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Parameters of genetic and phenotypic type in pigs mating in pure breed and crossbreeding on litter size

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The aim of this experiment is to investigate the effect of crossbreeding pure breeds on reproductive traits and the effective costs in pigs. The study was conducted on 21,431 records concerning the reproductive traits of 4 pure breeds Large Yorkshire (LY), Swedish Landrace (SL), Duroc (D), and Hampshire (H) and their reciprocal F_1 crosses. Data processing method was by the least squares for testing in animal. The improvement of reproductive traits by crossing pure breeds was shown in the results. The improvements were more pronounced in the Three ways crossing and Back way crossing. By using the crossing breeds, the number of live births and weaned piglets increased while the number of stillborn piglets decreased compared to pure breeds. It can be seen that, there are differences in terms of fertility between pure breeds which can be successfully used by crossing selected (specialized) or breed lines. Heterosis effect was manifested in reproductive traits, depending on the choice of crossing scheme involving one of 3 types of heterosis and breed selection for cross.

Key words: Pigs, sows, litter size, heterosis.

INTRODUCTION

There is a way to reduce the production cost of pigs by increasing the number of pollinated piglets per sow per year. By selection in a pure breed or crossing either there can be a genetic improvement of quantitative (productive) characteristics of pigs. Therefore, it should be noted that, the selection and crossing (as mating system) are not alternative. Crossing is the fastest way to increase the number of piglets per litter. Crossing is known as a procedure originally used to combine the desired properties of two or morebreeds or lines of pigs and it is used to take advantage of heterosis effect. Intersection of different genetic constitution of the pig was applied to benefit the breeding process, to modify the genetic structure of populations, to exploit one of 3 types of heterosis.

Heterosis is highest for low heritability traits, such as litter size in pigs where genetic effects share of 5 to 25% (Gordon, 1997) depending on the genetic differences between breeds used in crossbreeding. Goldek (1969) was the one who summarized the results of many experiments and came to a conclusion that the heterosis effect in F_1 or F_1 generation of feedback compared to pure breed was higher by 5% in the number of new born piglets, 5 to 10% in the number of piglets educational and the mortality to weaning is reduced by 10 to 15%.

It can be noted that, in the last decade in pig farms in Serbia, crossing between the breeds has become an important feature and integral aspect of current breeding programs. There are significant differences between the same crossing schemes, involving different breed, defined by different types of heterosis in quantitative traits. It is the usual practice that, pigs on the farm population

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Table 1. The number of records in pure breeds and cross breeds.

Boar	Sows				
	Yorkshire	Landrace	F1(Yorkshire × Landrace)	F1(Landrace × Yorkshire)	Total
Yorkshire (LY)	804	2753	821	437	4815
Landrace (SL)	467	5161	1786	506	7920
Duroc (D)	25	96	4445	1579	6145
Hampshire (H)	8	65	1740	738	2551

consist of two or more breed, and so they created a certain preconditions that contribute to the intersection with the selection of genetic improvement of quantitative traits that reduce costs production.

In order to utilize heterosis effect in crossbred sows and increase in the efficiency of the crossing, one has to go to the breeding sows crossbred F_1 generation with boars that have already been used (Back way crossing) or with a third breed boars (Vidović et al., 2011a; 2012). During the crossing programs, Large Yorkshire (LY) and Swedish Landrace (SL) were used as basic breed because of the good maternal and reproductive characteristics and solid constitution. Better results were seen in the combination of these two breeds for sow fertility status compared to other racial combinations.

Therefore, the aim of this study was to evaluate the effect of crossbreeding pure breeds on reproductive traits in pigs.

MATERIALS AND METHODS

The process of evaluating the effect of crossing between breeds, and the effect of various crossing schemes were carried out on 21431 records in the period from 2000 to 2008 year. The total number of records (reproductive traits) in pure breeds and crossbreeding is shown in Table 1. Animals were fed with standard diets by categories and breed requirement of animals. The animals were kept in production conditions. Mating did not occur until relationship. Artificial insemination was applied for sows insemination. As the basic source of data for certain crossing combinations data from the population register (insert farms) were used. Data of four pure breeds LY, SL, Duroc (D), and (H) ampshire H and F1 sows from reciprocal crossing Large LY and SL were used and analyzed.

