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Effect of size of the litter in which Polish Landrace and Polish Large White sows were born on the number of piglets born and reared

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The aim of the study was to determine the effect of size of litter in which sows were born on the number of piglets born alive and number of piglets at 21 days of age. The study included data on reproductive performance of Polish Landrace (PL) and Polish Large White (PLW) sows (1791 and 1047 records, respectively), which were raised in 2004-2009 in pedigree herds from Mazovian breeding region. The sows were divided into groups according to the size of litter of origin: group I ≤9, group II – 10, group III – 11, group IV – 12, group V – 13, group VI ≥14. Total changes in the number of piglets born alive (group 6 vs. group 1) were +1.52 piglets for the PL breed (P≤0.01) and +0.40 piglet for the PLW breed. The results show that to improve fertility in sows of domestic maternal breeds, gilts for herd replacement should be selected from highly fertile sows, and it is unjustified to select gilts from females born in small litters (≤10) as mothers of the next generation. Young females born in litters of at least 13 (PL) and 12 (PLW) piglets should be chosen as mothers of the next generation.

KEY WORDS: sows / size of litter of origin / reproductive indexes

Breeding performance traits in sows are characterised by low heritability and repeatability [27]. They are dependent on the effects of both the external and internal environments [21]. Expression of even the best genotype may be limited by poor living conditions [17], as a result of which existing high breeding potential of sows is not fully utilised. The environment exerts its effect through nutrition and feed metabolism, maintenance, reproduction techniques and use of animals.

Dependencies have been found between the location of uterine implantation of embryos, their number, rate of metabolic processes in the body and their survival and growth, as explained by the theories of Mossman (1937), Hammond (1944) and Eckstein (1955) [21].

Analyses of sex ratios in the litter of origin of females indicate that a greater share of females in the litter provides potential for further improvement of reproductive indexes, including litter size in multiparous species [22]. However, in mammals the share of sexes in the litter depends on many diverse factors; as a consequence the final result, i.e. the level of reproductive indexes, such as fertility, is very difficult to predict. As it is reported by Górecki and Kościński (2003), cited after Rekiel et al. [21], reproduction results are affected by hormone levels in females, the interval between ovulation and fertilisation, embryo mortality, feed consumed by the female, the female's age, body condition, her position in the herd, as well as stress factors or the intrauterine fetus position. In turn, Chen and Dziuk [5] attributed a special role to the effect of the initial uterine length on the developing embryos. Those authors were of an opinion that ovulation rate is correlated with the length of uterine horns, while prenatal survival is associated with uterine space. In comparison to fetuses developing under normal conditions those developing in a crowded uterus face a greater risk of death during the perinatal and postnatal period, with dying fetuses being predominantly male. Some embryos atrophy before day 17 of pregnancy, while successive losses are recorded between days 29 and 35. In the opinion of Wu et al. [29], the minimum uterine space required for physiological fetus development at day 50 of pregnancy needs to be 36 cm.

Experiments on selection indicate that in successive generations the number of corpora lutea may increase considerably (to a total of 6.5); nevertheless, it provides an increase in litter size by as little as 0.8 piglets [12]. For this reason in the opinion of Ruiz-Flores and Johnson [25] we may expect further improvement in litter size by max. 8-10%.

At present sows are expected to produce large numbers of live-born and reared piglets, both per year and during their productive lives. The potential of improved breeds seems to be considerable in this respect; however, the opposite is true. In American herds in the 100 years of the 19th century litter size per sow increased from 7-8 to 8-9 piglets, while for female lines it was only to 10-11 piglets, respectively [28]. Slight changes in fertility in the period of the last 4 decades were also observed in the German Landrace and Large White pigs in Germany [4]. At present the number of piglets in the litter born by German Landrace sows is 12.2, at a much greater potential estimated at 16.4 piglets. A similar situation is found in Polish pig breeding. For this reason it is advisable to search for various methods to improve reproductive indexes.

The effect of reproduction performance of the dam on the reproduction performance of her daughters and granddaughters is considered to be disputable. Opinions on the problem vary [13, 24]; nevertheless, it remains an important issue to be solved.

The aim of this study was to determine the effect of the size of the litter of origin for sows of maternal breeds, i.e. Polish Landrace and Polish Large White, on selected indexes of their reproduction performance, i.e. the number of piglets born and reared in the litter.

