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Reproductive traits in relation to crossbreeding in pigs

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The aim of this study was to evaluate the effect of crossbreeding pure breeds on reproductive traits in pigs. The study was conducted on 2,431 record concerning reproductive traits of four 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 adapted and introduced Harvey (1990). The results indicated improvement of reproductive traits by crossing pure breeds. The improvements were more pronounced in three way crossing and back way crossing. By crossing breeds, the number of live births and weaned pigs increased while the number of still born piglets decreased compared to pure breeds. Differences in terms of fertility between pure breeds can be successfully used by crossing selected (specialized) or race 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 cross.

Key words: Pigs, litter size, crossing, heterosis effect.

INTRODUCTION

The production cost of pigs can be reduced by increasing the number of pollinated piglets per sow per year. Therefore, a fundamental prerequisite for good fertility economical is needed. Genetic improvement of quantitative (reproductive) characteristics of pigs can be achieved either by selection in a pure breed or crossing (Vidović, 2009). Crossing is the fastest way to increase the number of piglets per litter. Crossing as a procedure originally used to combine the desired properties of two or more breeds or lines of pigs and 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 three types of heterosis. Past research has shown that reproductive traits generally have low heritabilities (Kaufmann et al., 2000; Chen et al., 2003; Stella et al., 2003; Ehlers et al., 2005; Vidović and Lukač, 2010).

However, the primary maternal pure breeds of swine in the USA (yorkshire and landrace) have shown genetic progress in reproductive traits (See et al., 2000; Stalder et al., 2000). 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) summarized the results of many experiments and concluded 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 reduced by 10 to 15%. Brun and Saleil (1994) have estimated heterosis of 15.2, 20.1 and 6.7 for the traits total litter size, born alive and number of weaned young. Nofal et al. (1996) give values of 12.5, 10.0 and

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

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

5.5% of heterosis for the same traits.

In the last decade in our pig farms, crossing between the breeds has become an important feature and integral aspect of current breeding programs. Significant differences between the same crossing scheme, involving different breed, are defined by different types of heterosis in quantitative traits (Vidović and Lukač, 2010).

Usually, pigs on the farm population 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 the efficiency of the crossing, 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, 2009). During the crossing programs, large yorkshire (LY) and swedish landrace (SL) were used as basic race because of good maternal and reproductive characteristics and solid constitution. The combination of these two breeds is getting better 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. The results are important in to increase the number of piglets per litter and to increase the final product -fattening or breeding.

MATERIALS AND METHODS

Evaluation 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. The total number of records (reproductive traits) in pure breeds and crossbreeding is shown in Table 1. Animal feeding was standard diets by categories of animals. The animals were kept in production conditions. Mating didn't occur until relationship. Artificial insemination was applied for sows insemination.

The basic source of data for certain crossing combinations were from the population register (insert farms). Data of four pure breeds (large yorkshire (LY), swedish landrace (SL), duroc (D) and hampshire (H) and F1 sows from reciprocal crossing Large yorkshire and Swedish landrace were used and analyzed. A total of 21431 record were analyzed in this study of which 5965 record obtained from pure breed, 3414 record obtained from two way crossing, 8502 record obtained from three way crossing and 3550 record obtained from back way crossing. The results of sows farrowing to parity 13 were used. Higher parity sows (> 13) were not included in the results. Data of boars that have a minimum of 200 litters were used. In this study, the most important reproductive traits of sows: the number of live born piglets, still born piglets, litter size and weaning of piglets were evaluated.

The evaluated data were live born, still born, litter size and weaned piglets in relation to breed, crossings and number of parity. Data are presented as an average ± standard deviation. Differences between average values were determined by ANOVA followed by comparisons using miltifactorial ANOVA. Differences with $P < 0.01$ or $P < 0.05$ were considered significant. For extraction and clarification given to the impact of system was implemented by the method of Least squares for testing in animal adapted and introduced Harvey (1990). The model used is

$$Yijkl = \mu + Vi + Pj + Rk + eijkl$$

where is:Y= phenotipic value of observed traits; μ = general mean value; Vi = fixed effect of the calving year, season; Pj =effect farrowing in a row; Rk = effect combination breeding; eijkl = other uncontrollable effects (random error).

