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PROLIFICACY OF OLD GENOTYPE LITHUANIAN WHITE SOWS IN SMALL CLOSED POPULATION

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The objective of this study was to examine the influence of generation, parity number and year on sow prolificacy in the nucleus herd of the closed population of old genotype Lithuanian White pigs. Data on farrowing and litter size (total born, born alive, including sex of piglets, stillborn) were available per parities for individual sows from 2000 to 2011. The piglets originated from 395 litters (104 dams and 28 sires) of five generations. The generation showed effects on the number of total born piglets, piglets born alive, including males (p<0.01) per litters and did not appear to affect the number of stillborn piglets. The parity showed overall effects on the numbers of total born and stillborn piglets (p<0.01). Least square means for these traits increased with increasing parity number and reached significant (p<0.05) increase in parity 5. The year of farrowing showed the overall effect on the numbers of total born (p<0.01), born alive (p<0.001), including their sex and stillborn piglets (p<0.05). The decline in the numbers of piglets born alive was observed from 2008. This study showed that breeding of old genotype Lithuanian White pigs in a small closed population over the first four generations had no clear negative influence on sow prolificacy.

Key words: generation, litter traits, parity, pigs

INTRODUCTION

During the recent years, there was a renewed interest in the genetic improvement of sow prolificacy. Litter size is a major component of the breeding goal in pig dam lines (Webb, 1994; Estany et al., 2002; Serenius et al., 2004; Quinton et al., 2006; Fix et al., 2010). Large litters of high-quality piglets from females that breed and rebreed at regular intervals with minimal involuntary culling provide the best opportunity for long-term viability and profitability (Moeller et al., 2004). Within each nucleus breeding line, a particular programme of selection is undertaken and the selection programme will not be the same for each of the lines and breeds having different end-users (Whittemore, 1998). The total genetic gain of sow prolificacy increase could be shared between a higher gain due to immigration and lower gain within–line selection (Bolet et al., 2001). Lithuanian White pig was the breed used for producing dam lines and F_1 females. However, a drastic decline in the numbers of Lithuanian White has occurred and the solution adopted by the Institute of Animal Science was to conserve the remaining of the original Lithuanian White pig breed in a closed herd. Nowadays this herd is the single herd of the old genotype Lithuanian White pigs and there is no possibility for immigration of purebred Lithuanian White pigs. Small breeding populations of different pig types with nucleus herd sizes of 50-250 sows named as Zoo need specific care for no selection objective to be pursued, but for maximum variation in the gene pool to be maintained (Whittemore, 1998). On the other hand, rare breeds face not only conservation challenges, but also represent development opportunities and both these goals need to be reconciled (Lauvie et al., 2011). Although familial selection leads to a lower rate of directional selection, in the long term, genetic load could be almost identical for both mass and familial selection for populations of up to 200 individuals. Therefore, familial selection could be proposed for use in management programs of such small populations ($N \leq 50$) since it increases genetic variability and short-term viability without impairing the overall persistence times (Theodorou and Couvet, 2003).

The objective of this study was to examine the reproductive performance on the sow level and to analyse the influence of factors like generation, parity number and year in the nucleus herd of closed old genotype Lithuanian White population.

MATERIALS AND METHODS

Experimental design

The experiment took place in the established herd for the conservation of the critical old genotype Lithuanian White pig at the Institute of Animal Science of Lithuanian University of Health Sciences. With the aim to minimize the increasing kinship in the closed herd, four disconnected pedigree pig groups were collected for founder generation, and on the basis of experience in the Lithuanian pig breeding system a special circular breeding scheme was established as prepared by Šveistys (1967; 1982). The progeny of the founder generation, or the animals of the first generation in one group, were mated with the progeny of the founder generation from another non-related group. After the progeny of the new generation was available, their mating with the progeny from the third group of the first generation was carried out in order to obtain the second generation, etc. (Table 1). All sows were fed twice a day using a standard feed (13.1 MJ/DM) according to feeding pattern. Litters were born in individual farrowing pens. The data on farrowing and litter size (born alive, including sex of piglets, stillborn found at the first litter examination after birth) were available per parity for individual sows from 2000 to 2011. The material comprised 5478 piglets. The piglets were from 395 litters (104 dams and 28 sires) of five generations. Unsuccessful farrowings in Lithuanian practice named as emergency farrowings with 1-6 piglets was not excluded from the analysis. The sows were culled for the following reasons: failure to conceive, poor health or injury problems, absence of right sire, change of generation.

