CORRELATION OF LITTER SIZE TRAITS

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Abstract: Heredity and correlation of litter size traits were observed in 3693 litters, i.e. in 1622 daughters of two genotypes Swedish Landrace genotype - SL; and F1 ♀ SLxLW. The study included daughters (minimum ten daughters per sire) of 24 sires. Heritability estimates for the total number of piglets per litter in the first, the first two parities, and for all three parities was 0.174; 0.167 and 0.135. Heritability estimates for the number of piglets born alive were 0.181; 0.160 and 0.121, and for the weight of litter at birth 0.166; 0.174 and 0.150. On the other hand, very low heritability was determined for the number of weaned piglets, litter weight of piglets reared, individual weight of born and reared piglets, i.e. for the traits that are under greater influence of the environment (from 0.004 to 0.037). Phenotypic and genetic correlations ranged from weak to complete ($r_p = 0.021$ to $r_p = 0.973$ and $r_g=0.188$ to $r_g=0.999$, respectively). Analysis of the significance of correlations showed that the genetic correlations were statistically highly significant (P <0.01).

Keywords**:** sow, piglet, heritability, phenotypic correlations, genetic correlations

Introduction

Reproduction in pig production is necessary to achieve adequate yearly and lifetime production of piglets per sow. This can be achieved if sows have good fertility and regular farrowing and if the genetic potential of breeding pigs is used to the maximum, i.e. as long as they have vital litters with lot of piglets. Fertility of pigs is a key characteristic of this species of domestic animals, which constitutes the main importance which the production of pigs and pork have in the modern livestock production, both in terms of quantity of product and in terms of economic efficiency of production. Fertility of sows depends on the properties that can be

conditionally divided on reproductive traits and traits of the litter size. The reproductive traits include age at first puberty oestrus, age at conception and age at farrowing, period from weaning to oestrus and conception of sows and duration of exploitation of sows, while the litter size traits include the size and weight of the litter at birth and weaning. Production of pigs is expensive and very complex process in pig breeding. The litter size of primiparous sows contributes significantly to improving the economy of pig production, and is one of the most important breeding goals. The litter size and the number of piglets born alive per litter and sow per year are subject to constant research, although it is known that the selection in a short time cannot achieve significant genetic improvement, primarily due to the low heritability (h^2 = 0.02 to 0.17) (*Serenius et al., 2003; Popovac et al., 2012; Lukač et al., 2016*). Numerous authors have dedicated their research to monitoring reproductive traits which are subject to the influence of the sire, genotype, maternal effect, parity, as well as to functioning of the external factors (*Petrović et al., 2000; Varona and Noguera, 2001; John and Wähner, 2002; Popov et al., 2003; Serenius et al., 2003; Kosovac et al., 2005; Radović et al., 2006; Stančić et al., 2006; Radojković et al., 2007; Vidović et al., 2011; Lukač et al., 2014*).

Material and methods

Heredity and correlation of litter size traits were observed in 3693 litters, i.e. in 1622 daughters of two genotypes Swedish Landrace genotype - SL; and F1 ♀ SLxLW. The study included daughters (minimum ten daughters per sire) of 24 sires. The litter size traits (number of live born piglets, number of stillborn piglets, number of piglets per litter, number of piglets weaned at 28 days, litter weight at birth, litter weight at 28 days, the individual weight of piglets at birth and individual weight of piglets 28 days) were monitored in the first three parities in the period of five years and parities which took place in two seasons of fertilization (very warm - *season 1*, June, July, August and September, and cooler - *season 2*, January, February, March, April, May, October, November and December). Processing of data was done by implementation of adequate programme, i.e. use of the method of least squares (*LSMLMW and MIXMDL-Harvey, 1990*). The models for analysis are included fixed effect of genotype (G_i=1,2), fixed effect of farrowing year (Y_j=1, 2,..,5), fixed effect of fertilization season ($S_{k \text{ or } l}$=1, 2), fixed effect of parity (P_k=1, 2, 3), random effect of father ($f_{l \text{ or } m}$=1, 2,..., 24) and random error.