Material and Methods

Material for analyses comprised data on reproduction performance of sows of two breeds, i.e. Polish Landrace (1791 records) and Polish Large White (1047 records), used in the years 2004-2009 in nucleus herds of the Mazovian breeding region. Based on the size of their litter of origin the sows were assigned to 6 groups: I ≤9, II – 10, III – 11, IV – 12,

V – 13 and VI ≥14 piglets, respectively. When analysing the observations it was decided to focus on two reproduction traits, i.e. the number of live-born piglets and the number of piglets reared to day 21 of life. The tables give arithmetic means and standard errors. Differences between the groups were verified using the Duncan test [26].

Results and Discussion

Results for both investigated traits and the significance of differences between the groups for PL are given in Table 1. Changes in the number of live-born piglets in group II compared to group I amounted to +0.78 piglets (P≤0.01), group III to II +0.22, group IV to III +0.12 and V to IV +0.28 (P≤0.01), while for group VI in relation to group V it was +0.12 piglets; the total change in group VI in comparison to I was +1.52 piglets (P≤0.01). In turn, changes for PLW for both these indexes were less marked (Table 2), as in the number of live-born piglets they were as follows: group II in comparison to I –0.02 piglets, group III to II +0.17, group IV to III +0.10, group V to IV +0.17 piglets, and VI to V –0.02; the total change in group VI compared to group I was +0.40 piglets. Significance of differences between the groups in the number of piglets born in the litter was found only for some groups, i.e. II-V and II-VI (P≤0.01) as well as I-V, II-IV and III-V (P≤0.05). In the case of the number of piglets at day 21 statistically significant differences were recorded for groups I-VI, II-V, II-VI (P≤0.01) as well as groups I-V, II-III and II-IV (P≤0.05).

Results of studies conducted in the 1990's concerning the effect of the size of the litter of origin for sows on their future reproduction performance are inconclusive. Jarczyk et al. [10] were of an opinion that gilts from highly fertile dams show a much lesser fertility than their mothers. Daughters from dams of low fertility are characterised by greater fecundity, which results from the fact that piglets from small litters already during their fetal life develop under better conditions, while after birth each piglet has optimal growth conditions thanks to the potential intake of greater amounts of colostrum and milk. In the opinion of

Table 1

Effect of size of the litter in which the PL sow was born on number of piglets born alive and reared to 21 days (n=1791)

Trait	Group						Se
	I	II	III	IV	V	VI	
	Size of litter of origin						
	≤9	10	11	12	13	≥14	
	No. of sows in group (n)						
	45	184	413	567	285	297	
No. of piglets born alive	10.23 ABCDE	11.01 AFGH	11.23 BIJ	11.35 CFKL	11.63 DGJK	11.75 EHJL	0.045
No. of piglets at 21 days	9.35 ABCDE	10.08 AFGHa	10.34 BIa	10.43 CFb	10.47 DG	10.65 EHIb	0.041

A, A – P≤0.01; a, a – P≤0.05.

Table 2

Effect of size of the litter in which the PLW sow was born on number of piglets born alive and reared to 21 days (n=1047)

Trait	Group						Se
	I	II	III	IV	V	VI	
	Size of litter of origin						
	≤9	10	11	12	13	≥14	
	No. of sows in group (n)						
	49	157	217	264	190	170	
No. of piglets born alive	11.29 a	11.27 ABb	11.44 c	11.54 b	11.71 Aac	11.69 B	0.048
No. of piglets at 21 days	10.19 Aa	10.26 BCbc	10.54 b	10.49 c	10.65 Ba	10.69 AC	0.042

A, A – P≤0.01; a, a – P≤0.05.

Rudlegde [24], gilts from small litters are best candidates for dams. They are characterised by a greater number of ovulating egg cells and a higher number of embryos at day 28 of pregnancy, they also produce by 1.18 more piglets than gilts from more numerous litters. Breeding farms have always provided better environmental conditions that commercial production farms, thus better reproduction results were obtained from dams of medium and high fertility. Lewczuk et al. [15] indicated that for reproduction purposes it is optimal to select gilts from dams with mean fertility exceeding 10 piglets. This is also shown by the analysis of results obtained in this study, while additionally litter size of origin of a gilt selected to be a future dam is also breed-dependent. For PL litter size should be 13 and occasionally even 14 piglets, which is confirmed by the highly significant statistical differences (P≤0.01) between most compared traits for the number of piglets born in the litter, at a lack of significant differences (P>0.05) for this trait between groups II-III, III-IV and V-VI. For PL sows the progression of values for the analysed indexes was constant, with maximum values obtained for the two analysed traits in group VI in comparison to groups I-V. Piglet wastage from birth to day 21 was comparable in the groups and amounted to: group I – 0.88 piglets, II – 0.93, III – 0.89, IV – 0.92, V – 1.16 and VI – 1.10 piglets, respectively.

