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Genetic analysis of mothering ability in sows and the relationship to reproduction and piglet mortality

B. Hellbrügge[1], K.-H. Tölle[2], C. Henze[1], J. Bennewitz[1], U. Presuhn[3] and J. Krieter[1]*

1Christian-Albrechts-Universität Kiel
Faculty of Agricultural and Nutritional Science
Institute of Animal Breeding and Husbandry
Olshausenstraße 40, 24098 Kiel
Germany
*email: bhellbruegge@tierzucht.uni-kiel.de

[2]Chamber of Agriculutre Schleswig Holstein,
24327 Bleckendorf, Germany

[3]farm concepts, 23812 Wahlstedt, Germany

1. Abstract

Records were available from 13,971 piglets and 1,538 purebred Landrace litters of the year 2004. To characterise mothering abilities the sow's reaction to the separation from her litter during the first 24 h after birth, the reaction towards the playback of a piglets distress call and the reaction towards an unknown noise (music) were used. The heritabilities were estimated with a multiple ordered threshold model and rank from $h^2 = 0.09$ to $h^2 = 0.14$. For the number of piglets born alive, stillborn piglets and piglets born in total the heritabilities were estimated with a linear model. Different causes of piglet losses were evaluated as binary traits of the sow with survival rate (84.3 %), different definitions for crushing by the sow, underweight and stunting. The variance components were estimated with a threshold model and rank from $h^2 = 0.03$ to $h^2 = 0.05$. The genetic correlations were analysed bivariate and showed that more responsivness sows had fewer piglet losses. The analysis of the different behaviour-tests suggested that they were responsive to different patterns of behaviour

2. Introduction

The decrease in piglet losses is an important factor for improving economic success in pig production, i.e. the number of piglets weaned (Röhe and Kalm, 2000). Piglet mortality varies between systems and farms and remains a problem in spite of the use of farrowing crates. Even in loose-housed sows, piglet mortality tends to be a great problem (Damm et al., 2005). Therefore, it is becoming more and more important that sows respond to signals from their piglets and behave carefully to minimize the risk of crushing them (Grandinson, 2005). The aim of the study was to analyse the genetic background of different traits to characterize the mothering ability of sows and to evaluate the relationship to different causes of piglet losses.

3. Materials and Methods

Data

Data were recorded in a nucleus herd of the breeding company 'Hülsenberger Zuchtschweine' from January to December 2004 by one person. 943 Landrace (LL) sows with 1,538 purebred litters from 82 sires were available. The sows were housed in farrowing crates. All farrowing pens were of homogeneous type with a dimension of 2.74 m x 1.75 m. 13,971 Landrace piglets were weighed individually and earmarked within the first 24 hours after birth. The weight of the piglets was also recorded at the age of 21 days. Special explanatory notes on the condition of their bodies were made. Piglets which were mummified, stillborn and born alive were counted and their sex was noted. All fully developed piglets found lying dead and with their amnion behind the sow were defined as stillborn. Lost piglets were weighed and the cause of death was determined. 10 % of the piglets were cross-fostered. Age, nurse sow and weight was also documented for these piglets.

Mothering ability

Different traits to characterize the mothering ability of sows were recorded during the period of lactation. For the present study, the focus was on the sow's reaction to the separation from her litter during the first 24 hours after birth (SEPA), the sow's reaction to the playback of a piglet's distress call (SCREAM) and to an unknown noise (MUSIC). These tests were performed after farrowing in a compartment. The sow's response was evaluated in five categories. Due to the low number of observations in the category 'very strong reaction', categories 4 and 5 were analysed together.

