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Genetic analysis of on-farm tests of maternal behaviour in sows

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Abstract

In this field-study, four behaviour traits were genetically evaluated as possible selection traits for improving piglet survival: the sow's reaction to a piglet scream, the sow's reaction to her piglets being handled, avoidance of and aggression towards the stockperson. The scream test was recorded on the first day after farrowing, and the other tests around day 4. Variance components were estimated using a linear-threshold model and Gibbs sampling. Recordings were done in 10 herds and the analyses of the tests included 741–1335 records on Swedish Yorkshire sows. The estimated heritability for the scream test was 0.06, the handling test had a heritability of 0.01, and fear and aggression both had a heritability of 0.08. No phenotypic relation between either of the behaviour tests and piglet mortality was found; however, there were moderate genetic correlations between response in the scream test and mortality of piglets born alive (−0.24) and between avoidance and mortality (0.37). This indicates that selection for a strong response in the scream test, or selection against sows that avoid humans would result in a correlated genetic improvement in piglet survival. Avoidance may reflect underlying fear, and selection for lower levels of fear in sows would improve both sow and piglet welfare.

Keywords: Heritability; Variances; Correlation; Swine; Piglet mortality; Fear

1. Introduction

The sow's behaviour during lactation has significant consequences for the survival rate of her piglets. The new-born piglets are completely dependent on the sow for access to colostrum and milk, but at the same time the sow constitutes the greatest risk factor to their health and welfare. Today, high piglet mortality is an important welfare issue in pig production, in addition to being a source of economic loss to the farmer. Many breeding programmes focus on selection for larger litters at birth, putting even higher demands on the sows' maternal abilities. Even though there has been an increase in both litter size at birth and at weaning over the last years, piglet survival has not improved. On the contrary, mortality is known to increase as litters become larger (Roehe and Kalm, 2000; Edwards, 2001; Lund et al., 2002).

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In order to benefit from the genetic gain in litter size at birth and improve the welfare of piglets during the lactation period, we need to balance the breeding goal with traits that describe the sow's ability to successfully raise her litter. One possible approach is to include maternal behaviour in the selection programme.

Most mortality occurs during the first week after birth. About 45% of all piglet deaths are caused by crushing (Edwards et al., 1986; Grandinson et al., 2002), while an additional 20% are caused by inadequate nutrition. Crushing occurs when a piglet gets trapped under the sow, as she is sitting or lying down. There is considerable individual variation among sows in how they behave when they lie down and how responsive they are to vocal and tactile stimuli from the piglets that get caught under them (Cronin and Cropley, 1991; Hutson et al., 1991; Wechsler and Hegglin, 1997). When a piglet gets caught under the sow, the risk of dying increases with the time the piglet remains trapped under the sow (Weary et al., 1996). Consequently, the sooner the sow responds to signals from the piglet and stands up again, the greater are the trapped piglet's chances of survival. Hutson et al. (1991) showed that screaming is the most important stimulus that the sow responds to when lying on a piglet, while tactile stimuli are less important. The response seemed to be 'all or nothing', where 60% of the sows were classified as auditory responders, which is in agreement with Cronin and Cropley (1991) who found that 58% responded to the sound of a piglet scream. Previous experience did not seem to influence this response, as gilts did not respond differently compared to older sows (Hutson et al., 1992). Sows that show a strong response to the sound of a screaming piglet seem to display less risky behaviour around their piglets early postpartum (Thodberg et al., 2002; Wechsler and Hegglin, 1997), and have fewer crushed piglets (Wechsler and Hegglin, 1997). The individual variation observed (Cronin and Cropley, 1991; Hutson et al., 1991; Wechsler and Hegglin, 1997) implies that there could be genetic variation in this trait.

