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THE EFFECT OF PARITY AND DATE OF SERVICE ON THE REPRODUCTIVE PERFORMANCE OF POLISH LARGE WHITE × POLISH LANDRACE (PLW × PL) CROSSBRED SOWS*

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Abstract

The aim of this study was to demonstrate the influence of the month of insemination on the reproductive performance of crossbred sows in moderate climates. The research material consisted of 309 primiparous and 625 multiparous (PLW×PL) sows kept on an industrial-scale farm. Analysis included 2457 litters obtained during a five-year period from 2006 to 2011. Statistically, the lowest number of piglets born alive and weaned was observed as a result of summer month insemination (July, August, September) compared to the winter months (February, March) ($P \leq 0.01$ and $P \leq 0.05$). Inseminations in the first four months of the year resulted in a higher number of piglets born alive in second and following parities ($P \leq 0.01$). Statistically significant differences in litter size due to the month of insemination were observed for sows in parities 4 and 5–11 ($P \leq 0.01$ and $P \leq 0.05$). The shortest farrowing interval was demonstrated for sows inseminated in November, the longest in January, March ($P \leq 0.01$) and April, July ($P \leq 0.05$). The results indicate that the insemination month of the sow may affect some reproductive parameters.

Key words: month, insemination, reproductive performance, crossbred sows

A major problem for industrial pig farms is to ensure the continuity and stability of production throughout the year. Concomitant with progress, it is even possible to note an increasing sensitivity to the environment. Achieving a high level of fertility in sows forces the continuous search for reserves in the physiological and environmental conditions. An especially important moment is the time of insemination, fertilization and implantation.

Ovulation occurs on average between 30–40 hours of oestrus and lasts 4–7 hours (Krzymowski and Przała, 2010). At this time, the mean number of ovulating follicles

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oscillates from 1 to 25. The number of fertilized ova and the implantation process (occurring between days 13 and 24 after fertilization) impacts on results of delivery (Ren et al., 2010). The highest levels of embryo mortality are noted up to the 18th day of pregnancy. The physiological norm for embryo death is about 20–30% (Einarsson et al., 1996). Whole born litters constitute from 55 to 65% of the total number of oocytes released by the ovarian follicles during ovulation.

The impact of the external environment (such as daylight length, season, and welfare) and the weather conditions have mostly been discussed in the context of the time of farrowing (Stasiak et al., 2006; Kawęcka et al., 2007; Nowicki and Schwarz, 2010), weaning-oestrus interval (Marchev and Szostak, 2007), tropical conditions (Gourdine et al., 2006; Suriyasomboon et al., 2006), and even the quality of the milk of sows (Skrzypczak et al., 2012). Research into the impact of a moderate climate on reproductive performance has only recently been started and the significance of the insemination-implantation period has been suggested in recent works (Basset et al., 2001; Knox and Zas, 2001; Roca et al., 2006; Bloemhof et al., 2008). The effect of season has been shown on: farrowing rate, litter size, the presence of the oestrus, the weaning-oestrus interval (Peltoniemi et al., 2000). Hansen et al. (2001), in a review study on cattle additionally suggest: reduced expression of oestrus behaviour, altered follicular development, impairment of oocytes, impact on the number of fertilized ova and inhibiting embryonic development. Similar observations were carried out on pigs (Peltoniemi et al., 2000). The main role in all-year-round cycle is played by: daylight length, temperature and the associated heat stress, as an important part of the season, and also inherited individual predispositions. For European wild boar (*Sus scrofa*), as the ancestor of modern pigs, daylight length regulates reproductive processes and this is based on changes in the secretion of melatonin (Gourdine et al., 2006). If the organism of a warm-blooded animal (such as a pig) is not in optimal condition, the mobilization of internal systems for the maintenance of temperature is maintained at the cost of production reserves.