Statistical analysis was done using the software STATISTICAL 9.

RESULTS

The evaluated data of live born, still born, litter size and weaned piglets in relation to breed, crossings and number of parity are shown in Tables 2 to 5. In Table 2 can clearly see the improvement of reproductive traits by crossing breeds. The average number of piglets born alive was the highest in three way crossing and back way crossing (9.7 or 9.53), while the lowest in the breeding of pure breed and two way crossing (9.23 and 9.42). Two ways crossing in our research have increased the number of piglets born alive with some reduction in the number of stillborn piglets. From the results shows that there is a heterosis effect in three way crossing. The occurrence of heterosis in two way crossing or three way crossing confirmed the presence of non-additive gene effect in inheritance of reproductive traits of swine. The combination of two ways crossing and three ways crossing significantly improved fertility in relation to breeding in the pure breed and back way crossing.

Influence of fathers, breed (mating combinations), year, season and parity of sows on reproductive traits is shown in Table 3. The influence breeds, year, the season and parity on the number of piglets born alive, total born

Table 2. Average values and standard deviations of reproductive traits in pure breeds and crossings.

Crossing	Breed sows	Breed boar	Litter size	Live born	Still born	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 ± 2.98	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	10.86 ± 2.41	10.26 ± 2.27	0.60 ± 0.89	8.52 ± 3.50
	Landrace	Yorkshire	10.38 ± 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 average of back way crossing			10.21 ± 2.92	9.55 ± 2.96	0.66 ± 2.92	8.49 ± 4.44
Whole average of population			10.19 ± 2.91	9.57 ± 2.92	0.61 ± 1.19	8.33 ± 4.06

piglets and weaned pigs was statistically highly significant, while the influence of fathers was significant. The effect of year, season and parity on the number of stillborn piglets was statistically highly significant, while the influence breeds and fathers was significant.

From data in table, 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% sixth. From data in Table 5 we can see that the genetic and phenotypic correlation between the traits great and highly statistically significant.

DISCUSSION

In the examined period, the average number of stillborn piglets at the level of the entire population is smaller than the results obtained by Merks (2003) (0.81); Hanenberg et al. (2001) (0.85), and more of the results obtained Kosovac et al. (2005) (0.43). Throughout the world, between 0.9 and 1.2 piglets per litter are delivered stillborn (Bedrijfsvergelijking Siva-produkten, 1999; Pig CHAMP Breeding Herd Summary U.S.A., 2000). There is a small but significant genetic influence on stillbirth (Hanenberg et al., 2001; Knol et al., 2002). Maternal genetic and direct genetic effects influence the occurrence of stillbirth (Knol et al., 2002), indicating that genes of both the sow and the piglets are involved. Genetic selection against the number of stillborn piglets per litter is possible because considerable genetic variation exists for this trait (Hanenberg et al., 2001; Knol et al., 2002). Knol et al. (2002) performed a genetic analysis of the number of stillborn piglets per litter using a model that included direct genetic and maternal genetic effects.

They found a significant influence of both effects, indicating a role for both genes of the piglet and genes of the sow in the occurrence of stillbirth. 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. So English association of pig farmers suggests that the number of stillborn piglets should not exceed 7%, and that over 10% is discarded in production (Swinw 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),

Table 3. Influence of fathers, breed, year, season and parity on reproductive traits of sows.

Sources of variability	D.F	M.S	F
Number of piglets born alive			
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**

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

Kosovac et al. (2005) (10.28) and Luković et al. (2006) (9.91). 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) 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 achieves its shortening.

The impact of pure breed, two ways crossing, three ways crossing and back way crossing is presented in Table 2. Results indicated improvement of reproductive traits by crossings. The average number of litter size was the highest in two way crossing, three way crossing and back way crossing (10.26, 10.23 and 10.21), while the lowest on pure breeds (10.07). Using crosses F1 generation reproduction, maternal heterosis for litter size at farrowing increased by 0.6 to 0.7 pigs compared to pure breed (Rothschild and Bidanel, 1998). 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 F1 generation, and significant differences were found between sow pure breed and crossing.