It is likely that natural selection in the wild boar favours a willingness to protect piglets from intruders and predators, as suggested by theories that emphasise the adaptive functions of aggression- and fear-related defensive behaviours (Archer, 1976; Plutchik and Kellerman, 1980; Marks and Nesse, 1994), and the fact that free-ranging pigs isolate themselves from the rest of the flock prior to farrowing (Jensen, 1986). Protectiveness could be measured by studying how the sow responds when the stockperson handles her piglets. In a number of studies (reviewed by Rushen et al., 1999), fear responses of animals to humans have been shown to influence both production and reproduction traits in several species. A high level of fear in young gilts, as indicated by passive avoidance of a human being, seems to be negatively associated with mating rate (Hemsworth et al., 1990), and sows showing high levels of fear have higher stillbirth rates (Hemsworth et al., 1999). Hemsworth et al. (1990) estimated a moderately high heritability for the trait fear of humans in young gilts, and avoidance of humans in sheep has been shown to have a low heritability (Lambe et al., 2001). Hansen (1996) showed that in mink, selection for fear-related behaviour markedly changed the behaviour of the animals in the selected line so that they consistently responded aversively to human contact. There appears to be a negative phenotypic association between fear- and aggression-related behaviour that sows direct towards a human (Forde, 2002). If there is a relation between piglet survival and the sow being very protective of her litter, selection for improved survival could lead to a higher level of aggression towards humans. Although aggressive sows may be a disadvantage for the stockperson, recent results indicate that their piglets may have higher growth-rates (Forde, 2002).

In this study, we recorded four behaviour traits that may play a role in the maternal ability of a sow: a sow's response to the sound of a piglet screaming, a sow's response towards the stockperson handling her piglets, and avoidance of and aggression towards the stockperson during the piglet handling. Our objective was to investigate the genetic background of these traits, and to estimate the phenotypic and genetic relationship to piglet survival.

2. Material and methods

2.1. Data

Recordings were carried out between 1999 and 2001 in nine Swedish breeding herds and at Lövsta

Research Station, Swedish University of Agricultural Sciences. Three farms were excluded for the piglet scream test, and two farms were excluded for the handling test, fear and aggression, as they had fewer than 10 tested sows. Recordings were done by the stockperson. All the sows tested were pure-bred, of the Swedish Yorkshire breed. Sows were housed in farrowing pens without crates. Cross-fostering was practised in the breeding herds, but not at the research station.

The number of piglets born alive that had died prior to the handling test (on average day 4) was recorded in six of the breeding herds and at Lövsta Research Station. In addition to this, Lövsta and five of the breeding farms also recorded the number of crushed piglets prior to the handling test. The stockperson determined the cause of death by visual inspection of the piglet.

2.1.1. The piglet scream test

The piglet scream test was used to test a sow's reaction to the distress call from a piglet, as when it is being crushed under the sow (Thodberg et al., 1998). In total, 903 sows, with 1448 litters, were tested in the piglet scream test. The test was done on the farrowing day or the following day. When the sow was lying on her side, but not nursing, the stockperson quietly placed a small tape recorder into the pen and the recorded sound of a screaming piglet was played to the sow for approximately 20 s. The same scream recording used on all the farms, was recorded from a piglet that was held and squeezed firmly by a person. The sow's maximum response to the sound was scored as falling into four ordered categories: no reaction, lying down and looking for the sound, sitting up, or standing up.

Records were discarded if they had missing pedigree information, or if parity or litter size at birth was not known. Furthermore, some litters were excluded because of illness or injury in the sow, such as fever or leg injuries, or because of a prolonged and difficult farrowing. After data editing, 829 sows with 1335 records remained. These sows were born from 397 dams and sired by 209 boars. Of the dams, 156 had observations for the scream test.

2.1.2. The piglet handling test

A total of 836 sows, with 1228 litters, were tested in the piglet handling test. The test was done around day 4 (mean 3.85, S.D. 0.90), in connection with normal routine treatment of the piglets, such as castration and iron supplementation. If no piglets were castrated in a litter and no iron was given, the stockperson was instructed to pick up the piglets anyway, hold them and, if necessary, squeeze them lightly until they screamed. Twelve of the litters were treated in this way. Depending on farm routines, the treatment of the piglets was done either beside the pen or away from the pen where the sow could not see or hear the piglets.