Table 1. Frequency (n) and percentage (%) of the behaviour levels

Level	Description	SEPA (n = 1,327)		SCREAM (n = 1,453)		MUSIC (n = 1,453)	
		n	%	n	%	n	%
1	No reaction	291	22.0	925	63.6	203	14.0
2	Little reaction	305	22.9	254	17.5	236	16.2
3	Middle reaction	384	28.9	224	15.4	801	55.1
4	Strong reaction	307	23.1	40	2.8	186	12.7
5	Very strong reaction	42	3.2	10	0.7	27	1.9

Causes of losses (COL)

To determine the ultimate cause of piglet losses, the individual birth weight, the weaning weight and the explanatory notes on the constitution of the piglet were used. The different COL (Table 2) were defined as binary traits (0/1) with one for 'true' and zero for 'false' for the respective trait. Underweight piglets (800g or less) were regarded as weighing less than normal but still healthy. Stunt was defined to be unthrifty in growth development.

Table 2. Declaration, number (n) and percentage (%) of the causes of a loss (COL)

COL	Description	n	%
Survival rate (SR)	Survival of piglets from birth to weaning	11,778	84.3
Crushing (CRUSH)	Piglets died by crushing under the sow	1,733	12.4
Crushing – early (CRUSH_E)	Piglets died by crushing under the sow during the first three days of life	1,231	8.8
Crushing – heavier piglets (CRUSH_H)	Piglets with more than 800g birth weight died by crushing under the sow	1,525	10.9
Underweight piglets (UW)	Piglets which died with less than 800g birth weight or which were given the condition 'life weak'	361	2.6
Stunt (STU)	Piglets died because of starvation or piglets had an individual 21-day weight of less than 3 kg	307	2.2

Statistical analyses

The analysis of the fixed effects and their interactions were tested with the MIXED procedure from the statistical software SAS (SAS, 2004). For the behaviour traits the fixed effects of the farrowing batch (8 classes), parity of the sow (7 classes), distance between test date and farrowing date (8 classes) and the random permanent effect of the sow were used. For the fertility traits number piglets born alive (NBA), number of stillborn piglets (NSB) and number of piglets bon in total (NBT) the fixed effects of farrowing batch, parity of the sow and the random permanent effect of the sow were applied in the model. The COL were regarded as traits to characterize the merit of the sow, and the fixed effects farrowing batch, parity of the sow, cross-fostering (yes or no), sex of the piglet (m/f), the random permanent effect of the sow and the random permanent effect of the litter were used. The variance components for the behaviour traits and the COL were estimated by Bayes approach (Sorensen et al., 1995) using an animal threshold model. Following this, the posteriori distribution for the additive genetic variance and the permanent environmental variance of the liability were estimated by Gibbs-Sampler algorithm using the LMMG_MTH program, which is a threshold derivative of LMMG (Reinsch, 1996). The variance components for the traits of mothering ability were estimated with the multiple ordered threshold model. The variance components for the fertility traits were estimated with VCE 4 (Neumaier and Groeneveld, 1998). Additionally, genetic correlations between fertility, the COL and the behaviour traits were estimated bivariately.

RESULTS AND DISCUSSION

Landrace sows had on average 10.4 piglets born alive per litter with a standard deviation of s = 3.4, 0.8 stillborn piglets (s = 1.3), a mean individual birth weight of the piglets of 1.55 kg (s = 0.4) and a weaning weight of 6.3 kg (s = 1.5). The estimated heritabilities for the traits of litter size ranked from $h^2 = 0.05$ to 0.10.

The heritability for the number of piglets born in total with $h^2 = 0.09$ was slightly lower than for the number of piglets born alive ($h^2 = 0.10$). The estimated heritabilities were in agreement with the literature (Röhe and Kennedy, 1995; Adamec and Johnson, 1997). The genetic correlation between NBA and NBT was ($r_g = 0.98$) on a high level but were approved in literature. Röhe and Kennedy (1995) stated, that there is no need to implement the number of piglets born in total in the breeding goals because of the risk to increase the number of stillborn piglets coevally. The estimated heritabilities for the behaviour traits ranged from $h^2 = 0.09$ to 0.14 (Table 3) and were higher than given in literature (Grandinson et al., 2002; Løvendahl et al., 2005). The correlation between the separation test and the reaction to the piglet's distress call was nearly zero. This suggested that both traits were genetically different. A high correlation was found with $r_g = 0.72$ between SEPA and MUSIC. For the respective traits (i.e. SEPA und MUSIC) a negative relation to the NBA was estimated, so that more reactive sows had fewer piglets born alive.

