Biotechnology in Animal Husbandry 32 (3), p 261-269 , 2016 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 636.43'636.08
DOI: 10.2298/BAH1603261L

ESTIMATION OF GENETIC PARAMETERS AND BREEDING VALUES FOR LITTER SIZE IN THE FIRST THREE PARITY OF LANDRACE SOWS

Dragomir Lukač[1], Vitomir Vidović[1], Teodora Vasiljević[2], Oliver Stanković[3]

[1]University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, 21 000 Novi Sad, Serbia
[2]Patent co. doo, Vlade Ćetkovića 1a, 24211 Mišićevo, Serbia
[3]Patent IEC, Moše Pijade bb, 25220 Crvenka, Serbia
Corresponding author: Dragomir Lukač, dragomir.lukac@stocarstvo.edu.rs
Original scientific paper

Abstract: The aim of this study was to estimate the genetic parameters and breeding values for reproduction traits of Landrace sows in the first three parities by Animal model. Records of 2238 first parity; 2125 second parity and 1872 third parity Landrace sows farrowing between 2007 and 2012 were included in the analysis. The traits included in the analyses were total pigs born (TB), number of pigs born alive (NBA), number of pigs weaned (NW) and litter weaning weight (LW) in the parities. The genetic parameters were estimated using a multivariate analyses Animal model using REML procedure. Estimates of heritability for TB were 0.03, 0.05 and 0.18, for NBA were 0.04, 0.02 and 0.17, for NW were 0.08, 0.08 and 0.01 and for LW were 0.09, 0.11 and 0.03 for parities 1 to 3. Genetic and phenotypic variance were increased from the first to the third parity. Between the majorities of studied reproductive traits were the recorded positive genetic and phenotypic correlations, except between LW and other analyzed properties where they recorded a high correlation negative in third parity. Means of estimated breeding values of reproductive traits from first parity to third parity was indecreased.

Key words: genetic parameters, breeding values, liter size, parity

Introduction

From the viewpoint of profit to producers, improvement of productive traits in pigs is a very important issue. Sow productivity is recognized as a key factor affecting the efficiency and economic viability of the pig industry and is a leading concern of commercial producers and breeders (*Kim, 2001*). In current pig breeding programs, great emphasis is placed on improving reproduction traits in

dam lines (*Hanenberg et al., 2001*). The breeding goal is generally to increase the number of piglets weaned per sow per year. The number of piglets born or born alive per litter is still the only reproduction trait used in most breeding programmes (*Rydhmer, 2000*).

Because of the negative genetic correlations between many production and reproduction traits, the improvement of productive traits ignoring reproductive traits causes poor genetic progress populations. To wit, knowledge of genetic parameters for reproductive traits is essential to estimate accurate breeding values by accounting for all correlations available in a multivariate BLUP analysis. Estimates of genetic parameters for sow productivity traits are generally of low heritability (*Popovac et al.*, 2012; *Dube et al., 2012*; *Radojković et al*., 2012; *Roehe et al., 2009*). Low estimates of heritability for these traits do not discourage genetic selection in the populations studied. The heritability estimates give an indication of the rate of genetic progress that can be achieved when genetic selection is applied (*Dube et al., 2012*).

Estimates of genetic parameters can be biased by involuntary and directional selection from parity to parity. In order to account for this possible bias, reproductive traits of the sow recorded in parities one to three were treated as separate traits. The objective of this study was to estimate the genetic parameters and breeding values for Landrace sow reproduction traits in the first three parities by Animal model. Such results are prerequisite parameters in the breeding value estimation.

Material and Methods

Reproductive data were obtained for the first three parities of purebred Landrace sows breed. Litter size records proceeded from 6235 litters born (2238 first parity; 2125 second parity and 1872 third parity) from 2238 sows and from 94 sire landrace breed (3882 liters) and 73 sires Yorkshire breed (2353 liters), farrowed between January 2007 and December 2012 were used. Only sows with complete litter records were included. The traits included in the analyses were total pigs born (TB), number of pigs born alive (NBA), number of pigs weaned (NW), and litter weaning weight (LW) in the first, second and third parity.