The sow's body posture at the start of the test, just before the piglets were picked up by the stockperson, was recorded in four ordered categories: (1) lying on her side, (2) lying on her belly, (3) sitting, or (4) standing. After the piglets were taken out and handled, the sow's maximum response to the handling of her piglets was recorded using the same four categories. The response to the piglets being removed from the pen and subjected to handling was then analysed as the difference in category number between sow posture after and before the test, as shown in Fig. 1.

Nine sows shifted from a higher order category to a lower, e.g. from lying on their belly to lying on their side. These sows were scored 0. Sometimes the

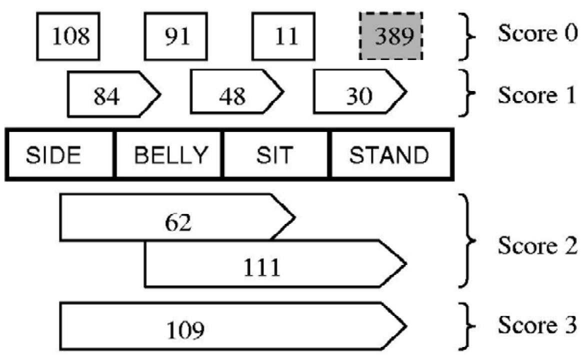

Fig. 1. Description of how the scores were created for the piglet handling test. The absolute number of observations is given within each square/arrow. The middle row shows the four categories used to score the test. The top row is a record of those instances in which the sow did not move at all during the test, and was thus given a score of 0 (e.g. at 108 occasions the sow was lying on her side at start of the test and was still lying on her side at the end of the test). The second row shows those occasions during which the sow moved from one category to the next, all giving a score of 1, e.g. 84 sows shifted from lying on their sides to lying on their bellies. A total of 389 of the sows were already standing at the onset of the test, and these were excluded from further analyses.

stockperson had to enter the pen in order to catch the piglets. In 43 such cases, the stockperson had to force the sow to stand up when entering the pen, because she was lying down and in the way. These sows were also scored 0, since they had proven unwilling to move on their own.

Sows that were already standing at the start of the test (389 records) were excluded as missing observations, because these sows were already at the maximum of the scale. Records were also discarded if they had missing pedigree information, or if parity or litter size at birth was not known. Furthermore, some observations were excluded because of sickness in the sow or difficult farrowings. After data editing, 552 sows with 741 records remained. These sows had 172 sires, and 316 dams of which 97 had observations for the handling test.

2.1.3. Fear and aggression

Avoidance of the stockperson was used as an indicator of fear and was measured in connection with the piglet handling test by recording how the sow positioned herself in relation to the person handling the litter. Sows that moved toward the handler were given a score of 1, sows that did not move at all were given a score of 2 and sows that moved away from the handler were given a score of 3. Sows that did not stand up were regarded as not having moved, and were scored 2. Stockpeople were also asked to report if they perceived the sow to be aggressive towards them during the handling, by answering a yes or no question. After data editing and removal of records with missing pedigree information, unknown parity or litter size, 738 sows with 1107 records remained for the avoidance test. These sows had 385 dams and 196 sires. Of the dams, 138 had records for the avoidance test. For the aggression test, 766 sows with 1161 records remained after data editing. These sows had 197 sires and 392 dams, of which 140 had records for the test.

2.2. Genetic analysis

A threshold-linear model was used to analyse the relationship between the behaviour traits and piglet mortality. The threshold concept was applied for the behaviour traits, assuming an underlying non-observable normally distributed variable, known as liability. When the liability exceeds a certain threshold, the outcome of the behaviour falls into the next category. The unobservable liabilities were created using data augmentation. Mortality of live-born and crushing were analysed as a percentage of the number of live-born piglets. The mortality traits were assumed to be normal traits.