A value is also assigned to the parity number. Gilts are characterized by lower reproductive performance and are probably more susceptible to environmental factors (Tummaruk et al., 2000; Babicz et al., 2011). The best results are achieved by sows in their 3rd parity, when there is also the best lactation (Szulc et al., 2011). The 3rd parity is sometimes referred to as the pinnacle of a sow's reproductive abilities. Subsequent parities are characterized by smaller litter sizes and also the health status is lower. However, some studies have shown that a clear potential decrease starts after parities 6 and 7 (Tantasuparuk et al., 2000; Tummaruk et al., 2000).

Few studies have tried to focus on genetic variation in sow tolerance to heat stress. However, lines preferred in warmer climates are not necessarily characterized by good results in moderate climates (Bloemhof et al., 2008).

The aim of the present study was to determine the influence of the insemination month and parity of crossbred sows (PLW × PL) on piglets born alive and farrowing interval in moderate climate.

Material and methods

The research material consisted of 309 primiparous and 625 multiparous sows (PLW × PL). Sows were chosen from different parities without analysing whole live production. Animals were housed in a state-owned industrial piggery (i.e. PPH Ferma-Pol Zalesie), located in the Opole region in the period January 2006 to July 2011.

Symptoms of oestrus in sows were detected twice a day in the presence of a boar (visual and olfactory contact). Sows were inseminated with fresh semen (stored at most 48 h at a temperature of 15°C) collected from the piggery's own boars and with spermatozoa concentration of 3.5×10^9 per 100 ml dose. Semen was diluted in a seminal solvent BTS boar semen extender (Minitube). Before insemination, the seminal dose was heated up to a temperature of 35°C. For intra-cervical insemination, Safe Blue Clear Glide™ (Minitube) catheters were used. Reinsemination was performed 24 h later.

After weaning (mean±SD) (28.1±6.19 day) sows were housed in individual pens, where they spent a month after insemination. Then, sows were in group housing (from 8 to 10 individuals) with a short covered outdoor range. A week before the predicted end of gestation, sows were moved into farrowing pens. The following feed mixtures were used: after weaning and until day 85 of gestation, and after day 85 of gestation and during lactation. During first and mid period of gestation the sows were fed 2.3 kg feed/day and after 85 day 2.8 kg feed/day. During lactation sows had free access to feed. Sows had continuous access to drinking water. Animals were fed according to Polish Swine Nutrition Requirements (1993).

Collected numerical material concerned: date of next sow inseminations, parity number (1, 2, 3, 4, 5–11), number of piglets born alive, number of piglets weaned and farrowing intervals. A total of 2,453 litters were analysed in the research population and the average parity was (mean±SD) 2.4±1.57 (from 1 to 11).

The collected results of the study were analysed statistically using StatSoft STATISTICA® version 10 (2012). Comparison between means was performed using one-way and two-way (for influence of month of insemination and parity) analysis of variance (ANOVA) with Tukey's multiple range test. Results presented in tables were shown as mean values of parameters with standard deviations. Levels of significance of difference were given conventionally: significant $0.01<P\leq0.05$ and highly significant $P\leq0.01$.

Results

Average temperatures and humidities in each month around the farm originated from the database of the meteorological station (Institute of Meteorology and Water Management – National Research Institute) situated near the farm. The average maximum and minimum outdoor monthly temperature and monthly humidity were shown in order to present the climatic conditions of the research area (Figure 1).

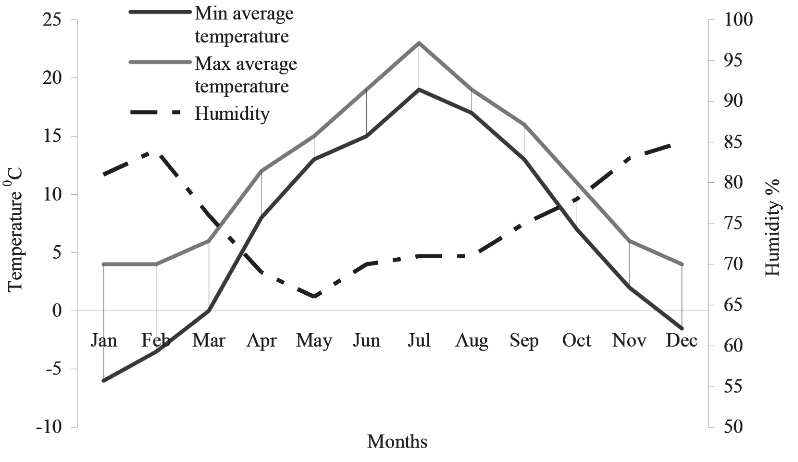


Figure 1. Average of maximum and minimum monthly outdoor temperatures and daily humidity between 2006 and 2011, near the farm