Statistical analyses were conducted with statistical software program Statistica 12 for Windows, significance of fixed effects, included in the model were tested using PROC GLM procedures. Farrowing season was defined as a four month period: I season (November, December, January, February); II season (March, April, September, October); III season (May, June, July, August), and was fitted for all traits. Lactation length was grouped into five intervals: till 20 days; from 30 days; from 21 to 29 days – three intervals, each three days long.

The model for estimate genetics parameters included year-season, sire breed and lactation length as fixed effects, and additive genetics effects of the animal as random effect:

$$Y_{ijklm} = \mu + A_i + YS_j + SB_k + LG_l + e_{ijklm}$$

where Y_{ijklm} - represents the values of reproductive traits; μ - average mean; A_i = animal; YS_j = year-season; SB_k = sire breed; LG_l - lactation length; e_{ijklm} - random error

Genetic parameters of reproduction traits were estimated using the restricted maximum likelihood (REML) method based on an animal model using the WOMBAT software (*Meyer, 2007*) with multivariate analyses. The model can be represented in matrix terms by

$$y = Xb + Za + e$$

where ***y*** = vector of observations; X = incidence matrix of fixed effects; b = vector of fixed effects; Z = incidence matrix of random effects; a= vector of random effects; e = vector of residuals.

Results and Discussion

The mean, standard deviation and coefficient of variation for each trait in the first three parity are summarized in Table 1. Means and standard deviations of TB, NBA, NW and LW increased from first parity to third parity, that is, from 9.47 ± 2.64 to 11.12 ± 2.78, from 8.89 ± 2.58 to 10.55 ± 2.70, from 8.32 ± 1.30 to 10.49 ± 3.43, and from 56.54 ± 12.71 to 69.45 ± 24.67, respectively. Coefficient of variation for TB and NBA from first parity to third parity decreased from 27.83 to 24.99 and from 29.00 to 25.62, while the for NW and LT increased from 15.62 to 32.71 and from 22.48 to 35.52. This indicates that reproductive performance of sows for TB and NBA in the population was improved after the first parity, and that variation of individuals was decreased, thereby the variation for NW and LT increased. In research *Ziedina et al. (2011)*, the average number of NBA in the first parity was 9.1 and in the second 10.3 piglets per litter, thereby, 92% of the sow's had 6 - 19 piglets and only 8% up to five piglets per litter. The average number of NW in the first parity was 9.1 and in the second 10.00 piglets per litter, and LW 21-day is indecreased from 57.1 to 64.5 kg. In research *Oh et al. (2006)*, number of TB, NBA, NW and LW piglets has increased from first parity to later parities, from 11.22 to 12.50, from 10.55 to 11.65, from 9.08 to 9.35, and from 57.73 to 63.95, respectively.

Table 1. Summary statistics for reproductive traits by first, second and third parity in a Landrace sows

Parity	Traits	Mean	SD	CV	Min	Max
1	TB	9.47	2.64	27.83	3	18
	NBA	8.89	2.58	29.00	3	16
	NW	8.32	1.30	15.62	2	16
	LW	56.54	12.71	22.48	10	126
2	TB	10.57	2.87	27.14	3	23
	NBA	10.23	2.70	26.44	3	18
	NW	10.08	3.07	30.47	2	24
	LW	68.51	22.35	32.63	12	175
3	TB	11.12	2.78	24.99	3	21
	NBA	10.55	2.70	25.62	3	18
	NW	10.49	3.43	32.71	2	24
	LW	69.45	24.67	35.52	13	201

TB - total piglets born, NBA - number of piglets born alive; NBW - number of piglets weaned; LW - litter weaning weight

Genetics and phenotypic variances and erro for the first, second and the third parity are summarised in Table 2. Genetics variances for TB, TB, NBA, NW and LW in the first parity were 0.24, 0.25, 0.13 and 13.02, and have increased to the third parity to 1.28, 1.20, 0.98 and 19.08, respectivel, which is in direct relation with the increase in the standard deviation of the traits. In research *Paura et al. (2014)*, the genetics variance for NBA was 0.77 and 0.84 and for LW was 16.98 and 14.18 in first parity and later parities Landrace sows. Phenotypic variances for TB, TB, NBA, NW and LW in the first parity were 6.37, 6.20, 1.67 and 135.78, and have increased to the third parity to 6.94, 6.94, 5.57 and 491.12.