All of the behaviour traits, except the handling test, were analysed together with both the mortality traits in bivariate models. Preliminary results for the handling test showed that there was very little genetic variation in this trait and, therefore, no genetic correlations with other traits were estimated. The models for the four behaviour traits and the mortality traits were based on results from preliminary analyses using a linear model and included the following effects:

$$l_{\text{scream}} = herd + parity + litter\ size + testorder + perm.\ env. + animal + e$$

$$l_{\text{handling}} = herd + parity + person + perm.\ env. + animal + e$$

$$l_{\text{avoidance}} = herd + parity + person + perm.\ env. + animal + e$$

$$l_{\text{aggression}} = herd + parity + perm.\ env. + animal + e$$

$$y_{\text{mortality}} = herd + parity + litter\ size + breed + cross\text{-}fostering + age + perm.\ env. + animal + e$$

where:

l denotes the liability of the observation y for the sow's response in the behaviour tests, and $y_{\text{mortality}}$ is the observation for mortality rate in her litter

herd is the fixed effect of the herd the sow farrowed (eight classes)

parity is the fixed effect of the sow's parity (1,2, . . . ,5+; five classes)

litter size is the fixed effect of number of live born piglets (<5,6,7, . . . ,17,>18; 13 classes)

testorder is the fixed effect of the order in which the sows were tested, when more than one sow

was tested around the same time in the same stable (first, second, third or later; three classes)
person is the fixed effect of the person performing the piglet handling in the handling test (within herd) (17 classes)
breed is the fixed effect of breed of the service sire of the litter
cross-fostering is the fixed effect describing cross-fostering (piglets moved from the litter, no cross-fostering, or piglets moved to the litter; three classes)
age is the fixed effect of the litter's age when the mortality was recorded (day at handling), (2,3 . . . ,6; five classes)
perm. env. is the random effect of permanent environment of the sow, ~IND(0, σ^2_{pe})
animal is the random genetic effect of the sow, ~ND(0, $A\sigma^2_a$)
e is the random residual effect, ~IND(0, σ^2_e)

The residual variance for the binary trait aggression was set to 1. Vague priors were used for both the fixed effects and the variances and covariances. The phenotypic variance σ^2_{P} was defined as $\sigma^2_{pe} + \sigma^2_a + \sigma^2_e$ and the heritabilities were calculated as $\sigma^2_a/\sigma^2_{\mathrm{P}}$.

The Gibbs sampling algorithm, implemented in Korsgaard et al. (1999), was applied. The Gibbs sampler was run as single chains, with 1 500 000 samples. The first 15 000 samples were considered a burn-in period and removed. Of the following samples, every 15th was saved and post-Gibbs analyses were performed on the remaining 99 000 samples. Point estimates of the parameters were defined as the mean of the marginal posterior distributions.

To investigate the influence of the priors on the results, one second chain was run for each of the behaviour traits using priors considerably different from those used in the first chains.

2.3. Analysis of environmental factors

To test the influence of time intervals between farrowing and the tests, the time of farrowing was recorded for a smaller part of the dataset. Farrowings were not supervised; thus, when sows farrowed during the night the exact time was not known. The next morning, the stockperson estimated the farrowing time, as having taken place during the early morning, at night or during the previous evening. The time of day when the respective tests were done was also noted for this data subset, which included between 40 and 50% of the total number of observations for the tests. Time of farrowing was classified as having taken place at 01:00, 06:00, 14:00 or 19:00 h. The interval from time of estimated farrowing to the recording of the scream test was calculated in hours. The intervals were divided into four groups: <7, 8–12, 13–18, and >18 h. The interval from farrowing to the test for the other behaviour tests was calculated in days, varying from 2 to 6 days. This subset was analysed using SAS (1990) Proc GLM.

3. Results

The average mortality rate of live-born piglets up to the day of the handling test was 11% (S.D. 13%), varying from 6 to 13% between farms. On average 7% (S.D. 11%) were considered to have died from crushing. In 40% of the litters no piglets died after birth until the day of the handling test, and in 57% of the litters no piglets were crushed during this time period. The frequencies of responses in the four behaviour tests are shown in Fig. 2. The significance levels for different fixed effects tested on the smaller subset of the data are shown in Table 1. The time intervals between farrowing and tests were not significant for any of the test. There was a tendency that sows farrowing during the day were more responsive in the handling test compared to sows farrowing during the night or early morning.