For the PLW breed the indexes reached maximum values for the size of litter of origin of 13 (the number of piglets born in the litter) and ≥14 (the number of piglets at day 21). Piglet wastage levels up to day 21 of rearing were comparable in the groups, amounting to: group I – 1.10 piglets, II – 1.01, III – 0.90, IV – 1.05, V – 1.06 and VI – 1.00 piglets. The increase in litter size was not found to be related with the level of piglet wastage, as indicated by results of some studies [19, 20]. Evaluation of the results does not provide a definite answer on the size of the litter, at which gilts should be selected to become prospective dams. However, an appropriate approach seems to consist in the selection from litters of minimum 12 piglets born. In the opinion of Lewczuk et al. [15], piglets coming from average-sized litters have good conditions for development and may exhibit good individual performance; this is particularly true for large commercial farms. On smaller family farms

the best results were recorded for sows coming from very large litters. On farms keeping on average 20 sows environmental conditions were very good, which promoted high fertility of sows coming from the most numerous litters [9]. This study analysed results recorded in the herds, which in the period of analysis consisted of 5 to 50 sows, thus they may be considered medium-sized or small in comparison to other Polish herds. When comparing them with Polish herds of various types (nucleus, productive) it should be stated that the analysed results came from small farms providing at least good environmental conditions. Better fertility and piglet rearing results to day 21 were found for sows coming from litters of 13 and more piglets. They are not completely consistent with the results of other studies [7, 11], indicating that the best results are obtained for sows from litters of medium size, preferably from dams with 10.5 piglets per litter. It may be assumed that the differences result from the changes occurring over a period of approx. 20 years, concerning both the value of animals and their management and nutrition. Very high fertility of dams in combination with low piglet weight at birth results in a decreased fertility of their daughters, while this effect is maintained even at advantageous changes in environmental conditions [7, 11]. In the opinion of the authors, it is advisable for further breeding to select gilts from litters of 10-12 piglets. Our study shows that sows coming from small litters (≤9 and/or 10 piglets) also produced small litters, which is confirmed by the results of other studies [8, 14]. Our data indicate advisability of assigning females from numerous herds for herd replacement, which is confirmed by mean results reported for domestic maternal breeds [2] as well as results of other researchers [23]. For the entire investigated pool of PL sows in comparison to PLW sows the mean total number of live-born piglets in the litter was by 0.29 piglets smaller, while at day 21 it was by 0.24 piglets lower. In group I the analysed indexes for PL and PLW differed markedly, as the number of live-born piglets was 10.23 and 11.29, respectively (the difference between the breeds of 1.06 piglets), while at day 21 it was 9.35 and 10.19, respectively (the difference of 0.84 piglets). In group VI values of the traits for PL and PLW were comparable. In terms of values of the investigated indexes more frequently statistically significant differences were recorded between the six compared groups for Polish Landrace pigs rather than Polish Large White sows. It seems that for the evaluated breeds these differences may be the basis for the formulation of recommendations concerning litter size when selecting gilts to be future dams.

A study by Revelle and Robison [23] is considered as pioneering and providing grounds for improved sow fertility. Analyses concerning Yorkshire and Duroc sows as well as F1 crosses of these breeds showed the best reproduction results for daughters reared in numerous litters of highly fertile sows, although they exhibited lower fertility than their mothers. Daughters from sows of low fertility showed greater fertility than their mothers; nevertheless, those authors stated that the best results were obtained for sows coming from highly fertile mothers. It was shown that if the size of the litter of origin of the mother was greater by 1, fertility of her daughters decreased by as little as 0.1 to 0.2, which guaranteed an improved final effect. The improvement in sow fertility by 1, recorded in this study, means that the use of the daughters potentially will result in an increase in their fertility by as much as 0.8-0.9. Gilts coming from the most numerous litters showed greater fertility than gilts coming from small litters. Thus sows coming from small litters need to be eliminated from breeding, since they slow down breeding progress.

Lewczuk and Rymkiewicz [14] when analysing causes for limited efficiency of selection for reproduction performance traits indicated their low heritability and the decision to keep gilts from the least numerous litters for further breeding. Such gilts exhibit a greater body weight, faster growth rate and better conformation. In the opinion of Łyczyński et al. [16] and Bocian et al. [3], improvement and upgrading carcass meatiness in pigs may result in a deterioration of reproduction performance indexes. Orzechowska and Tyra [19] recorded negative dependencies between meatiness and the number of live-born piglets, while Grzyb et al. [6] did not confirm such a dependence for PL sows.