Table 2. Genetic and phenotypic variances for reproductive traits on first, second and third parity in a Landrace sows

Parity	Traits	Genetic variance	Phenotypic variance
1	TB	0.24 (0.18)	6.37 (0.24)
	NBA	0.25 (0.04)	6.20 (0.23)
	NW	0.13 (0.06)	1.67 (0.64)
	LW	13.02 (5.38)	135.78 (5.24)
2	TB	0.36 (0.28)	7.14 (0.31)
	NBA	0.18 (0.24)	6.87 (0.29)
	NW	0.52 (0.28)	6.14 (0.27)
	LW	62.16 (26.29)	524.35 (23.40)
3	TB	1.28 (0.50)	6.94 (0.37)
	NBA	1.20 (0.48)	6.94 (0.37)
	NW	0.98 (0.26)	5.57 (0.28)
	LW	19.08 (25.68)	491.12 (25.61)

TB - total piglets born, NBA - number of piglets born alive; NBW - number of piglets weaned; LW - litter weaning weight

Heritability, genotypic and phenotypic correlations and are phenotypic variances summarized in Table 3. The heritabilities for TB were 0.03, 0.05 and 0.18, for NBA were 0.04, 0.02 and 0.17, for NW were 0.08, 0.08 and 0.01 and for LW were 0.09, 0.11 and 0.03 for parities 1 to 3. To wit, for TB and NBA there was an increase of heritability with increasing parity, while the NW and LW heritability decreased, which is consistent with results *Hanenberg et al. (2001)*. In research *Radojković et al. (2011)*, introduction into the analysis of the results pertaining to the second, third and subsequent parities lead mainly to detection of lower values of heritability coefficients for TB, NBA and NBW. Heritability estimates of TB, NBA, NW and LW in this study were slightly lower than those previously reported *Oh et al. (2006)* (0.27 for TB, 0.25 for NBA, 0.16 for NW and 0.20 for LW in first parity and 0.15, 0.15, 0.08, 0.11, respectively in later parities). In research *Ziedina et al. (2011)*, the heritability estimates in the first parity were 0.07, 0.16 and 0.36 and in second parity were 0.07, 0.39 and 0.17 for NBA, NW, LW-21 days, respectively. *Paura et al. (2014)* obtained the heritability for the NBA 0.05 and 0.10 and for LW 0.23 and 0.20 in first parity and later parities Landrace sows. In research *Hamann et al. (2004)* heritabilities for NBA in first and later parity in Landrace sow were 0.15 and 0.11, respectively. In study *Chen et al. (2003)* low heritability estimates of 0.08 to 0.10 for NBA, 0.07 to 0.09 for LW, and 0.02 to 0.06 for NW were reported. *Hermesch et al. (2000)* are reported heritability estimates for NBA of 0.08, 0.09, and 0.08 in the first, second and third parity.

Between the majority of studied reproductive traits were the recorded positive genetic and phenotypic correlations, except between LW and other analyzed properties, where they the recorded a high correlation negative. Obtained genetic correlations were higher than phenotypic correlations in all parities. Genetic correlations between TB and NBA were 0.94, 0.99 and 0.98, between TB and NW were 0.75, 0.64 and 0.82, between TB and LW were 0.10, -0.28 and -0.83, between NBA and NW were 0.69, 0.61 and 0.77, between NBA and LW 0.00, -0.04 and -0,92 and between NW and LW were 0.09, 0.16 and -0.84 for parities from 1 to 3. Phenotypic correlations between TB and NBA were 0.91, 0.94 and 0.93, between TB and NW were 0.63, 0.58 and 0.78, between TB and LW were 0.02, -0.18 and -0.60, between NBA and NW were 0.57, 0.60 and 0.66, between NBA and LW 0.02, -0.01 and -0,84 and between NW and LW were 0.72, 0.10 and -0.80 for parities from 1 to 3.