When analysing the total data set, herd was highly significant for all behaviour tests. Gilts reacted more strongly than older sows in the scream test, except for sows of parity five and higher, whose responses did not significantly differ from those of the gilts. If several sows were tested in the scream test directly after each other in the same stable, the order in which they were tested had a significant effect on how they responded. The sows tested first had stronger reactions than those tested as number two. Sows tested as number three or later did not differ significantly from the other two groups. The person performing the castration and iron supplementation in the handling test significantly influenced how the sow responded in the handling and the avoidance

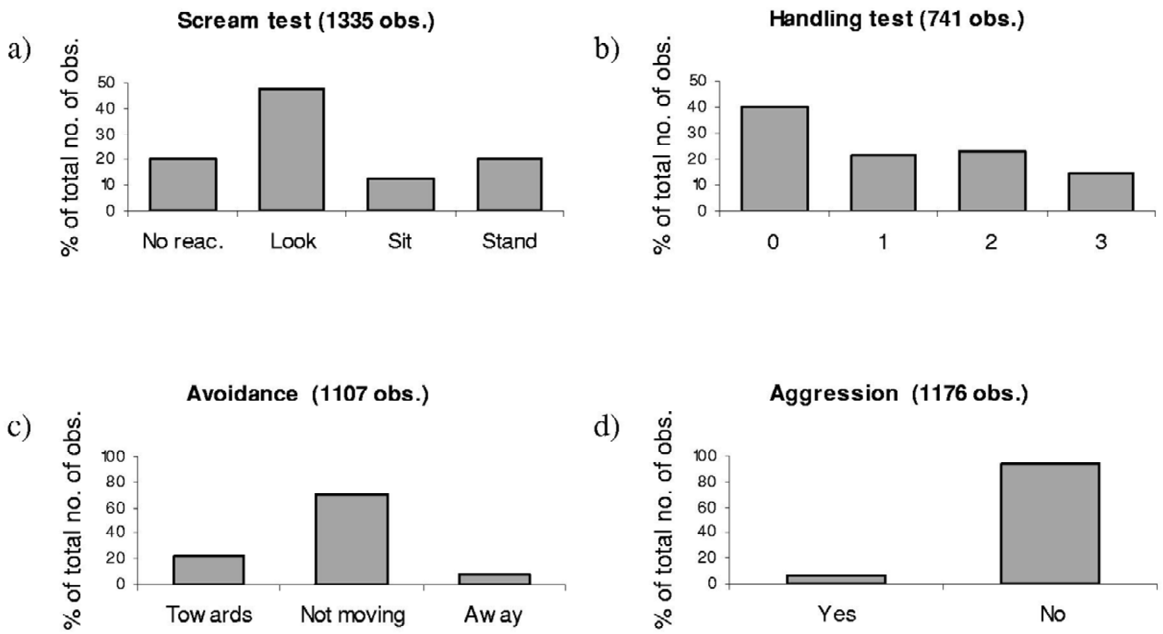

Fig. 2. The relative distribution among categories for (a) the piglet scream test, (b) the handling test (showing number of shifts between categories), (c) avoidance of the stockperson, and (d) aggression towards the stockperson.

