Genetic analyses of mothering ability in sows using field-recorded observations

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ABSTRACT

The improvement of the postpartum survival rate of piglets is important for pig breeding nowadays. For the improvement, breeding for good mothering abilities of sows offer a promising strategy. The aim of the following study was to estimate genetic parameters for mothering ability traits recorded on an five-point ordinal scale (1="best" to 5="worst"). Information of 48,028 litters and 15,688 sows belonging to different lines and crosses was available. Genetic parameters were estimated by applying a linear mixed- and a threshold model. Pairwise bivariate analyses were conducted for the linear mixed model (LMM) in order to calculate correlations.

The estimates for the heritability (repeatability) using the LMM are between 0.02 and 0.07 (0.05 and 0.09). With the threshold model the heritability (repeatability) estimates are between 0.05 and 0.15 (0.08 and 0.17). The difference between repeatability and heritability points to a huge impact of the permanent environment. The threshold model seems to be more suitable for analysing the data. The heritability estimated for group – and nursing behaviour with the threshold model was highest (0.15 and 0.10). All the correlations were positive and the genetic correlations were in accordance with the phenotypic correlation. The genetic correlation for piglet vitality and estrus behaviour was zero. The highest genetic correlations were estimated between nursing – (group behaviour) and litter balance and piglet weaning weight. For nursing behaviour and piglet weaning weight the genetic correlation was 0.86.

Accelerating genetic gain for good mothering abilities of sows will be possible. Especially nursing – and group behaviour seem to be promising traits. For the implementation in breeding programs, clearly defined traits are required and correlations between mothering ability and common production traits (e.g. daily weight gain) should be investigated.

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1. Introduction

From an economical point of view pig production is highly dependent on the productivity of the sow, defined as the number of piglets weaned per sow per year. A main objective is to achieve high numbers of piglets in balanced litters with a high survival rate of piglets. Piglet losses before weaning are the reason why productivity cannot be measured immediately after birth (Lund et al., 2002). A low heritability for survival rate of piglets until weaning, the ongoing breeding for high leanness, high growth rates and a good feed efficiency have led to a slight decrease in piglet (Grandinson et al., 2002; Grandinson, 2005; Kerr and Cameron, 1996; Knol et al., 2002; Roehe and Kalm, 2000). Moreover the present development in the field of sow management (more opened husbandry systems, growing farm structures) as well as ongoing debates about animal welfare have increased the demand for sows with better mothering ability.

Because of this issue the search for improvement options of the survival rate of piglets moves in the focus of breeding tasks. Breeding for good mothering ability of sows offer an important and promising strategy to improve the postpartum survival rate of the piglets (Grandinson et al., 2003; Lund et al., 2002). Numerous characteristics for a comprehensive description of sow maternity were already pinpointed and genetically evaluated in some studies (Grandinson et al., 2003, 2005; Gäde et al., 2008a, 2008b; Hellbrügge et al., 2006a, 2006b, 2008a, 2008b; Løvendahl et al., 2005; Vangen et al., 2005). All those studies have in common that the estimates of the heritability are general low.

For practical operations an easy and immediate data recording is needed. To fulfil these essential requirements the pig breeding association "Schweinezuchtverband Baden-Württemberg e.V." (SZV) has developed a practical possibility to develop a comprehensive data base. Since 2011, the data of seven mothering ability traits, were recorded on farms in Germany and Switzerland. The
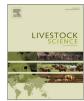
Table 1
Mothering ability traits as well as their abbreviations (in parenthesis) with description. The definitions are only shown for the best (1) and worst (5) category on the five-point scale.

Traits	Description	Definition
Estrus behaviour (EB)	Clarity, intensity, period	1: Estrus on time, distinct tolerance 5: Bad/no estrus, bad/no tolerance
Group behaviour (GB)	Inconspicuous, dominant, aggressive	1: Calm 5: Aggressive, dominant
Farrowing behaviour (FB)	Behaviour during farrowing, aggressiveness towards piglets, mothering abilities	1: Sow remains lying during farrowing, is not biting or snapping, rapid parturition /no help is needed 5: Sow stands up frequently during farrowing, is biting or snapping, heavily delayed parturition
Piglet vitality (PV)	Lively, lethargic, birth weight, colostrum intake	1: Birth weight > 1.2 kg, piglets suckle immediately and stimulate the udder well 5: Birth weight < 1 kg, many piglets have problems in locating the udder or are even not able to find it
Nursing behaviour (NB)	Nursing behaviour, quality of teats including	1: Sow feeds the piglets until satiation, all udder complexes are fully developed and functional 5: Sow is laying on the udder, feeds the piglets short, injured/ non-functional udder complexes
Litter balance (LB)	Homo-/heterogeneity of piglets in litter	1: No underweight piglets, litter is balanced 5: Many underweight piglets, litter is unbalanced
Piglet weaning weight (PW)	Average weight of piglets in the litter	1: Weight: 4 weeks: > 8 kg 3 weeks: > 6.5 kg 5: Weight: 4 weeks: < 8 kg 3 weeks: < 6.5 kg