In research *Oh et al. (2006)*, genetic correlations between sow reproductive traits in the first parity were estimated as 0.95, 0.78 and 0.62 between TB and NBA, NW and LW, 0.86 and 0.74 between NBA, NW and LW, and 0.85 between NW and LW. In the results of the same authors, phenotypic correlations was 0.86, 0.48 and 0.38 between TB and NBA, NW and LW, 0.59 and 0.51 between NBA, NW and LW, and 0.80 between NW and LW. In research *Radojković et al. (2005)*, genetic correlations between sow reproductive traits were in range from low

(0.230) to complete (1.197). *Hermesch et al. (2000)* reported estimates of genetic correlations between NBA and LW for the first, second and third parities were -0.14, -0.15, and -0.75, respectively. Genetic correlations between NBA, LW and NW have been reported *Chen et al. (2003)* that ranged from 0.10 to 0.15 between NBA and LW, 0.07 to 0.20 between NBA and NW, and 0.65 to 0.75 between NW and LW.

Table 3. Heritability (diagonal), genetic (below diagonal) and phenotypic correlations (above diagonal) for reproductive traits on first, second and third parity in a Landrace sows

Parity	Traits	TB	NBA	NW	LW
1	TB	**0.03 (0.01)**	0.91 (0.04)	0.63 (0.02)	0.02 (0.01)
	NBA	0.94 (0.06)	**0.04 (0.01)**	0.57 (0.02)	0.02 (0.01)
	NW	0.75 (0.04)	0.69 (0.03)	**0.08 (0.03)**	0.72 (0.01)
	LW	0.10 (0.03)	0.00 (0.03)	0.09 (0.03)	**0.09 (0.01)**
2	TB	**0.05 (0.02)**	0.94 (0.00)	0.58 (0.03)	-0.18 (0.03)
	NBA	0.99 (0.02)	**0.02 (0.01)**	0.60 (0.03)	0.01 (0.03)
	NW	0.64 (0.04)	0.61 (0.01)	**0.08 (0.02)**	0.10 (0.00)
	LW	-0.28 (0.01)	-0.04 (0.03)	0.16 (0.09)	**0.11 (0.04)**
3	TB	**0.18 (0.06)**	0.93 (0.00)	0.78 (0.03)	-0.60 (0.03)
	NBA	0.98 (0.01)	**0.17 (0.06)**	0.66 (0.03)	-0.84 (0.03)
	NW	0.82 (0.07)	0.77 (0.02)	**0.01 (0.02)**	-0.80 (0.01)
	LW	-0.83 (0.08)	-0.92 (0.06)	-0.84 (0.01)	**0.03 (0.01)**

TB - total piglets born, NBA - number of piglets born alive; NBW - number of piglets weaned; LW - litter weaning weight

Statistics of breeding values for each reproductive trait are presented in Table 4. Means of estimated breeding values of reproductive traits from first parity to third parity was indecreased. The breeding values for TB were -0.043, -0.029 and 0.011, for NBA were -0.044, -0.030 and 0.012, for NW were -0.046, -0.002 and 0.023 and for LW were -0.126, 0.206 and 0.404 for parities 1 to 3. Also, standard deviations of breeding values in later parities were larger than in the first parity.