Table 1
Significance levels for various effects for the four behaviour traits, estimated using SAS (1990) Proc GLM on the smaller subset data ($n=312$–681 observations)

Effect of	Significance			
	Scream test	Handling test	Avoidance	Aggression
Herd (2 herds)	***	(*)	n.s.	n.s.
Parity	**	n.s.	n.s.	n.s.
Litter size at birth	n.s.	n.s.	n.s.	n.s.
Piglet breed (pure- vs. crossbred)	n.s.	n.s.	n.s.	n.s.
Time interval, farrowing to test	n.s.	n.s.	n.s.	n.s.
Time of farrowing	n.s.	(*)	n.s.	n.s.
Time of day when tested	n.s.	n.s.	n.s.	n.s.
Person doing the test	(*)	***	***	n.s.
Testing order of the sows	n.s.	n.s.	n.s.	n.s.
Type of treatment	–	n.s.	n.s.	n.s.
Treatment next to the pen or away	–	n.s.	n.s.	n.s.

n.s. = non-significant ($P>0.10$); (*) = tendency ($0.10>P>0.05$); ** $P<0.01$; *** $P<0.001$.

tests. The person had no effect on whether the sow was aggressive or not. Of the sows scored to be aggressive, 92% moved towards the stockperson during piglet handling.

Variance components and heritabilities for the traits analysed are shown in Table 2. Except for the handling test, the heritabilities for the behaviour tests were slightly higher than those estimated for the mortality traits. The estimated genetic correlations between the behavioural traits and mortality are shown in Table 3. Response in the scream test was negatively correlated with mortality, so that a strong response in the scream test was associated with low mortality in the litter. No clear correlation was seen

Table 2
Estimates of variance for permanent environment of the sow (σ^2_{pe}), genetic variance (σ^2_a) and residual variance (σ^2_e) for the traits analysed

Trait	σ^2_{pe}	N_e	σ^2_a	N_e	σ^2_e	N_e	h^2
Scream test	0.058±0.019	12 903	0.020±0.009	4194	0.251±0.021	35 241	0.06±0.03
Handling test	0.009±0.007	6192	0.005±0.003	1300	0.556±0.054	73 698	0.01±0.01
Avoidance	0.019±0.010	2074	0.013±0.008	512	0.143±0.013	12 579	0.08±0.04
Aggression	0.001±0.001	3095	0.093±0.080	614	1	–	0.08±0.06
% Mortality of live-born	7.69±3.74	7581	4.39±2.45	1030	140.8±7.18	19 543	0.03±0.02
% Crushing	8.00±3.44	11 715	3.82±2.10	1178	86.4±4.96	13 418	0.04±0.02

Effective number of independent samples (N_e) is given for each respective parameter estimate.
All parameters are presented as means±standard errors of the marginal posterior distributions. For the scream test, avoidance and aggression, estimates are from the bivariate analyses with mortality of live-born, for the handling test from a univariate analysis, and for the mortality traits from the bivariate analyses with the scream test.

Table 3
Estimates of genetic correlations between the behaviour traits and the mortality traits

Traits	Genetic correlation with			
	% mortality of live-born	N_e	% crushing	N_e
Scream test	−0.24±0.31	1698	−0.16±0.32	1163
Avoidance	0.37±0.34	1467	0.27±0.34	695
Aggression	0.01±0.40	1255	0.03±0.37	1013

Effective number of independent samples (N_e) is given for each respective parameter,
All parameters are presented as means±standard errors of the marginal posterior distributions.

between aggression and mortality, but avoidance seemed to be positively correlated with mortality. For response in the scream test and fear of humans, the correlations with crushing rate was slightly weaker compared to the correlations with total mortality of live-born piglets, but the difference was not significant. The phenotypic correlations between all behaviour traits and mortality were close to zero. Marginal posterior distributions for the genetic correlations are illustrated in Fig. 3.