The number of piglets born alive and weaned relative to the month of insemination is presented in Table 1. For the piglets-born-alive parameter statistically significant differences were demonstrated between February and March, which presented the highest number, compared to July and August with the lowest ($P \leq 0.01$) and September ($P \leq 0.05$). For the other months the number of piglets born alive was similar and ranged between 10.40 and 10.62. Analysing the number of piglets weaned similar results as for the piglets born alive were reported. However, statistically significant differences were proven at a lower level ($P \leq 0.05$) for February and March compared to July and August. Between February, March and September the same differences were noted as were observed in piglets born alive.

Table 1. Number of piglets born alive and piglets weaned by insemination months

Month	Number of litters (n)	Piglets born alive (head ± SD)	Piglets weaned (head ± SD)
January	284	10.42±1.84	9.55±1.69
February	288	10.74±1.78 Aa	9.83±1.63 a
March	310	10.74±1.76 Aa	9.79±1.61 a
April	298	10.62±1.92	9.73±1.76
May	146	10.40±1.73	9.57±1.59
June	114	10.50±1.21	9.56±1.11
July	106	10.02±1.29 B	9.21±1.19 b
August	163	10.14±1.30 B	9.23±1.18 b
September	196	10.21±1.51 b	9.29±1.37 b
October	192	10.45±1.59	9.55±1.45
November	205	10.40±1.57	9.49±1.43
December	151	10.48±1.34	9.59±1.22
Total	2453	10.48±1.66	9.58±1.52

a, b – values in column with different letters differ significantly ($P \leq 0.05$).
A, B – values in column with different letters differ significantly ($P \leq 0.01$).

Effect of parity due to insemination month is demonstrated in Table 2, with statistical differences within parity in months. In the first four months of the year it was confirmed statistically (P≤0.01) that the lowest number of piglets was born by primiparous sows (0.5 and more piglets). Other months of insemination were characterized by the predominance of parity 2, 3 and especially 4, 5–11 compared with primiparous sows but with non-significant differences. Generally, growth in the number of piglets born alive was related to parity. The lowest total rates were recorded for primiparous and the highest for parity 5–11.

Table 2. Effect of parity on the number of piglets born alive in each month, in which the sows were inseminated (mean±SD)

Month	Parity 1 (n = 932)	Parity 2 (n = 610)	Parity 3 (n = 377)	Parity 4 (n = 255)	Parity 5–11 (n = 279)
January	9.62±1.90 B	10.64±1.84 A	11.18±1.39 A	11.11±1.66 A	11.06±1.24 A
February	9.96±1.74 B	10.77±1.46 A	11.39±1.46 A	11.23±1.87 A	11.74±1.80 A
March	9.93±1.54 B	10.96±1.69 A	10.94±1.49 A	11.86±2.06 A	11.28±1.64 A
April	10.14±2.08 Bb	10.66±1.60	10.84±1.66	11.26±1.70 a	11.67±1.73 A
May	9.98±1.80	10.62±1.98	10.97±1.33	10.77±1.48	9.90±1.52
June	10.41±1.25	10.48±1.33	10.36±0.86	11.14±1.46	10.29±0.95
July	9.70±1.75	10.18±0.98	10.15±1.04	10.10±0.88	10.13±0.64
August	9.82±1.43	10.42±1.23	10.37±1.07	10.20±1.26	10.50±1.07
September	9.86±1.47 B	10.50±1.47	10.42±1.61	9.92±1.25 b	11.08±1.41 Aa
October	10.23±1.35	10.51±1.66	10.70±1.88	10.50±1.53	10.62±1.66
November	9.89±1.74	10.51±1.43	10.83±1.32	10.83±1.53	10.82±1.37
December	10.27±1.39 b	10.68±1.15	10.72±1.51 a	10.60±1.26	10.27±1.27
Total	9.97±1.69	10.62±1.55	10.81±1.47	10.92±1.69	11.06±1.56

a, b – values in rows with different letters differ significantly (P≤0.05).
A, B – values in rows with different letters differ significantly (P≤0.01).

