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Estimation of genetic parameters for teat number and reproduction and production traits from different data sources for Czech dam breeds

Emil Krupa*, Eliška Žáková, Zuzana Krupová, Monika Michaličková

Institute of Animal Science, Přátelství 815, Prague 10400, Czech Republic

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ABSTRACT

Genetic parameters for total number of teats (TNT), total number of piglets born (TNB), number of weaned piglets (NW), lean meat content, and average daily gain were estimated for the populations of Czech Large White and Czech Landrace pig breeds. TNT was defined as sum of all measurable teats without taking into account of between teats and was counted during the identification of piglets up to 10 days after birth. Two main resources of data for TNT were analyzed: (1) TNT recorded only for breeding pigs in the national performance testing scheme (animals with at least 14 teats in total) as the pre-selected performance data set (PT; 94,500 animals); and (2) TNT recorded in nucleus and multiplier farms (F). In this data set (40,160 animals), whole litter information, including negatively selected piglets, was considered. Only 6.7% of animals from farmers' data set showed optimal production in the performance test. The average number of piglets evaluated in the PT and F data sets per litter was 2.7 and 9.4, respectively. The TNT was analyzed using single-trait and five-trait animal models by using production and reproduction data to determine heritability and genetic correlations between TNT and production and reproduction traits. As expected, the farmers' data set was characterized by higher variability of TNT than the performance data set. The estimated heritability for TNT ranged from 0.28 to 0.30 (regarding the data and models used). The genetic correlations of TNT with production and reproduction traits were negligible and varied from −0.096 to 0.080 depending on the datasets and models used. A very high significant genetic correlation (0.782 and 0.793) was found between TNB and NW. Our hypothesis of impact of raw data inclusion on estimated genetic parameters for the trait TNT was rejected. Our findings suggested no significant differences for the estimated heritabilities of TNT among the analyzed datasets and models. The breeding values for TNT can be estimated by using single as well as multi-trait animal models, because no genetic correlations with production and reproduction traits were found.

1. Introduction

Since 2005, Czech dam pig breeds have been genetically evaluated using a four-trait animal model that considers traits such as lean meat content (LM), average daily gain (ADG) from birth till the end of the field test, number of piglets born alive in the first litter, and number of piglets born alive in the second and subsequent litters (Wolf et al., 2005). Over the years, this evaluation has guaranteed a continuous growth in the number of piglets born alive. With an increased litter size, it is necessary to ensure that all piglets in the litter receive sufficient nutrition during the lactation period. Therefore, the number of teats can limit effective pig breeding at the commercial level.

A combined genetic evaluation for all possible traits needs to be generally performed because, during selection, not only a trait value but also an animal as a whole is considered. Further, consideration of additional genetic parameters such as genetic correlations contributes to an increased accuracy of the genetic evaluation. Several studies have focused on the genetic correlation of teat number with reproduction and growth traits. Some authors concluded negligible or no genetic correlations between these two parameters (Chalkias et al., 2013; Lundeheim et al., 2013; Zhang et al., 2000), whereas others suggested the existence of some relationship (Fernández and Mateos, 1998, 2005; Haley et al., 1995).

The threshold selection based on the minimal number of teats is used in many breeding organizations; in some Czech pig breeding systems, only animals with at least 14 teats are reared and performance tested. However, variability in the pre-selected data and that in the whole population could cause a bias in genetic evaluation. Moreover, the data containing information for all piglets in the litter could provide a more accurate statistical evaluation about the biological variability of traits and reflect the biological potential of parents with higher accuracy.

This study aimed to estimate heritability for the total number of teats (TNT) and its genetic correlation with other production

* Corresponding author.
E-mail address: krupa.emil@vuzv.cz (E. Krupa).

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(LM and ADG from birth to the end of the field test) and reproduction (total number of piglets born per litter [TNB] and number of piglets weaned per litter [NW]) traits in Czech Large White (CLW) and Czech Landrace (CL) breeds. Further, the influence of the source of teat data (data involving all piglets in a litter versus pre-selected data) on the estimated genetic parameters was analyzed.