In examining the first farrowing, the following mixed model of least squares was used:

$$Y_{ijklm} = \mu + G_i + Y_j + S_k + f_l + e_{ijklm}$$

The following mixed model was used in examining thr first two parities:

$$Y_{ijklm} = \mu + G_i + Y_j + P_k + S_l + f_m + e_{ijklmn}$$

The following mixed model was used in examining the first three parities:

$$Y_{ijklm} = \mu + G_i + Y_j + P_k + S_l + f_m + e_{ijklmn}$$

Results and Discussion

Table 1 shows the heritability values of litter size traits for the first parity, first two parities, and first three parities. Based on the results presented in the table it can be seen that the heritability values are almost equal for the trait - total number of piglets per litter (0.174, 0.167 and 0.135), number of piglets born alive (0.181, 0.160 and 0.121), and the weight of the litter at birth (0.166, 0.174 and 0.150). On the other hand, we see very poor heritability for other investigated traits due to the increasing influence of the environment (from 0.004 to 0.037).

Table 1. Heritability (h^2) for litter size

Trait	first parity (n=1622)	first two parities (n=2785)	first three parities (n=3693)
Total number of piglets in litter	0.174	0.167	0.135
Number of live born piglets	0.181	0.160	0.121
Number of piglets reared 28 days	0.022	0.037	0.028
Weight of litter at birth, kg	0.166	0.174	0.150
Weight of litter at 28 days, kg	0.015	0.031	0.021
Individual weight of piglets at birth, kg	0.004	0.015	0.020
Individual weight of piglets at 28 days, kg	0.029	0.027	0.020

Based on the presented results it is obvious that the heritability was slightly higher for the total number of piglets per litter and the number of live born piglets in the first, in relation to the first two parities, as well as in relation to the first three parities. In regard to the weight of litter at birth, it is established that the degree of heritability was higher in the first two parities compared to the first litter and determined h^2 values for the first, second and third litter. The determined value of heritability in our study is in agreement with the results reached by (*Petrović et al., 2000; Popovac et al., 2012*). In regard to the share of 62.1% for the first three parities, *Wolf et al., (2008)* have found approximately the same heritability values: 0.13 for the total number of born, and 0.14 for the number of live born piglets. *Lukač et al. (2016)* have found lower values of heritability in the first two parities while for the third parity approximately the same values are determined for the

total number of live born piglets (0.18 and 0.17), as well as for the the number of reared piglets and weight of the litter of reared piglets (0.01 and 0.03). In relation to our research somewhat lower heritability values for Landrace and Large White in the first two parities have been determined by *Vidović et al. (2011).*

Table 2 shows the coefficients of phenotypic and genetic correlations (r_p and r_g) for reproductive traits in the first parity. On the basis of these phenotypic correlations, it can be seen that the total number of piglets per litter was positively correlated with the total number of piglets born alive ($r_p = 0.967$), while the correlation was not found between the total number of piglets per litter and the number of piglets reared at 28 days ($r_p = 0.055$), as well as between the number of piglets born alive and the number of piglets reared at 28 days ($r_p = 0.063$). While observing the genetic correlations for the same studied traits, it can be seen that the correlations are positive and stronger compared to the phenotypic correlations. In the examination of the statistical significance, it was determined that phenotypic correlations between the total number of piglets and the number of pigs reared at 28 days were not significant, as well as between the weight of litter at 28 days ($P > 0.05$), while the number of live born and reared piglets at 28 days was were correlated statistically significantly ($P < 0.05$). For the other stated phenotypic correlations, as well as genetic correlations, it was established that they were highly statistically significant ($P < 0.01$).