Table 3. Heritabilities and genetic correlations between the traits of mothering ability[A]

Traits	SEPA	SCREAM	MUSIC
Separation test (SEPA)	**0.09±0.04**	- 0.02±0.24	0.72±0.23
Piglets distress call (SCREAM)		**0.13±0.05**	0.48±0.16
Unknown noise (MUSIC)			**0.14±0.05**

[A]Heritabilities (±s.e.) in bold, genetic correlations (±s.e.) above the diagonal.

In the present study, 31.3 % of the piglet losses occurred during the first day, 68 % during the first three days and 82 % in the first week. The estimated heritabilities for the COL ranged from $h^2 = 0.03$ to 0.05, the standard errors varied from SE = 0.01 to 0.03. Grandinson et al. (2002) estimated for crushing a heritability of $h^2 = 0.06$. This value was slightly higher than estimated in this study.

SEPA and MUSIC possessed a negative genetic correlation towards the NBA, NSB and NBT ($r_g = -0.22$ to -0.73). This suggest that more reactive sows showed a tendency to give birth to smaller litters. For the number of stillborn piglets, the genetic correlation was lower than for the other traits of litter size ($r_g = -0.38$ to -0.11). Between the reaction towards a piglet's distress call (SCREAM) and the fertility traits the genetic correlations were low.

Table 4. Genetic correlations (± s.e.) between the traits of mothering ability and the fertility traits

Traits	NBA	NSB	NBT
Separation test (SEPA)	- 0.59±0.34	- 0.38±0.22	- 0.73±0.28
Piglets distress call (SCREAM)	0.12±0.21	- 0.11±0.24	0.06±0.20
Unknown noise (MUSIC)	- 0.28±0.22	- 0.22±0.23	- 0.33±0.19

The correlations between the SEPA, MUSIC and the survival rate were positive (rg = 0.14 to 0.26), the correlation with SCREAM (rg = 0.08, table 4) was lower but also positive. This indicates that more reactive sows had fewer piglet losses which is confirmed in the literature (Grandinson et al., 2002; Wechsler and Hegglin, 1997). With increasing number of piglets born, the chance of being crushed under the sow was higher (rg = 0.30 to 0.47). The correlations with the crushed piglets suggest that the chance of being crushed depends on both the number of piglets born and on the behaviour of the sows but standard errors of estimated parameters were still high.

Table 5. Genetic correlations (±s.e.) **between the traits of mothering ability, number of piglets born alive (NBA) and the causes of piglet losses**

Traits	SR	CRUSH	CRUSH_E	CRUSH_H	UW	STU
SEPA	0.14±0.28	0.26±0.36	0.30±0.25	0.09±0.30	0.26±0.52	- 0.43±0.34
SCREAM	0.08±0.21	- 0.03±0.21	0.15±0.22	- 0.12±0.21	0.77±0.75	- 0.70±0.37
MUSIC	0.26±0.18	- 0.28±0.19	0.04±0.19	- 0.45±0.21	023±0.42	0.002±0.29
NBA	- 0.60±0.19	0.47±0.19	0.35±0.23	0.30±0.21	0.52±0.35	0.47±0.29

The reaction towards a piglet's distress call seems to be genetically different from the other behaviour traits. The test showed a low but positive correlation with the NBA (Table 4), but with the SR and the traits of crushing the correlations were much lower than the standard error. High correlations were estimated between UW and STU. The calmer sows tended to have fewer lighter piglet losses (rg = 0.77), but also these piglets seem to be stunted in development.

CONCLUSION

These results suggest that breeding for mothering ability under production conditions is possible if scoring of behaviour follows a clearly standardized scheme. The correlations suggest that different behaviour-tests are responsive to diverse patterns of behaviour. Analysis of further documented behaviour traits and the recorded video material should give a more precise breeding strategy to optimize both piglet survival and litter size.

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