Record that was analyzed was in total of 21431 in this study of which 5965 record was obtained from pure breed, 3414 record was obtained from Two ways crossing, 12052 record was obtained from the combinations of Three way crossing, where crossed. The results of sows farrowing toparity 13 were used. Higher parity sows, over 13, were not included in the results. Data of boars that have a minimum of 200 L were used. In this study, the most important reproductive traits of sows: the number of live born piglets, stillborn piglets, litter size and weaning of piglets were examined. The data presented are live born, stillborn, litter size and weaned piglets in addition to number of parity. Data are presented as an average ± standard deviation. Differences between average values were determined by ANOVA followed by comparisons using multifactorial ANOVA. Differences with $P < 0.01$ or $P < 0.05$ were considered significant. The following Mixed Model Equation (MME) used the following model:

$$Y_{ijkl} = \mu + V_i + P_j + R_k + e_{ijkl}$$

Where Y = phenotipic value of observed traits, μ = general mean value, V_i = fixed effect of the calving year, season, P_j = effect farrowing in a row, R_k = effect combination breeding, e_{ijkl} = other uncontrollable effects (random error). Statistical analysis was done using the software statistica 12.

RESULTS AND DISCUSION

The results show that, the present mean values for reproductive traits in the whole population, live born, stillborn; litter size and weaned piglets in addition to number of parity pure breed and crossing breed are shown in Tables 2 to 5, and in Figure 1.

In the period in which the examination took place, the average number of stillborn piglets at the level of the entire population is smaller than the results obtained by Hanenberg et al. (1999) (0.85), Merks (2003) (0.81), Lend and Rens (2003) (0.84), and more of the results was obtained by Kosovac et al. (2005) (0.43). The causes that were the most common for the increased number of stillborn piglets prematurely end the cord, before separation of the placenta from the uterus, preventing blood flow to the fetus during uterine contractions, the duration of gestation was less than 112 and more than 116 days (Swine Repronet, 2003), then, sow condition, use of oxytocin during farrowing, the use of vaginal palpation, the appearance of mummified fetuses, increased weight of piglets at birth (Lucia et al., 2002; Quiniou et al., 2002).

According to Gordon (2003), to achieve good production results at the farm, the number of stillborn piglets should be about 5%, while increasing to 8%, a serious problem. Thus, it can be noted that, English association of pig farmers suggests that, the number of stillborn piglets should not exceed 7%, and that over 10% is discarded in production (Swine production management UK, 2003). The average number of piglets born alive during this period amounted to 9.57, which is lower than the results obtained by Vincek (2005) (9.81), Kosovac et al. (2005) (10.28).

Data show that, the average number of weaning piglets is low, and on average is 8.33, which is almost comparable to the results obtained by Kosovac et al. (2005) (8.36).

Table 2. Mean values for reproductive traits in the whole population.

Trait	$\overline{X}$	SD
Number live born	9.57	2.92
Number stillborn	0.61	1.19
Litter size	10.19	2.91
Number weaning piglets	8.33	4.26

Table 3. Average values and standard deviations of reproductive traits in pure breeds and crossbreeding.