Table 2. The coefficients of phenotypic and genetic correlation for reproductive traits in the first parity (n=1622)

Traits			r_p	r_g
Total no. of piglets in litter	:	Number of live born piglets	0.967 **	0.999 **
Total no. of piglets in litter	:	No. of piglets reared at 28 d.	0.055 ns	0.336 **
Total no. of piglets in litter	:	Litter weight at birth, kg	0.847 **	0.997 **
Total no. of piglets in litter	:	Litter weight at 28 d., kg	0.040 ns	1.157 **
Number of live born piglets	:	No. of piglets reared at 28 d.	0.063 *	0.393 **
Number of live born piglets	:	Litter weight at birth, kg	0.877 **	0.975 **
Number of live born piglets	:	Litter weight at 28 d., kg	0.036 ns	1.172 **
No. of piglets reared at 28d.	:	Litter weight at birth, kg	0.059 ns	0.677 **
No. of piglets reared at 28d.	:	Litter weight at 28 d., kg	0.639 **	0.374 **
Litter weight at birth, kg	:	Litter weight at 28 d., kg	0.042 ns	1.343 **

-) tab $_{0.05}$ =0.062 (P<0.05); tab $_{0.01}$ =0.081 (P<0.01);

Phenotypic and genetic correlations for reproductive traits for first two parities are presented in Table 3. Significance of correlation showed that the genetic correlations were highly statistically significant ($P < 0.01$). Also, we can see that the genetic correlation is greater than the phenotypic between the weight of the litter at

birth and litter weight at 28 days ($r_p = 0.047$ (P<0.05) and $r_g = 0.734$). Also, testing the significance of correlation showed that the genetic correlations were statistically highly significant (P<0.01).

Table 3. The coefficients of phenotypic and genetic correlation for reproductive traits for the first two parities (n=2785)

Traits			r_p	r_g
Total no. of piglets in litter	:	Number of live born piglets	0.973 **	0.998 **
Total no. of piglets in litter	:	No. of piglets reared at 28 d.	0.060 ns	0.211 **
Total no. of piglets in litter	:	Litter weight at birth, kg	0.850 **	0.988 **
Total no. of piglets in litter	:	Litter weight at 28 d., kg	0.026 ns	0.689 **
Number of live born piglets	:	No. of piglets reared at 28d.	0.068 *	0.188 **
Number of live born piglets	:	Litter weight at birth, kg	0.873 **	0.976 **
Number of live born piglets	:	Litter weight at 28 d., kg	0.021 ns	0.629 **
No. of piglets reared at 28 d.	:	Litter weight at birth, kg	0.070 *	0.294 **
No. of piglets reared at 28 d.	:	Litter weight at 28 d., kg	0.613 **	0.649 **
Litter weight at birth, kg	:	Litter weight at 28 d., kg	0.047 ns	0.734 **

-) tab $_{0.05}$ =0.062 (P<0.05); tab $_{0.01}$ =0.081 (P<0.01);

Based on the results presented in Table 4, the following phenotypic and genetic correlations for reproductive traits for the first three parities can be seen. The total number of piglets per litter was positively correlated with the total number of piglets born alive ($r_p = 0.971$ and $r_g = 0.999$), whereas no correlation was determined with the number of piglets reared at 28 days. The correlation between the total number of piglets per litter and litter weight at birth is very strong and complete ($r_p = 0.848$ and $r_g = 0.978$). There was no correlation between the total number of piglets per litter and litter weight at 28 days ($r_p = 0.027$; P> 0.05), while the genetic correlation was very strong ($r_g = 0.755$). By testing the significance values according the values in tables, it can be seen that the genetic correlations were statistically highly significant (P<0.01), while the phenotypic correlations ranged from insignificant to a highly statistically significant. Also, it can be seen that the genetic correlations were somewhat stronger than the phenotypic correlations for studied traits.

Table 4. The coefficients of phenotypic and genetic correlation for reproductive traits for the first three parities (n=3693)

Traits			r_p	r_g
Total no. of piglets in litter	:	Number of live born piglets	0.971[**]	0.999[**]
Total no. of piglets in litter	:	No. of piglets reared at 28d.	0.052[ns]	0.207[**]
Total no. of piglets in litter	:	Litter weight at birth, kg	0.848[**]	0.978[**]
Total no. of piglets in litter	:	Litter weight at 28 d., kg	0.027[ns]	0.755[**]
Number of live born piglets	:	No. of piglets reared at 28d.	0.057[ns]	0.190[**]
Number of live born piglets	:	Litter weight at birth, kg	0.873[**]	0.967[**]
Number of live born piglets	:	Litter weight at 28 d., kg	0.023[ns]	0.686[**]
No. of piglets reared at 28d.	:	Litter weight at birth, kg	0.073[*]	0.256[**]
No. of piglets reared at 28d.	:	Litter weight at 28 d., kg	0.604[**]	0.643[**]
Litter weight at birth, kg	:	Litter weight at 28 d., kg	0.060[ns]	0.795[**]