Table 1. Circular breeding scheme adopted for conserved small population of Lithuanian White pigs

Generation		Disconnected pedigree animal groups (genealogical lines)							
		1		2		3		4	
		Female	Male	Female	Male	Female	Male	Female	Male
Founder	Parents	AxB		CxD		ExF		GxH	
	Progeny	A_1	B_1	C_1	D_1	E_1	F_1	G_1	H_1
I	Parents	A_1xH_1		C_1xB_1		E_1xD_1		G_1xF_1	
	Progeny	A_2	H_2	C_2	B_2	E_2	D_2	G_2	F_2
II	Parents	A_2xF_2		C_2xH_2		E_2xB_2		G_2xD_2	
	Progeny	A_3	F_3	C_3	H_3	E_3	B_3	G_3	D_3
III	Parents	A_3xD_3		C_3xF_3		E_3xH_3		G_3xB_3	
	Progeny	A_4	D_4	C_4	F_4	E_4	H_4	G_4	B_4
IV	Parents	A_4xB_4		C_4xD_4		E_4xH_4		G_4xH_4	
	Progeny	A_5	B_5	C_5	D_5	E_5	H_5	G_5	H_5

Statistical analyses

The data were processed by the general linear model (GLM) procedure in Minitab. The model included the fixed effects of generation, parity, sex and year of farrowing. Tukey's HSD significance test was used to ascertain the existence of significant differences between the traits. The significance was determined at $p<0.05$, but differences of $0.05 \leq p<0.10$ were considered as trends. Values are presented as least square mean with standard error.

RESULTS

The animals of the founder generation in the established herd for conservation of the old genotype Lithuanian White pig produced 2-3 litters and were replaced by the next generation in which breeding of pigs started only within the herd. The number of females and percent of surviving in the next parities produced litters by generation are presented in Table 2. Although farrowing rate of sows in the closed herd was noted until parity 10, the farrowing rate of the sows of the sixth and seventh parities significantly decreased. Small and large litters were found within all generations (Table 3). The generation showed overall effect on the numbers of total born and born alive piglets, and the numbers of males per litters ($p<0.01$). The highest litter size increase in the first generation was found with increased number of males in the litters. The litter size decreased from the second generation. The generation did not appear to affect ($p=0.117$) the number of stillborn piglets.

The parity showed overall effect on the number of total born and stillborn piglets ($p<0.01$; Table 4). The number of total born and stillborn piglets increased with increasing parity number and reached a significant ($p<0.05$) increase in parity 5. The number of piglets born alive, including males tended to increase in parity 3 ($0.05 \le p<0.10$). However, the parity affected the number of total born ($p<0.01$) and stillborn piglets ($p<0.001$), and showed effects on the number of piglets born alive ($0.05 \le p<0.10$) only in the first generation. In the first generation the number of total born and born alive piglets increased with increasing parity number and reached a significant ($p<0.05$) increase in parity 3 (data not shown). The number of stillborn piglets in this generation decreased in parity 2. However, a significant ($p<0.001$) increase was reached in parity 5 (16.9%) and the maximum number of stillborn piglets (18.5%) was reached in parity 10.