2. Materials and methods

2.1. Data

The analyses were performed using production and reproduction trait data for CLW, CL dam breeds and their crosses. Detailed pedigree information about the analyzed breeds has been reported by Krupa et al. (2015). The production data included LM in percentage at the end of the performance test estimated from ultrasonic measurements unadjusted for live weight and ADG from birth till the end of the field test (in g/d) calculated as weight divided by age at the end of the test. The field test to measure production traits was started at the age of 80–88 days and lasted between 56 and 70 days (since January 1, 2003, this interval was changed to 49–63 days for gilts; the duration of the test for young boars was not affected). The live weight at the beginning of the test was approximately 30 kg. The TNB and NW were evaluated as reproduction data. The number of piglets weaned is the number of piglets living at the age of 21 days (from 18 to 24 days), regardless the fact the sow nurses them or not. Performing genetic analysis did not require editing of production data since all records were in the required structure. For the trait litter size, only the data fulfilling some conditions mentioned below were used. Complete information for all litter size for purebred CLW and CL breeds and their F1 crosses was considered. Gestation length was between 105 and 125 days. The minimum age at the first farrowing was 300 days. Data for sows with one parity and those with number of parities greater than 10 were not considered in the evaluation. The age of sows for parities 1–10 had to be in the following intervals: 300–500 d, 450–750 d, 600–950 d, 750–1150 d, 900–1350 d, 1050–1550 d, 1200–1750 d, 1350–1950 d, 1500–2150 d, and 1650–2350 d. The TNB was at least 4. The number of piglets that died from birth until weaning was not greater than 4. The farrowing interval was between 130 and 300 days.

The TNT was defined as the sum of all measurable teats without considering the distance between teats and counted during the identification of piglets up to 10 days after birth. The following two main resources of data for TNT were analyzed:

1) TNT recorded from breeding pigs in the national performance testing scheme (PT) as the pre-selected performance data set (94,500 animals) in the production field test conducted between 2000 and 2014. Only piglets with at least 14 teats were assumed to be breeding pigs and were integrated in the field test of the Czech Pig Breeders performance testing scheme. Animals with less than 14 teats were fattened.
2) TNT recorded on nucleus and multiplier farms (F). In this data set (40,160 animals), whole litter information (including negatively selected piglets) from farrowing between 2007 and 2014 was included. The TNT recording was done in both cases with technicians.

Both data sets (PT and F) were merged into the PTF dataset that included all teat data from both the sources (135,110 animals). The only 2684 animals from F data set have had own production information in PT data set, which represent 6.7% of animals from F data set.

2.2. Statistical methods

The general linear model (GLM) and mixed model procedures implemented in the statistical package SAS® (SAS Institute Inc., 2008) were used to investigate the influence of various factors on TNT. The factors affecting other production and reproduction traits were analyzed in our previous study (Krupa and Wolf, 2013).

Genetic parameters were estimated for the following models:

Model 1: TNT trait model contains only PT data set
Model 2: TNT trait model contains only F data set
Model 3: TNT trait model contains merged PTF data set
Model 4: five trait model (LM, ADG, TNT, TNB, NW) includes only PT data set
Model 5: five trait model (LM, ADG, TNT, TNB, NW) includes merged PTF data set

The statistical models in the matrix notation can be written as follows:

$$y = Xb + Za + Wz + e$$

where, y is the vector of observations of traits under investigation; X, Z, and W are known incidence matrices for the fixed effects, random additive genetic animal effect, and remaining random effects, respectively; b is a vector of fixed effects; a is a vector of additive genetic animal effect; z is a vector of further random effects; and e is a vector of residuals.

Vector b comprises the fixed effects and covariates, and vector z consists of the two random factors (the litter to which the animal belongs and permanent environmental effect of the sow). All used effects are summarized in Table 1. The combination of the effects for a given trait was the same in the different models.

The factor "breed" was consisted of two levels: 1) purebred CLW animals and their F1 crosses with CL breed; 2) purebred CL animals and their crosses with CLW. The levels for crosses have not been created due to the relative low number. These were incorporated to the corresponding breed group according to breed affiliation of the crosses dam. The "parity class" effect had to be additionally edited to maintain the number of records for the

Table 1
Factors included (x) in the animal models for the estimation of genetic parameters.

Factor in the model	Type of factor[a]	Trait[b]				
		TNT	TNB	NW	LM	ADG
Weight at the end of the test	C	–	–	–	x	–
Quadratic regression on a covariate[c] within parity	C	–	x	x	–	–
Parity class	F	–	x	x	–	–
Device for ultrasonic measurement of lean meat content	F	–	–	–	x	–
Type of test	F	–	–	–	x	x
Breed	F	x	x	x	x	x
Herd-year-season	F	x	x	x	x	x
Mating type	F	–	x	x	–	–
Sex	F	x	–	–	x	x
Animal	A	x	x	x	x	x
The litter to which the animal belongs	R	x	–	–	x	x
Permanent effect of the sow	R	–	x	x	–	–
Residual effect	R	x	x	x	x	x

[a] Type of factor: C, covariate; F, fixed; A, random animal additive genetic effect; R, random.
[b] Traits: TNT, total number of teats; TNB, total number of piglets born; NW, number of piglets weaned; LM, lean meat content; ADG, average daily gain from birth till the end of the field test.
[c] The covariate is the age at the first farrowing in the first parity and farrowing interval in the second and subsequent parities.

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