-) tab $_{0.05}$ =0.062 (P<0.05); tab $_{0.01}$ =0.081 (P<0.01);

The absence of correlation between the total number of piglets per litter and the number of piglets weaned at 28 days can be explained by equalisation of the litter which is the common procedure on the farm. On this occasion, piglets are brought under the that she has not given birth to but raised them as their own, which resulted in the presence and effect of the factors that could not be controlled. On the other hand, it can be seen that the milk yield of sows, as a form of manifestation of their maternal effect, influenced the litter weight at 28 days and individual weight of piglets at 28 days. Certainly, the results are influenced by the studied animals and their breed, as well as the housing conditions and nutrition.

Research that we conducted were consistent with the research of a number of authors (*Tolle et al., 1998; Wolf et al., 1999; Lukač et al., 2016*) who have determined the phenotypic and genetic correlations between reproductive traits ranging from weak to complete. *Roeh and Kennedy (1995)* have found also medium to strong genetic correlations for following traits: the total number of piglets between 1st and 2nd parity = 0.59, the number of live born piglets between 1st and 2nd parity = 0.49, the number of weaned piglets between 1st and 2nd parity = 0.17. Also, *Rydhmer et al. (1995)* have found a strong genetic correlation between the 1st and 2nd parities for litter size (0.67). *Popovac et al. (2012)* have found a greater correlation between the total number of piglets born and reared in comparison to our results (r_p = 0.227 and r_g = 0.619). In concordance with our research, complete phenotypic and genetic correlations between the total born and live born piglets (in the first, the first two and the first three parities) are found by *Lukač et al. (2016),* however, also weaker relation between the number of live born piglets and litter weight at weaning is determined by *Lukač et al. (2016)* as well as a stronger connection between the number of piglets born and reared, compared to our research.

Conclusion

The heritability value of traits - total number of piglets per litter and the number of live born piglets was the greatest for the first parity with respect to the first and second parity, as well as in relation to the first, second, and third parity.

This low value of heritability can be explained by the influence of the database structure, data distribution according to ordinal number of parity, as well as equalizing the litter that is normal and common processing operation on the farm. Phenotypic and genetic correlations ranged from weak to complete (r_p=0.021 to r_p=0.973 and r_g=0.188 to r_g=0.999). Significance of correlations showed that the genetic correlations were statistically highly significant (P<0.01).

Povezanost osobina veličine legla

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Rezime

Naslednost i međusobna povezanost osobina veličine legla praćene su za 3693 legla, odnosno kod 1622 kćeri dva genotipa švedski landras - ŠL; i F_1 ♀ŠLxVJ. Ispitivanjem su obuhvaćene kćeri (minimalno deset kćeri po ocu) od 24 oca.

Heritabiliteti za ukupan broj prasadi u leglu u prvom, prvom i drugom i za sva tri prašenja iznosio je 0,174; 0,167 i 0,135. Za broj živorođene prasadi vrednosi heritabiliteta su iznosile 0,181; 0,160 i 0,121, dok su za masu legla pri rođenju vrednosti 0,166; 0,174 i 0,150. Sa druge strane utvrđen je jako slab heritabilitet za broj odgajene prasadi, masu legla odgajene prasadi, individualnu masu rođene i odgajene prasadi odnosno za ispitivane osobine koje su pod većim uticajem okoline (od 0,004 do 0,037). Fenotipske i genetske korelacije kretale su se od slabih do potpunih (r_p=0,021 to r_p=0,973 odnosno r_g=0,188 to r_g=0,999). Testiranje značajnosti korelacija pokazalo je da su genetske bile statistički visoko značajne (P<0,01).

Acknowledgement

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