Table 2.The number (and percent surviving in each parity) of females that produced litters by generation and parity

Generation	Parity									
	1	2	3	4	5	6	7	8	9	10
Founder	7	9	1	–	–	–	–	–	–	–
I	17 (100)	15 (88.2)	13 (76.5)	10 (58.8)	5 (29.4)	3 (17.6)	2 (11.8)	2 (11.8)	2 (11.8)	1 (5.9)
II	23 (100)	18 (78.3)	17 (73.9)	12 (52.2)	9 (39.1)	6 (26.1)	3 (13.0)	2 (8.7)	2 (8.7)	–
III	29 (100)	25 (86.2)	19 (65.5)	16 (55.2)	11 (37.9)	9 (31.0)	5 (17.2)	4 (13.8)	2 (6.9)	1 (3.4)
IV	28 (100)	24 (85.7)	19 (67.9)	15 (53.6)	5 (17.9)	4 (14.3)	–	–	–	–

Table 3. The number of born piglets per litter by generation

Generation	Number of litters	Total born	Born alive	Sex of piglets born alive		Stillborn
				Males	Females	
Founder	17	11.71±0.72	11.00±0.69	5.18±0.52	5.82±0.50	1.50±0.45
I	70	$12.24 \pm 0.35^{a,c,t}$	$11.34 \pm 0.34^{a, c}$	$6.06 \pm 0.26^{c,t}$	5.29±0.24	1.80±0.22
II	92	10.96 ± 0.31^{b}	9.97 ± 0.30^{b}	4.91 ± 0.23^{d}	5.05±0.21	1.94±0.19
III	121	11.07 ± 0.27^{t}	$9.92 \pm 0.26^{b,d}$	4.98 ± 0.20^{d}	4.93±0.19	2.32±0.16
IV	95	$10.61 \pm 0.30^{b, d}$	$9.78 \pm 0.29^{b,d}$	5.16 ± 0.22^{t}	4.62±0.21	1.76±0.19
p		0.009	0.003	0.009	0.111	0.117

Values are presented as least square mean and standard error. Means with a different superscript letter within a column differ significantly (a-b=$p<0.05$; c-d=$p<0.01$). Means with a superscripts t within a column differ at $0.05 \le p<0.10$ level of probability

Table 4. The number of born piglets by parity

Parity	Number of litters	Total born	Born alive	Sex of piglets born alive		Stillborn
				Males	Females	
1	104	10.22±0.29[a,t]	9.44±0.28[t]	4.64±0.21[t]	4.81±0.20	1.69±0.18[c]
2	91	11.34±0.31	10.51±0.30	5.31±0.23	5.20±0.22	1.77±0.19[c]
3	69	11.67±0.36[t]	10.77±0.35[t]	5.67±0.26[t]	5.10±0.25	1.82±0.21[a]
4	53	11.23±0.41	10.38±0.39	5.51±0.30	4.87±0.28	1.96±0.26
5	30	12.43±0.54[b]	10.33±0.52	5.23±0.40	5.10±0.38	3.00±0.27[b,d]
6	22	11.41±0.63	10.41±0.61	5.14±0.46	5.27±0.44	1.83±0.36
7	10	10.20±0.93	9.50±0.91	5.00±0.69	4.50±0.65	1.75±0.62
8	8	12.25±1.04	10.88±1.02	6.13±0.77	4.75±0.73	2.75±0.62
9	6	10.83±1.21	8.83±1.17	4.83±0.89	4.00±0.84	3.00±0.62
10	2	13.50±2.09	11.00±2.03	5.50±1.54	5.50±1.46	2.50±0.88
p		0.010	0.131	0.158	0.851	0.007

Values are presented as least square mean and standard error. Means with a different superscript letter within a column differ significantly (a-b=p<0.05; c-d=p<0.01). Means with a superscripts t within a column differ at 0.05≤p<0.10 level of probability