Crossing	Breed sows	Breed boar	Litter size	Live born	Stillborn	Weaned
Pure breed	Yorkshire	Yorkshire	9.71 ± 2.71	9.07 ± 2.71	0.64 ±1.17	8.20 ± 4.21
	Landrace	Landrace	10.11 ± .98	9.40 ± 3.03	0.71 ± 1.35	7.71± 4.38
Whole average of pure breed			10.07 ± 2.95	9.36 ± 3.00	0.70 ±1.33	7.78 ± 4.36
Two way crossing	Yorkshire	Duroc	9.64 ± 3.12	9.4 ± 3.09	0.24 ± 0.59	7.76 ± 3.65
	Yorkshire	Hampshire	9.74 ± 2.49	9.12 ± 3.13	0.62 ± 1.06	7.75 ± 3.37
	Yorkshire	Landrace	9.63 ± 2.75	8.98 ± 2.70	0.65 ± 1.30	8.19 ± 3.62
	Landrace	Duroc	9.57 ± 3.12	9.10 ± 3.13	0.46 ± 0.67	7.60 ± 4.24
	Landrace	Hampshire	10.8 6 ± 2.41	10.26 ± 2.27	0.60 ± 0.89	8.52 ± 3.50
	Landrace	Yorkshire	10.3 8 ± 2.93	9.68 ± 2.91	0.70 ± 1.26	8.69 ± 4.36
Whole average of Two way crossing			10.26 ± 2.96	9.58 ± 2.90	0.68 ± 1.25	8.54 ± 4.24
Three way crossing	F1 (Y x L)	Duroc	10.32 ± 2.92	9.80 ± 2.93	0.52 ± 1.05	8.51 ± 4.29
	F1 (Y x L)	Hampshire	10.01 ± 2.76	9.58 ± 2.71	0.43 ± 0.91	8.59 ± 3.52
	F1 (L x Y)	Duroc	10.27 ± 2.93	9.74 ± 2.91	0.52 ± 1.11	8.58 ± 4.33
	F1 (L x Y)	Hampshire	10.09 ± 2.77	9.68 ± 2.66	0.41 ± 0.83	8.61 ± 3.43
Whole average of Three way crossing			10.23 ± 2.28	9.73 ± 2.86	0.49 ± 1.02	8.55 ± 4.08
Back way crossing	F1 (Y x L)	Yorkshire	10.22 ± 2.84	9.61 ± 2.81	0.61 ± 1.18	8.82 ± 4.45
	F1 (Y x L)	Landrace	10.26 ± 2.96	9.57 ± 2.99	0.69 ± 1.25	8.28 ± 4.30
	F1 (L x Y)	Yorkshire	10.12 ± 2.82	9.51 ± 2.84	0.61 ± 1.13	8.59 ± 4.53
	F1 (L x Y)	Landrace	10.11 ± 3.03	9.43 ± 3.14	0.68 ± 1.32	8.63 ± 4.82
Whole avarage of Back way crossing			10.21 ± 2.92	9.55 ± 2.96	0.66 ± 2.92	8.49 ± 4.44
Whole avarage of population			10.19 ± 2.91	9.57 ± 2.92	0.61 ± 1.19	8.33 ± 4.06

Short lactation certainly affects the reduction of weaning piglets, but it shortens the reproductive cycle, and increases the number of litters per sow per year. In this regard, Almond (2002) pointed out that, the shortening of lactation had negative effects on the reproductive parameters, while Pettigrew (1998) provided the economical benefits over the negative impact that, it achievesits shortening.

The impact of pure breed, Two way crossing, Three way crossing and Back way crossing can be seen in Table 3. Results led to indication that there was improvement of reproductive traits by crossings. Results in Table 3 indicated the improvement of reproductive traits by crossing. The average number of piglets born alive was the highest in Three way crossing and Back way crossing (9.7 and 9.53), while the lowest on Two way crossing and pure breeds (9.43 and 9.23). By using crosses F_1 generation reproduction, maternal heterosis for litter size at farrowing increased by 0.6 to 0.7 pigs compared to pure breed (Stella et al., 2003; Vidović et al., 2012).

In this study, there was an increase in the number of piglets born alive with reduction in the number of stillborn piglets upon crossing. Škorput et al. (2009) found no differences in litter size between sows crossbred F_1 generation, and significant differences ($P < 0.05$) were

Table 4. Influence of fathers, breed, year, season and parity on reproductive traits of sows.