Because the litter size characteristic of low heritability (Chen et al., 2003: Stella et al., 2003; Vidović and Lukač, 2010), in breeding and selection using crossing breed lines and heterosis effect is exploited to increase this trait. Vidović et al. (2004, 2011a, b) found that the litter size at birth in F1 sows higher than in the Landrace sows peers, as is the case in this study. It clearly evident from the results that there is a heterosis effect for three way crossing combinations of breeding as indicated by Veljić et al. (1997), Škorput et al. (2009); Tretinjak et al. (2009). The appearance of heterosis in the three ways crossing and two ways crossing confirmed the presence of performance no additive genes in the inheritance of reproductive traits of pigs.

From data in Table 4 is clearly evident that the number of piglets born alive is gradually increased till the fourth farrowing, and then gradually decreased till thirteen farrowing. Bartram (1926) 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), Knox (2005), See (2007), Tretinjak et al. (2009), Bobček et al. (2004), Lucia et al. (2002) Tummaruk et al. (2000) found that the number of piglets born alive increased to the fifth farrowing, and then slightly decreased in all genotypes. Number of stillborn piglets from the second parity increases nearly until the 11th farrowing which is consistent with the results of a Leenhouwers et al. (1999), Knox (2005), See (2007) which stated that the number of stillborn piglets increased from the second to the fifth parity. With increasing parity, number of stillborn piglets increased per litter (Swinw, 2003).

If we consider the parity structure that represents one of the factors of high production in Table 4., 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 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 is also important to sow the age structure of the farm. According to Vidović (2011). preferred structure of the population parity sows it, when the zero-parity sows have 20%, the first 18%, other 15%,

Table 4. shows mean values for fertility traits of sows farrowing to the thirteenth studied populations.

Parity	Number litter	Live born		Still born		Litter size		Weaned	
		$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ
I	5365	8.75	2.89	0.62	1.24	9.37	2.85	6.90	3.44
II	3739	9.82	2.85	0.49	1.11	10.31	2.88	9.07	4.07
III	2947	10.18	2.88	0.52	1.15	10.70	2.91	9.20	4.49
IV	2347	10.27	2.77	0.55	1.06	10.83	2.81	9.04	4.53
V	1890	10.07	2.84	0.63	1.09	10.71	2.92	9.26	4.46
VI	1449	9.84	2.82	0.66	1.14	10.51	2.82	8.89	4.46
VII	1137	9.67	2.74	0.65	1.17	10.33	2.73	8.71	4.13
VIII	890	9.30	2.90	0.76	1.36	10.07	2.93	8.79	4.45
IX	634	9.00	2.89	0.75	1.32	9.75	2.84	8.69	4.25
X	446	8.38	3.06	0.85	1.44	9.23	3.01	7.59	4.44
XI	280	8.05	2.94	0.97	1.51	9.03	2.68	8.02	4.41
XII	162	8.25	2.80	0.82	1.29	9.08	2.59	8.12	4.75
>XIII	145	7.94	2.79	0.89	1.33	8.83	2.80	6.53	4.85

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

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

14% of third, fourth 12%, 10% of the fifth, sixth, and 6% over seven 7%. A similar structure of proposed parity Tretinjak et al. (2009), Chen et al. (2003), Lucia et al. (2002), Hue et al. (1993).

Heritability, genetic and phenotypic correlations (Table 5) are in agreement with most researchers (Choi et al., 1995; Vidović et al., 2011a, b; Kaufmann et al., 2000; Chen et al., 2003; Stella et al., 2003; Vidović and Lukač, 2010).

Conclusion

Based on 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 breed breeding.

Differences 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 gradually grows to the fifth (10.07), sixth farrowing (9.84), after which there is a 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. The influence of breed, age, season and parity on the number of lives born and litter size, and the weaning of piglets is statistically significant. Mark genetic and phenotypic correlations for fertility traits of sows were positive, high and statistically very significant.

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