Table 5. The number of born piglets per litter by year

Year	No of litters	Total born	Born alive	Sex of piglets born alive		Stillborn
				Males	Females	
2000	14	12.43±0.79	11.71±0.75	5.57±0.58	6.14±0.54[a]	1.67±0.51
2001	17	9.65±0.71[t]	9.12±0.68[t]	4.29±0.52	4.82±0.49	1.13±0.44
2002	28	12.32±0.56	11.86±0.53[a,c,t]	6.25±0.41[t]	5.61±0.38[t]	1.08±0.36[a]
2003	16	12.88±0.73[t]	11.75±0.70[t]	6.44±0.54	5.31±0.51	2.25±0.44
2004	44	10.61±0.44	9.71±0.42[x]	4.59±0.33[t]	5.11±0.31	1.74±0.26
2005	37	11.76±0.48	10.89±0.46	5.81±0.35	5.08±0.33	2.00±0.31
2006	41	11.90±0.46	10.66±0.44	5.20±0.34	5.46±0.32[xt]	2.68±0.29[b]
2007	29	11.10±0.55	10.07±0.52	5.00±0.40	5.07±0.38	2.14±0.33
2008	38	10.47±0.48	9.11±0.46[d,t]	5.08±0.35	4.03±0.33[b,t,xt]	2.36±0.27
2009	41	11.27±0.46	9.85±0.44	5.15±0.34	4.71±0.32	2.07±0.24
2010	60	10.47±0.38	9.62±0.36[b]	4.88±0.28	4.73±0.26	1.76±0.23
2011	30	10.73±0.54	10.07±0.51	5.20±0.39	4.87±0.37	2.00±0.40
p		0.003	<0.0001	0.017	0.041	0.043

Values are presented as least square mean and standard error. Means with a different superscript letter within a column differ significantly (a-b=p<0.05; c-d=p<0.01). Means with a superscripts t within a column differ at 0.05≤p<0.10 level of probability

The year of farrowing (Table 5) showed the overall effect on the number of total born piglets ($p<0.01$) and born alive ($p<0.001$), including sex of piglets ($p<0.05$). The year of farrowing also showed the effect on the number of stillborn piglets ($p<0.05$). The highest least square mean for the number of total born piglets was observed in 2003 when it tended to be by 3.23 piglet higher ($0.05 \leq p<0.10$) than in 2001. The highest least square mean for the numbers of piglets born alive was in 2002 when it was significantly higher than in 2004, 2008 and 2010. However, the decrease in the number of piglets was not consequent upon pig breeding time length.

The effects of year in separate generations was estimated on the number of total born piglets and born alive in the founder generation ($p<0.05$) and on the number of stillborn piglets in the first generation ($p<0.001$; data not shown).

DISCUSSION

Familial selection is defined as the selective regime under which each family in the population contributes the same number of adults in the next generation. Selection acts among offspring within families and not among the entire set of offspring produced in the population as in the case of mass or ordinary selection (Theodorou and Couvet, 2003). Such selection principles can be observed in the breeding method of closed populations which was designed and proposed by Šveistys (1967; 1982) for Lithuanian White pigs and which is perfectly applicable for conserved critical Lithuanian farm animal breeds (Razmaite and Šveistiene). Although the results are limited by the size of our experiment, the information is provided regarding the effects of generation, parity and year for pig prolificacy in a small closed population. The obtained results verified that the property of adopted breeding method leads to a slower rate of inbreeding and retains high variability of reproductive traits and preserves the potential for future adaptations. In this study the farrowing rate of pigs is consistent with the results of Lucia et al. (2000) who reported that in herds having high-quality data about 15% of the removals occurred for parity 1 females and sow life expectancy corresponded to 3.3 parities at removal. In the present study there was no high farrowing rate decrease in the first two parities by generation. Xue et al. (1997) reported that the sows removed from the herds had a significantly shorter lactation length than did the sows of the same parity that were retained in the herds. In this experiment the sows had higher lactation length and higher rebreeding rate than the sows in the open Lithuanian pig farms as observed in our previous studies (Razmaite and Rekštys, 2006; Razmaite et al., 2008).