Sources of variability	Number of piglets born alive		
	D.F	M.S	F
Fathers	50	33.77	4.24*
Breed	3	79.40	9.98**
Year	8	87.20	10.96**
Seson	3	92.10	11.57**
Parity	12	683.92	85.96**
Number stillborn piglets			
Fathers	50	2.66	1.95*
Breed	3	3.12	2.29*
Year	8	56.09	41.14**
Seson	3	16.75	12.29**
Parity	12	16.72	12.26**
Litter size			
Fathers	50	32.49	4.13*
Breed	3	57.19	7.27**
Year	8	173.12	22.03**
Seson	3	147.02	18.71**
Parity	12	563.61	71.72**
Number weaned piglets			
Fathers	50	39.66	2.32*
Breed	3	308.20	18.03**
Year	8	188.67	11.04**
Seson	3	97.35	5.69**
Parity	12	1425.38	83.41**

* - P<0.05; ** - P<0.01.

Table 5. Heritability (on the diagonal, bold), genetic (above diagonal) and phenotypic (below diagonal) correlations between certain traits.

Trait	Live born	Stillborn	Litter size	Weaned
Live born	***0.10***	0.21	0.97	0.08
Stillborn	0.22	***0.01***	0.01	0.13
Litter size	0.91	0.08	***0.11***	0.11
Weaned	0.19	0.10	0.03	***0.11***

found between sow pure breed and crossing. Because the litter size characteristic of low heritability, in breeding and selection using crossing breed lines and heterosis effect is exploited to increase this trait (Kaufmann et al., 2000; Stella et al., 2003; Chen et al., 2003; Ehlers et al., 2005). Vidović et al. (2011a,b) found that, the litter size at birth in F_1 sows higher than in the Landrace sows peers, as is the case in this study.

It can be clearly seen that, from the results there is a heterosis effect for Three way crossing combinations of breeding. The sole appearance of heterosis in the Three way crossing and Two way crossing confirmed the presence of performance in no additive genes in the inheritance of reproductive traits of pigs. The combination of Two ways crossing, Three ways crossing and Back way crossing significantly improved fertility in relation to crossing pure bred. It may be noted that, the combination of different schemes crossing, a highly significant (P<0.01) affected the reproductive traits studied. Kosovac et al. (2005) in their work stated that, according to genotype and sows farrow in a row, a highly significant (P < 0.01) affect reproductive traits. Influence of fathers, breed (mating combinations), year, season and parity of sows on reproductive traits is shown in