The best reproduction results are observed for sows coming from numerous litters. However, some breeders take an irrational approach and select for further use bigger animals with greater weight gains, but coming from small litters. This has resulted in excessive improvement of fattening traits in breeding gilts from maternal breeds in relation to the assumed goals and in a reduced fertility of these breeds and herds [1]. In this situation it was rational to change the weight of traits in the BLUP model for sows of maternal breeds [30]. Results of annual analyses of reproduction performance traits in sows of native breeds are used to improve the pig population and to enhance production efficiency [18]. Separation of selection objectives for individual breed components has a positive effect on reproduction results in pigs of maternal breeds [1, 2]. One of the methods to improve reproduction performance may also be connected with a definite identification of litter size, from which gilts to be used as prospective dams should be selected.

In conclusion it needs to be stated that selection of gilts born in small litters (≤10) to be used as future dams is irrational. For such a purpose we should select females born in litters of minimum 13 (PL) and 12 (PLW) piglets. This means that in order to improve sow fertility in domestic maternal breeds, i.e. PL and PLW, gilts from highly fertile sows should be selected for herd replacement.

REFERENCES

1. BLICHARSKI T., PTAK J., SNOPKIEWICZ M., 2011 – Wyniki oceny trzody chlewnej w 2010 roku. Polski Związek Hodowców i Producentów Trzody Chlewnej „POLSUS", Warszawa.
2. BLICHARSKI T., PTAK J., SNOPKIEWICZ M., 2012 – Wyniki oceny trzody chlewnej w 2011 roku. Polski Związek Hodowców i Producentów Trzody Chlewnej „POLSUS", Warszawa.
3. BOCIAN M., JANKOWIAK H., GRAJEWSKA S., GAJDOŠOVÁ L., KAPELAŃSKA J., KAPELAŃSKI W., 2010 – Ocena wartości hodowlanej i rozpłodowej loch rasy wielkiej białej polskiej i polskiej białej zwisłouchej z regionu kujawsko-pomorskiego. ***Roczniki Naukowe Zootechniki*** 37, 2, 137-144.
4. BRÜSSOW K.P., WÄHNER M., JAŚKOWSKI J.M., 2011 – Biological limit of fecundity in sows – do they exist? ***Electronic Journal of Polish Agricultural Universities*** 14, 3.
5. CHEN Z.Y., DZIUK P.J., 1993 – Influence of initial length of uterus per embryo and gestation stage on prenatal survival, development, and sex ratio in the pig. ***Journal of Animal Science*** 71, 1895-1901.
6. GRZYB M., REKIEL A., WIĘCEK J., 2007 – Wpływ przyrostu dziennego, otłuszczenia i mięsności oszacowanych przyżyciowo loszek rasy pbz na ich użytkowość rozpłodową. ***Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego*** 3, 2, 71-77.