After litter size increase in the first generation compared to the founder generation there was a decrease registered in the second and further generations. The traits such as litter size are controlled by many genes of small effect. Selection exploits the resulting additive genetic variation, and depends for its success on understanding the nature of the observed phenotypic variation. As well as direct additive gene effects, variation results from maternal genes, from interaction among genes, from the maternal environment, and from the general environment (Webb, 1994). In the study of Kerziene and Juozaitiene (2004) the number of piglets born on Lithuanian pig farms was highly influenced by farm conditions. Therefore, the effect of year was included in the model of analysis. The effect of year which showed the general environment conditions on sow prolificacy was higher than the effect of generation. Every generation was closely related to the appropriate year, therefore, it is difficult to dissociate the effects of generation and year. Since the overall effect of generation on the numbers of females and stillborn piglets was insignificant, the effect of year was observed on all studied traits. Despite the fact that the studied parity and year factor affected the numbers of total born piglets and mortality rates at farrowing only in one and two generations, respectively, there was a high variation of the traits by all studied factors. Considerable variation on litter level for survival at birth was also reported by Kapell et al. (2011). In this study the mortality rate at farrowing corresponds with the studies of other authors (Serenius et al., 2003; Arango et al., 2005; Ibinez-Escriche et al., 2009) who analysed reproductive performance of different pig breeds. The literature survey regarding sex ratio theory indicates that genetic variance for sex ratio exists (Toro, 2006). A negative relationship between litter size and gender ratio (male based for small and female based for larger litters) has been observed by Gorecki (2003) in domestic pigs, by Servanty et al. (2007) in wild boar and by Razmaitë and Kerzienë (2009) in domestic pig and wild boar hybrids. In the current study male based sex ratio was increasing when the litter size increased and this is in contrast with the findings in the above mentioned studies. Insignificant effect of parity on litter traits was in disagreement with the findings of other authors, who reported that litter size increases with increasing parity number (Tummaruk et al., 2000; Arango et al., 2005; Hoving et al., 2011), whereas, the tendency of parity to affect the number of piglets born alive in the first generation could be considered to be in agreement with Arango et al. (2005) who reported that litter size tended to increase with parity from the first litter to the third one.

It can be concluded that the effect of generation on sow prolificacy was negligible and that breeding of old genotype Lithuanian White pigs in a small closed population over the first four generations had no clear negative influence on the prolificacy of pigs.

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PLODNOST LITVANSKIH BELIH KRMAČA STAROG GENOTIPA U MALOJ ZATVORENOJ POPULACIJI

RAZMAITE VIOLETA, JATKAUSKIENE VIRGINIJA i JUOZAITIENE VIDA

SADRŽAJ

Cilj ovih ispitivanja je bio da se utvrdi uticaj starosnog doba i pariteta na plodnost krmača u zatvorenoj populaciji litvanskih belih svinja starog genotipa. Podaci o prašenju i veličini legla po paritetu krmača (ukupan broj oprašene, živorođene i mrtvorođene prasadi, uključujući i njihov pol) su bili dostupni od 2000. do 2011. godine. Prasad je poticala iz ukupno 395 legala poreklom od 104 krmače i 28 veprova iz pet generacija. Starost krmača je uticala na ukupan broj oprašene prasadi i broj živo oprašene prasadi. Ovaj efekat je uočen i kod veprova ($p<0,01$) ali broj mrtvorođene prasadi nije bio značajno različit. Paritetet je imao uticaj na ukupan broj oprašene kao i na broj mrtvorođene prasadi ($p<0,01$). Srednje vrednosti ovih parametara su rasle sa paritetom i dostige su značajno povećanje ($p<0,05$) u paritetu 5. Godina prašenja je imala odraza na ukupan broj oprašene prasadi ($p<0,01$), živorođene prasadi ($p<0,001$) i mrtvorođene prasadi ($p<0,05$) uljučujući i pol. Pad broja živorođene prasadi se uočava od 2008. godine. Ovim ispitivanjem je dokazano da uzgajanje starog genotipa litvanskih belih svinja u maloj zatvorenoj populaciji u prve četiri generacije nema jasan negativan uticaj na plodnost krmača.