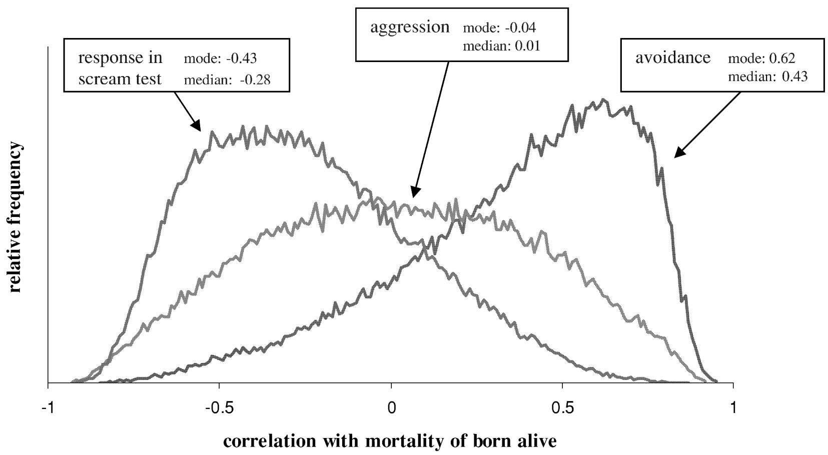

Fig. 3. Marginal posterior distributions of the genetic correlations between mortality until day 4 of piglets born alive and response in the scream test, avoidance of stockperson, and aggression towards the stockperson.

Changing the priors used in the Gibbs sampler somewhat affected the genetic variances and the covariances between traits. The heritabilities were, however, always in the same range (low) and the correlations between the traits were always in the same direction.

4. Discussion

In this study 33% of the sows shifted posture to sitting or standing in response to the playback sound of a screaming piglet, while the most common response was to just look for the sound. In most studies of the scream test, the playback sound was played while the sow was in the process of lying down, while in this study it was played to the sow when she was already lying on her side. Validation of the test, however, showed no significant difference in response rate from the sow if the test was performed while she was in the process of lying down or already lying. Furthermore, the validation showed no difference in response rate in the sows if they were subjected to the playback sound of one of their own piglets or an alien piglet (Thodberg et al., 1998). It could be argued that the sows' response in the piglet scream test may reflect a general level of reactivity to any sound or event, and does not necessarily describe her maternal qualities. However, previous studies have shown that sows react much more strongly to the sound of a piglet than they do to other sounds (Hutson et al., 1991).

Thodberg et al. (2002) showed that a high response in the scream test was associated with less risky behaviour around parturition. Sows that responded quickly in the test had a lower activity level on the farrowing day, thereby performing fewer movements that could put the piglets at risk of being crushed. Wechsler and Hegglin (1997) showed that sows who responded strongly in the scream test, in fact, had fewer crushed piglets in their litters. In spite of these indications of a phenotypic relationship between response in the scream test and piglet mortality, we could not confirm such a relationship in this study. The phenotypic correlation estimated in this material was close to zero (not shown). We did, however, find a moderate negative genetic correlation between response in the scream test and both mortality of live-born piglets and crushing. These results indicate that selection of sows who respond strongly in the scream test could be expected to give a correlated response in lower mortality.

We found very little genetic variation in the piglet handling test. This is probably due in part to the way the test was performed. The handling test was done around day four after farrowing, when sows are much more active than they are on the farrowing day, when the scream test was carried out. From a practical standpoint, it was not possible for the stockpeople to wait until the sow was lying down to do the test, as they did when performing the scream test, since the handling test was performed in connection with routine handling of the litter. Instead, the stockpeople could start the test regardless of the sow's position when they approached the pen. As a consequence, quite a large number of records (34%) were lost because the sows were already standing at the beginning of the test. Also, some of the remaining observations in the handling test are censored, because if a sow is sitting at the start of the test, for example, her maximum response can only be given the score 1. We do not know what she would have done if she had been lying down at the start. However, for more than half of the records included in the analyses the sows were lying on their side at the start of the test, and for less than 10% of the records the sow was sitting up.

Fear can be viewed as an aversive emotional state induced by the perception of any actual danger that threatens the individual (Marks, 1987; Boissy, 1995), and elevated levels of fear are normally associated with physiological symptoms of stress that may indicate reduced welfare in domestic animals (Toates, 1995; Jones, 1997). Many studies (reviewed by Rushen et al., 1999) describe how aversive handling by humans can induce fear in the animals, and how fear responses are often generalised to all humans, not just the aversive handler. Reduced production and reproduction, such as reduced growth, pregnancy rate and litter size, has been observed in these aversively handled animals (Hemsworth and Coleman, 1998). Since animals are often subject to different kinds of handling and treatment by humans, those that are fearful of humans must be considered to have a lower welfare, as they will experience more severe stress in connection with handling.