7. JARCZYK A., 1987 – Efekt mateczny u loch i jego wpływ na cechy rozpłodowe. ***Przegląd Hodowlany*** 6, 27-28.
8. JARCZYK A., KONRAD B., 1995 – Efekt mateczny u loch a wartość produkcyjno-hodowlana ich potomstwa. ***Trzoda Chlewna*** 12, 7-8.
9. JARCZYK A., KONRAD B., 2000 – Porównanie cech rozpłodowych loch półsióstr urodzonych w kolejnych miotach jako sposób określenia efektu matczynego. ***Zeszyty Naukowe Przeglądu Hodowlanego*** 48, 15-22.
10. JARCZYK A., ROGIEWICZ A., GROCHOWSKA M., 1999 – Kolejność miotu urodzenia i średnia płodność loch jako czynniki efektów matczynych, wpływających na jakość oraz liczbę odchowanych prosiąt i warchlaków. ***Zeszyty Naukowe Akademii Rolniczej*** im. H. Kołłątaja w Krakowie 352, 89-95.
11. JARCZYK A., VAN DER STEEN H.A.M., 1988 – Reproductive performance of breeding gilts reared from high and medium litters. ***Acta Academiae Agriculturae Technicae Olstenensis (Zootechnica)*** 31, 113-119.
12. JOHNSON R.K., NIELSEN M.K., CASEY D.S., 2001 – Responses in ovulation rate, embryonal survival, and litter traits in swine to 14 generations of selection to increase litter size. ***Journal of Animal Science*** 77, 541-557.
13. LEWCZUK A., JANISZEWSKA M., GRUDNIEWSKA B., BOCHNO R., 1991 – Odziedziczalność i powtarzalność cech dzielności rozrodczej loch hodowanych na terenie działalności OSHZ w Olsztynie. ***Acta Academiae Agriculturae Technicae Olstenensis (Zootechnica)*** 34, 23-32.
14. LEWCZUK A., RYMKIEWICZ J., 2001 – Wpływ liczby prosiąt odchowanych w trzech pierwszych miotach loch rasy wbp na użytkowość rozpłodową loszek w następnych pokoleniach. ***Przegląd Hodowlany*** 3, 14-16.
15. LEWCZUK A., RYMKIEWICZ J., GRUDNIEWSKA B., 1993 – Wpływ średniej liczby prosiąt żywo urodzonych w trzech pierwszych miotach loch założycielek rodzin na użytkowość rozpłodową loszek rasy pbz w następnych pokoleniach. ***Zeszyty Naukowe Przeglądu Hodowlanego*** 48, 40-46.
16. ŁYCZYŃSKI A., BARTKOWIAK Z., POSPIECH E., URBANIAK M., 2000 – Wpływ wybranych cech oceny przyżyciowej na użytkowość rozpłodową loch. ***Biuletyn Naukowy Uniwersytetu Warmińsko-Mazurskiego*** 7, 137-144.
17. ONTERU S.K., FAN B., NIKKILA M.T., GARRIK D.J., STALDER K.J., ROTHSCHILD M.F., 2011 – Whole-genome association analyses for lifetime reproductive traits in the pig. ***Journal of Animal Science*** 89, 4, 988-995.
18. ORZECHOWSKA B., MUCHA A., 2009 – Stan hodowli i wyniki oceny świń. Instytut Zootechniki – Państwowy Instytut Badawczy, Kraków.
19. ORZECHOWSKA B., TYRA M., 2000 – Zależność pomiędzy oceną przyżyciową a użytkowością rozpłodową loch. ***Biuletyn Naukowy Uniwersytetu Warmińsko-Mazurskiego*** 7, 327.
20. REKIEL A., OLEJNICZAK D., KACPRZAK D., 2009 – Produkcyjność loch hybrydowych w wybranych chlewniach krajowych. ***Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego*** 5 (4), 155-163.
21. REKIEL A., WIĘCEK J., WOJTASIK M., KULISIEWICZ J., BATORSKA M., 2010 – Środowisko wewnętrzne a reprodukcja u gatunków wielopłodowych. ***Roczniki Naukowe Zootechniki. Monografie i Rozprawy*** 44, 79-88.

22. REKIEL A., WIĘCEK J., WOJTASIK M., PTAK J., BLICHARSKI T., MROCZKO L., 2012 – Effect of Sex Ratio in the Litter in Which Polish Large White and Polish Landrace Sows were Born on the Number of Piglets Born and Reared. ***Annals of Animal Science*** 12, 2, 179-185.
23. REVELLE T.J., ROBISON D.W., 1973 – An explanation for the low heritability of litter size in swine. ***Journal of Animal Science*** 37, 668-675.
24. RUDLEGDE J.J., 1988 – Fraternity size and swine reproduction. I. Effect of fecundity of gilts. ***Journal of Animal Science*** 51, 868-870.
25. RUIZ-FLORES A., JOHNSON R.K., 2001 – Direct and correlated responses to two-stage selection for ovulation rate and number of fully formed pigs at birth in swine. ***Journal of Animal Science*** 79, 2286-2297.
26. SPSS 2011. User's Guide 14.0 SPSS Inc.
27. TYRA M., RÓŻYCKI M., 2000 – Odziedziczalność cech rozpłodowych różnych ras świń. ***Zeszyty Naukowe Przeglądu Hodowlanego*** 48, 387-388.
28. WÄHNER M., BRÜSSOW K.P., 2008 – Biologische Potenziale in der Sauenfruchtbarkeit. ***Zuchtungskunde*** 80, 370-377.
29. WU M.C., CHEN Z.Y., JARELL V.L. DZIUK P.J., 1999 – Effect of initial length of uterus per embryo on fetal survival and development in the pig. ***Journal of Animal Science*** 67, 1767-1772.
30. ŻAK G., RÓŻYCKI M., 2009 – Ocena wartości hodowlanej świń metodą BLUP. Użytkowość tuczna i rzeźna. Ocena wartości hodowlanej metodą BLUP dla użytkowości tucznej i rzeźnej oraz zbiorczej wartości hodowlanej na podstawie pomiarów przyżyciowych. Wyd. IZ-PIB, Kraków.