Table 3 presents the influence of month of insemination and parity number on piglets born alive calculated by the two-way ANOVA. The calculations showed that both month of insemination and parity had a significant impact on the number of piglets born. In addition a statistically significant (P≤0.05) interaction was observed between the two factors analysed.

Table 3. Influence of month of insemination and parity number on piglets born alive

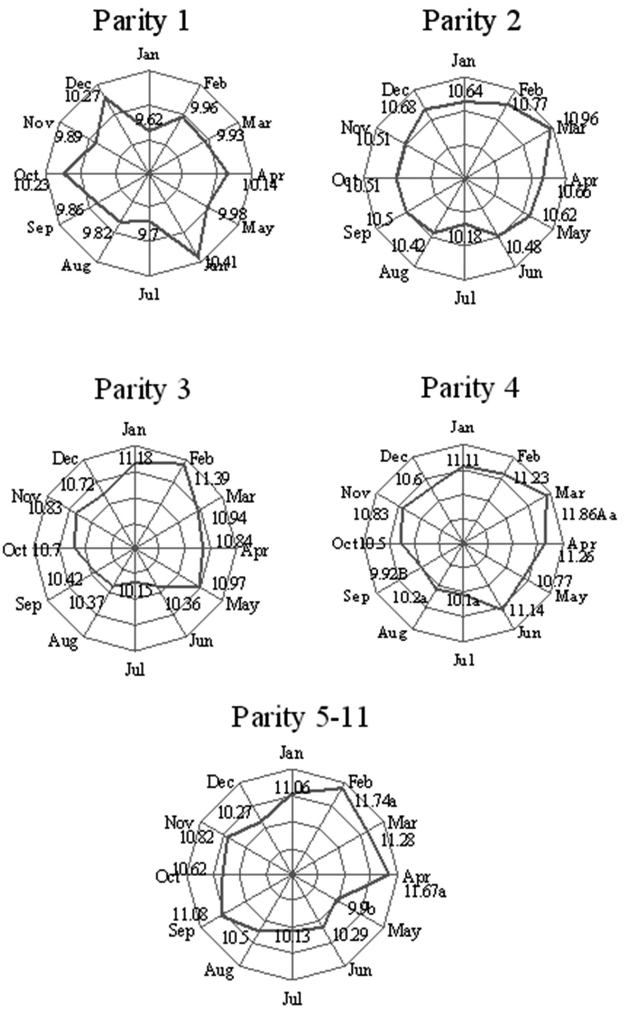
Source of variation	Sum of squares	Degrees of freedom	Mean square	F empirical	Significance level
Month of insemination	149.6	11	13.6	5.36	0.000
Parity	255.9	4	64.0	25.21	0.000
Interaction	163.1	44	3.7	1.46	0.026
Standard error	6083.9	2397	2.5		

The number of live born piglets in parities 1, 2, 3, 4, 5–11 in each insemination month is demonstrated in Figure 2.

Primiparous sows gave birth to more than 10 piglets after insemination in the months of April, June, October and December. Poorer results were noted in January and July. The differences were not confirmed statistically.

Very similar results were obtained in parity 2 where the average was 10.62 and the extreme values were 10.18 and 10.96.

Analysis of 377 sows in parity 3 showed that there were no significant differences, but deviation of the results was higher than in the two previous cases. The lowest number of piglets were born after the summer insemination (June; July; August) as compared to those obtained in the first quarter of the year (January; February; March).



