the four previously mentioned routines.

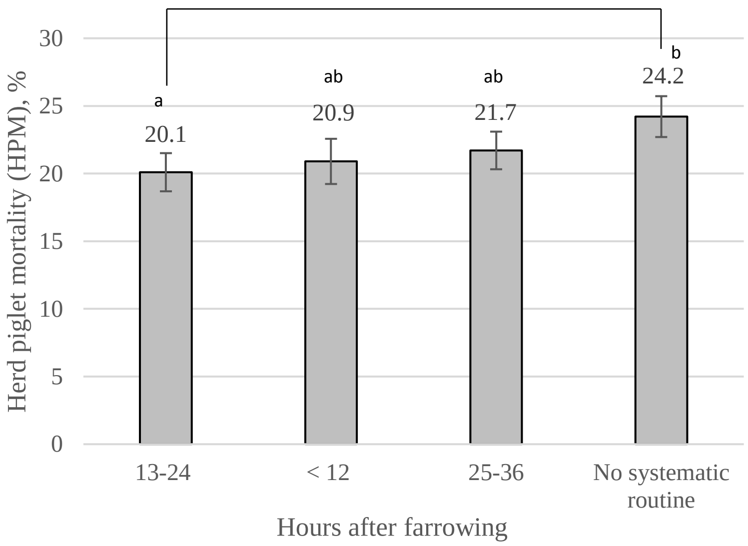

Figure 3. Distribution of predicted values of herd piglet mortality (HPM), % (mean ± S.E), with different routines of cross-fostering timing in the regression model (Differences between predicted HPM are indicated by letters: a and b: P = 0,01, ab: NS).