It is clear that fear of humans can develop through experience of aversive handling, but several studies have also shown individual differences and a genetic variation in this trait (Hemsworth et al., 1990; Boissy et al., 2002). In this study we confirmed that there seems to be a genetic component controlling this trait. The heritability estimated from our data is low compared to that reported by Hemsworth et al. (1990), in spite of the fact that our heritability is estimated on the underlying scale. This difference may be explained in part by the fact that our test of avoidance was not as well standardised as that used by Hemsworth et al. (1990). Even though we did not find any clear phenotypic correlation between avoidance of a human being and piglet mortality, we did find some evidence for a genetic correlation between these two traits. Selecting for sows that do not avoid humans will likely give a correlated genetic response in improved piglet survival rate. Such selection would therefore improve the welfare of both the sow and the piglets.

In this study we recorded avoidance during lactation; however, a benefit of this trait in terms of selection is that it can be measured earlier in a sow's life, before she is chosen for replacement. Janczak et al. (2002) recorded fear of humans in young gilts at 8 weeks of age. They found that gilts showing low levels of fear had shorter farrowings when they later became mothers, as well as fewer piglets die without milk in their stomachs. They were more responsive when lying on piglets, tended to have fewer stillborn piglets and also a lower total mortality in their litters during the first 3 weeks after farrowing. It is possible that a test response measured at 8 weeks would also give a higher heritability than we found in our study, since the influence of the environment and previous experience would be smaller.

It is commonly argued among farmers that sows who are successful mothers are also often the ones who display aggressive behaviour towards the stockperson. Few studies have been done to show whether there really is a correlation between aggression towards the stockperson and maternal success. Marchant (1998) found no relation between aggression towards the stockperson in gilts and piglet mortality, indicating that aggressive sows are not more successful mothers. According to our results, aggression seems to have a genetic background and should therefore be possible to select against, since it makes the sows more difficult for the farmer to handle. The estimated genetic correlation with litter mortality seemed to be close to zero, but this estimate is very uncertain. From our results, it is difficult to conclude whether selection against aggression would give any correlated response in piglet mortality.

Our study shows that there is genetic variation in different behaviour traits in sows, of which some seem to be associated with piglet mortality. The heritabilities estimated in this study are, however, quite low, making it more difficult to correctly rank the animals based on genetic merit for the behaviour traits. The trait with the strongest relation to piglet survival was avoidance of a human being. It is possible that a more standardised test, perhaps measured at a younger age, would give a higher heritability than what we found, which the results from Hemsworth et al. (1990) also indicate.

It is also possible that other ways of measuring behaviour traits should be considered. In a Norwegian study, maternal behaviour in sows was measured with the aid of a questionnaire that allowed the farmers to judge their sows' maternal behaviour. Farmers answered questions about traits similar to the ones tested in this study, namely the sows' carelessness around her piglets early in lactation, reaction to piglets being handled, and fear and aggression during routine management (Vangen et al., 2002). The heritabilities estimated by Vangen et al. (2002) were considerably higher than those we found for fear during management (0.29 vs. 0.08), aggression during management (0.19 vs. 0.08) and reaction to piglet handling (0.25 vs. 0.01). These Norwegian herds are small, and it can be assumed that the farmers know their individual animals quite well. It appears that, by letting the farmers judge behaviour over a longer period of time, instead of making a single test, the environmental variation can be reduced, and a truer estimate of the sow's temperament can be made. If this type of questionnaire also works on larger farms, where the farmer may know less about the behaviour of individual animals, it might represent an alternative method for measuring behavioural traits in the field.

5. Conclusions

This study shows that it is possible to measure sow behaviour on a larger scale. Response in the scream test and avoidance of humans seem to be genetically correlated with piglet survival. Because avoidance may reflect underlying fear and associated stress responses, selection for less fearful sows would be likely to increase the welfare of both sows and their piglets.

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