Table 4. Statistics for breeding value estimates of reproductive traits on first, second and third parity in a Landrace sows

	First parity				Second parity				Third parity			
	TB	NBA	NW	LW	TB	NBA	NW	LW	TB	NBA	NW	LW
Mean	-0.043	-0.044	-0.046	-0.126	-0.029	-0.030	-0.002	0.206	0.011	0.012	0.023	0.404
SD	0.428	0.445	0.436	1.864	0.412	0.419	0.435	3.981	0.659	0.647	0.478	2.482
Max	0.997	0.995	0.999	6.476	0.996	0.988	1.164	16.123	2.177	1.961	0.992	7.200
Upper 1%	0.975	0.976	0.989	4.807	0.966	0.961	1.012	13.113	1.682	1.611	0.973	6.444
Upper 5%	0.874	0.882	0.920	3.845	0.826	0.848	0.878	9.984	1.292	1.276	0.901	5.245
Upper 10%	0.777	0.795	0.830	3.282	0.697	0.724	0.779	8.321	1.124	1.113	0.817	4.506
Upper 25%	0.576	0.606	0.587	2.343	0.487	0.418	0.561	5.495	0.840	0.825	0.591	3.224
Median	-0.126	-0.119	-0.126	-0.297	-0.120	-0.112	-0.111	-0.192	0.115	0.109	0.112	0.151
Lower 25%	-0.505	-0.527	-0.510	-2.414	-0.539	-0.561	-0.534	-4.328	-0.830	-0.813	-0.644	-3.073
Lower 10%	-0.741	-0.750	-0.749	-3.169	-0.755	-0.807	-0.732	-5.980	-1.098	-1.098	-0.865	-4.235
Lower 5%	-0.864	-0.865	-0.866	-3.625	-0.876	-0.897	-0.834	-7.164	-1.259	-1.261	-0.933	-4.956
Lower 1%	-0.977	-0.975	-0.973	-4.303	-0.957	-0.979	-0.957	-9.594	-1.602	-1.589	-0.987	-6.074
Min	-0.996	-0.998	-0.998	-4.877	-0.993	-0.996	-0.999	-11.418	-1.739	-1.779	-0.998	-6.736

Conclusions

Sow reproductive traits had the low heritability in the first three parity (0.03, 0.05 and 0.18 for TB, 0.04, 0.02 and 0.17 for NBA, 0.08 and 0.01 for NW and 0.09, 0.11 and 0.03 for LW) and response to selection may therefore be slow. Since sows reproductive traits are lowly heritable, genetic selection may not always yield substantial additive gains. However, because of their economic importance an attempt should always be made to keep these traits at their optimum levels.

Acknowledgments

Research was financially supported by the Ministry of Science and Technological Development, Republic of Serbia, with in the project TR 31032.

Ocena genetskih parametara i oplemenjivačke vrednosti veličine legla u prva tri pariteta landras krmača

Dragomir Lukač, Vitomir Vidović, Teodora Vasiljević, Oliver Stanković

Rezime

Cilj ovog istraživanja je bio da se ocene genetski parametari i oplemenjivačka vrednost reproduktivnih osobina Landras krmača u prva tri pariteta

Animal modelom. U radu je analizirano 2238 prvih pariteta, 2125 drugih pariteta i 1872 trećih pariteta landras krmača oprasenih između 2007. i 2012. godine. Analizirane osobine su bile ukupan broj rođene prasadi (TB), broj živorođene (NBA) i zalučene (NW) prasadi i masa legla na zalučenju (LW). Genetski parametri su ocenjeni multivarijantnim Animal modelom upotrebom REML procedure. Ocenjene heritabilnosti za TB su bile 0,03, 0,05 i 0,18, za NBA 0,04, 0,02 i 0,17, za NW 0,08, 0,08 i 0,01 i za LW 0,09, 0,11 i 0,03 od 1 do 3 pariteta. Genetske varijanse za TB, NBA, NW i LW u prvom paritetu su bile od 0,24, 0,25, 0,13 i 13,02 i povećavale su se do trećeg pariteta do 1,28, 1,20, 0,98 i 19,08. Između većine ispitivanih reproduktivnih osobina su zabeležene pozitivne genetske i fenotipske korelacije, osim između LW i drugih osobina, gde su zabeležene negativno jake korelacije u trećem paritetu. Procenjene oplemenjivačke vrednosti reproduktivnih osobina su se povećavale od prvog do trećeg pariteta.