sows were evaluated based on a given catalogue, designed by the breeding association, including definitions and corresponding classifications of the traits (Table 1). Based on an internet platform a continuous data transfer from the farms to the SZV is guaranteed.

The aim of this study was to make use of their comprehensive data base to estimate genetic parameters of mothering ability traits by applying suitable linear mixed- and threshold models. Recommendations for the practical application in pig breeding programs will be given.

2. Materials and methods

2.1. Animals

The sows were kept on 90 farms in Germany and Switzerland between 2011 and 2014. Most of the farms worked in a three week rhythm. The parities of the sows ranged from 1 to 18. Information of 48,028 litters and 15,688 sows was available. In the first litter 26% of the sows provide data for the mothering ability traits. In the second litter 21% of the sows had observations, in the third litter 16% and in litters ≥ 4 approximately 37% had observations.

The sows belong to different lines and crosses. From the pure breed sows, German Landrace (GL, 33%) and Large White (LW, 28%) were most frequently represented followed by Piétrain (PI, 14%). From the cross breed sow 19% belong to the cross Leicoma (LC) $\times$ GL and 3.5% belong to the crosses LW $\times$ (LC $\times$ GL) and LW $\times$ GL. The pedigree of the sows was augmented with ancestral information from up to eighteen generations back and comprises information from 38,013 sires and dams, depending on the breed. The founder animals were assigned to six genetic groups.

2.2. Mothering ability traits

Before data collection started, a meeting of the farmers with the pig breeding association "Schweinezuchtverband Baden-Württemberg e.V." (SZV) was arranged to give detailed instructions for data recording during routine farm work. To fulfil the essential requirements of an easy and immediate data recording

the pig breeding association "Schweinezuchtverband Baden-Württemberg e.V." (SZV) has developed a practical possibility to develop a comprehensive data base. Each farmer received a catalogue, including classifications and corresponding trait definitions of the mothering ability and recorded the data. Based on an internet platform a continuous data transfer from the farms to the SZV is guaranteed. Vangen et al. (2005) showed that collecting data on maternal behaviour with questionnaires seems to work in a large scale under field conditions.

Data recording was done using a five-point ordinal scale including categories 1 until 5. The traits with description and definitions of the best (1) and worst category (5), representing biological extremes, are listed in Table 1. The categories 2 and 4 have been added on the catalogue by the SZV in 2013. This was done because a quantitative genetic background of the traits is assumed, which is better represented by more detailed categories. This is in accordance with the study of Gäde et al. (2008a) who also used 5 categories.

The following seven mothering ability traits were available: Estrus behaviour (EB), group behaviour (GB), farrowing behaviour (FB), piglet vitality (PV), nursing behaviour (NB), litter balance (LB) and piglet weaning weight (PW). The absolute number of observations for the seven behaviour traits as well as their proportion in the five categories are included in Table 2. The number of observations from the seven mothering ability traits recorded for the sows ranged from 13,905 for GB to 34,711 for FB. Most obvious are the low proportions of observations in categories 2 and 4 for all the traits. Therefore the observations for these traits were transformed into 0/1 (not good/good). Categories 1 and 2 were combined into the category "good" whereas 3, 4 and 5 were combined in the category "not good", which was done by summing up the proportions in categories 3, 4 and 5 (1 and 2) for all the traits. The proportions on the binary scale can be calculated from the proportions in the 5 categories listed in Table 2.

2.3. Statistical models

For the genetic analysis two statistical models were applied; a linear mixed model (LMM) and a threshold model (e.g. McCullagh and Nelder, 1989; Tempelman, 1998); Gäde et al. (2008a) have