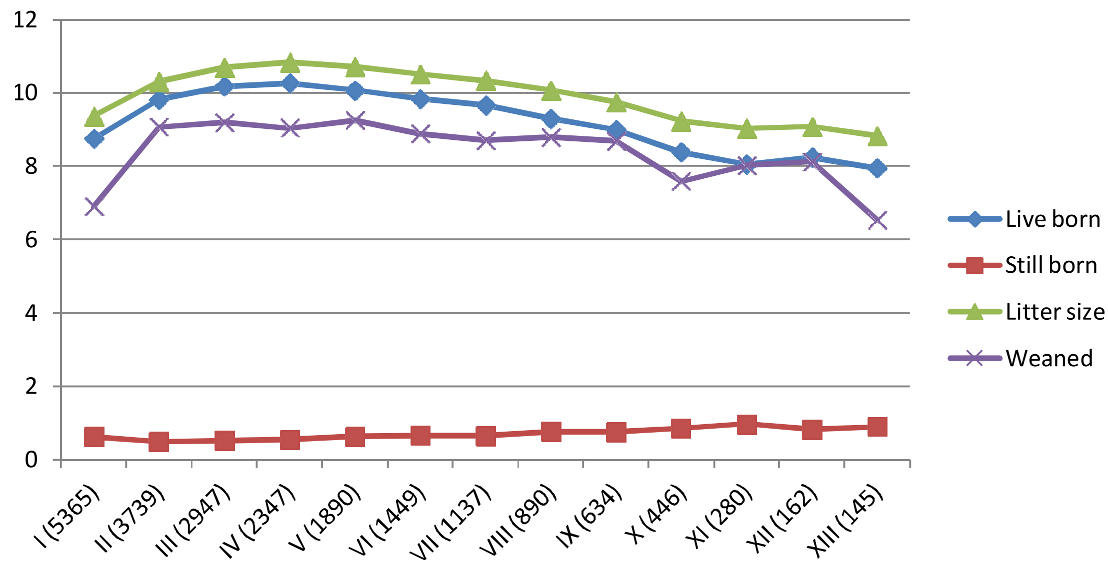

Figure 1. Effect of parity on reproductive traits.

Table 4.

Table 5 presents the results of genetic and phenotypic correlations between individual and reproductive traits. From the data in Table 5, we can see that, the genetic and phenotypic correlation between the traits is great and highly statistically significant (P<0.01). The results are in agreement with most researchers (Choi et al., 1995; Chen et al., 2001, 2003; Vidović et al., 2011a,b)

Figure 1 is used to present the effect of parity on reproductive traits. From data in the figure, it is clearly evident that, the number of piglets born alive is gradually increased till the fourth farrowing, and then gradually decreased till thirteen farrowing. Increasing the number of piglets born alive compared to the first litter was 10.89% in the second, 14.04% in the third, 14.80% in the fourth, 13.10% in the fifth, and 11.07% in sixth. Bartram (1926) was the one who pointed out to the increase in litter size in the next monitoring and according to his observations; the maximum is achieved somewhere in the sixth consecutive farrowing. Also Vincek (2005) and Tummaruk et al., (2000) found out that, the number of piglets born alive increased to the fifth farrowing, and then slightly decreased in all genotypes. It is evident that, the number of stillborn piglets from the second parity increases linearly until the 11^{th} farrowing which is consistent with the results of a Leenhouwers et al. (1999) which stated that, the number of stillborn piglets increases from the second to the fifth parity. With increasing parity, number of stillborn piglets increased per litter (Swine Repronet, 2003).

If we consider the parity structure that represents one of the factors of high production in Figure 1, we see that, there is a high percentage of first farrowing sows and another parity (25 or 17.44%), which from an economic point of view is very high and causing a high price production of piglets, which leads to the so called "syndrome of the second farrowing" (Lantz, 1998).

Gadd (2000), stated that, effective herd, from the standpoint of obtaining sufficient numbers of piglets and the provision of cheap materials they fattening, where the percentage of first farrowing in the overall structure of the parity does not exceed 18%.

For successful production of piglets it can be said that, it is also important to sow the age structure of the farm. The preferred age structure of sows (herd) when sowed (Senčić et al., 1996) with 3 to 6 L accounted for 50% herd first farrowing and two farrowing 35% herd, and when sowed with 7 L or more 15% of the herd was accounted for. Of course, this ratio refers to the assumption of a herd on a farm at the time of production.

Conclusion

On the basis of the results obtained in this study, we can see the improvement of reproductive traits by crossing breeds. By crossing breeds, litter size increased by 0.16 piglets, while the number of stillborn piglets decreased by 0.09 piglets compared to the pure race breeding. Differences that occurred in fertility between the pure breed can be successfully used by crossing selected (specialized) or bred lines. Heterosis effect was manifested in reproductive traits, depending on the choice of crossing scheme involving one of three types of heterosis and breed selection for crossing. The number of piglets stillborn is gradually growing to the fifth (10.07), sixth farrowing (9.84), after which there is a point of gradual reduction in the number of piglets born alive (8.65) with increasing parity sows. In parallel with increasing fertility of sows, number of stillborn piglets shows tendency to increase in successive farrowing. At the statistical significance, there is the influence of breed, age, season and parity on the number of lives born, litter size, and the weaning of piglets. Mark genetic and phenotypic correlations for fertility traits of sows were positive, high and statistically highly significant.

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