References

CHEN P., BAAS T.J., MABRY J.W., KOEHLER K.J., DEKKERS J.C.M. (2003): Genetic parameters and trends for litter traits in U.S. Yorkshire, Duroc, Hampshire, and Landrace pigs. Journal of Animal Science, 81, 46–53.

DUBE B., SENDEROS D., MULUGETA D., DZAMA K. (2012): Estimation of genetic and phenotypic parameters for sow productivity traits in South African Large White pigs. South African Journal of Animal Science, 42, 389-397.

HAMANN H., STEINHEUER R., DISTL O. (2004): Estimation of genetic parameters for litter size as a sow and boar trait in German herdbook Landrace and Pietrain swine. Livestock Production Science, 85, 201–207.

HANENBERG E.H.A.T., KNOL E.F., MERKS J.W.M. (2001): Estimates of genetic parameters for reproduction traits at different parities in Dutch Landrace pigs. Livestock Production Science, 69, 179-186.

HERMESCH S., LUXFORD B.G., GRASER H.U. (2000): Genetic parameters for lean meat yield, meat quality, reproduction and feed efficiency traits for Australian pigs 3. Genetic parameters for reproduction traits and genetic correlations with production, carcass and meat quality traits. Livestock Production Science, 65, 261-270.

MEYER K. (2007): wombat - A tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). Journal of Zhejiang University Science B., 8, 815-821.

KIM H.J. (2001): Genetic parameters for productive and reproductive traits of sows in multiplier farms. Ph.D. thesis, Georg-August- University of Gottingen, Gottingen, Germany.

PAURA L., JONKUS D., PERMANICKIS U. (2014): Genetic parameters and genetic gain for the reproduction traits in Latvian Landrace and Yorkshire sows populations. Animal and Veterinary Sciences, 2: 184-188.
POPOVAC M., RADOJKOVIĆ D., PETROVIĆ M., MIJATOVIĆ M., GOGIĆ M., STANOJEVIĆ D., STANIŠIĆ N. (2012): Heritability and connections of sow fertility traits. Biotechnology in Animal Husbandry, 28 (3), 469-475.
RADOJKOVIĆ D., PETROVIĆ M., MIJATOVIĆ M., RADOVIĆ I. (2005): Fenotipska i genetska povezanost osobina plodnosti plotkinja švedskog landrasa. Biotechnology in Animal Husbandry, 21 (3-4), 79-88.
RADOJKOVIĆ D., PETROVIĆ M., RADOVIĆ Č., PARUNOVIĆ N., POPOVAC M., GOGIĆ M. (2012): Heritability and correlation of litter traits in pigs determined by REML method. Biotechnology in Animal Husbandry, 28 (4), 771-778.
RADOJKOVIĆ D., PETROVIĆ M., MIJATOVIĆ M., RADOVIĆ Č., POPOVAC M. (2011): The effect of scope of analyzed data on the value of the heritability coefficient of litter size traits in pigs. Biotechnology inAnimal Husbandry, 27 (3), 777-783.
ROEHE R., SHRESTHA N.P., MEKKAWYA W., BAXTER E.M., KNAP P.W., SMURTHWAITE K.M., JARVIS S., LAWRENCE A.B., EDWARDS S.A. (2009): Genetic analyses of piglet survival and individual birth weight on first generation data of a selection experiment for piglet survival under outdoor conditions. Livestock Science, 121, 173-181.
RYDHMER L. (2000): Genetics of sow reproduction, including puberty, oestrus, pregnancy, farrowing and lactation. Livestock Production Science, 66, 1-12.
OH S.H., LEE D.H., SEE M.T. (2006): Estimation of Genetic Parameters for Reproductive Traits between First and Later Parities in Pig. Asian-Australasian Journal of Animal Sciences, 19, 7-12.
STATSOFT INC. (2013). Statistica (data analysis software system), version 12. www.statsoft.com
ZIEDINA L., JONKUS D., PAURA L. (2011): Genetic and Phenotypic Parameters for Reproduction Traits of Landrace Sows in Latvia. Agriculturae Conspectus Scientificus, 76, 219-222.

Received 20 April 2016; accepted for publication 7 June 2016