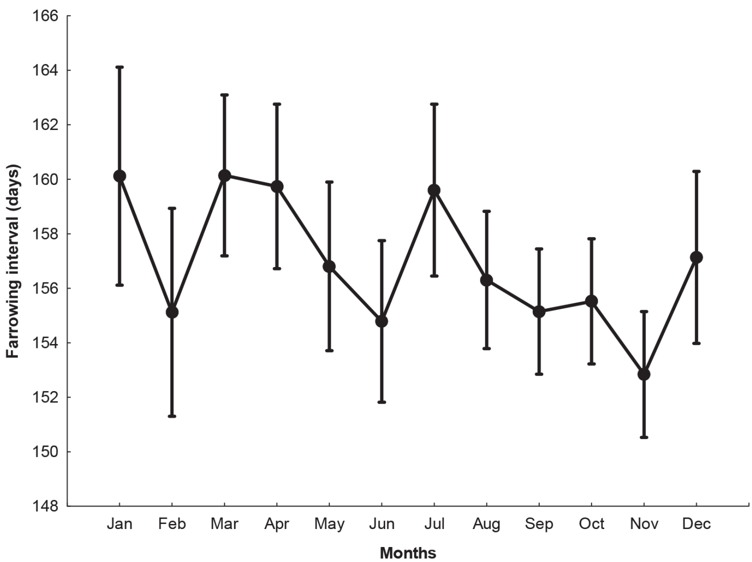
Values show significant differences in parity between months a, b ($P \leq 0.05$); A, B ($P \leq 0.01$).

Figure 2. Number of piglets born alive in sow parities 1, 2, 3, 4 and 5–11 by month of insemination

For sows in parity 4 a very large decline was observed during the summer. Statistically significant differences were demonstrated between March insemination and July/August insemination (P≤0.05) or even September (P≤0.01).

A higher number of piglets was born after insemination in the first four months of the year, for parity 5–11. February and April were the months in which there was a statistically significant difference (P≤0.05) compared with May.

Farrowing interval related to month of insemination was also analysed (Figure 3). Gestation length (114±3.2 days) and lactation length (28.1±6.19 days) were noted for the whole research population. The shortest farrowing interval was observed for insemination in November (152.84 days), in comparison with January (160.11 days) and March (160.14 days) and the differences were significant statistically (P≤0.01). In addition, the difference between the shortest farrowing interval (November) and insemination in April (159.74 days) or July (159.6 days) proved to be statistically significant (P≤0.05). The results for the other months were quite similar and oscillated within the range 154.78–157.13 days. The overall average for 1463 data was (mean days±SD): 156.47±16.04.



a, b – values show significant differences between groups (P≤0.05).
A, B – values show significant differences between groups (P≤0.01).

Figure 3. Farrowing interval depending on insemination month

Discussion

The moment of insemination is very important for the effects of the further reproductive performance of sows. The results of our study have shown that the period of insemination and parity demonstrated differences proven statistically at the level of

$P \leq 0.05$ and $P \leq 0.01$. Also, an interaction between those two parameters was observed ($P \leq 0.05$). The best results were noted in winter months and the worst in summer.

Certain relationships can be noticed by comparison with other experiments. In a study by Knox and Zas (2001), crossbred Large White × Landrace sows were characterized by the highest ovulation rate (97.3%) during the winter season, which could affect the results. The importance of the Polish Large White breed in the crossbreeding programme with the native Złotnicka Spotted breed in the winter season manifested itself in the very low number of piglets born (7.98) (Szulc et al., 2011). Even in tropical climates the influence of the time of mating and insemination on litter size has been observed (Suriyasomboon et al., 2006). It has been statistically proven that the winter season is the best for mating and insemination compared with the rainy season (July–September) ($P \leq 0.05$). However, in the hot season (March–June) compared to the summer time in moderate climates there were non-significant differences as opposed to the results of our study. Such relations were not demonstrated by Tummaruk et al. (2001).

These results can be compared with research conducted by Bloemhof et al. (2008), who analysed the effect on litter size of outdoor temperature during insemination. Differences in the temperature range 10–22°C were not high, but the lowest rates for Large White were noted in the temperature ranges 20–22°C and 12–14°C, as was partly the case in our study.

The summer period is characterized by higher temperature and can cause heat stress. For example, in cows it may decrease the follicular growth and reduce the follicular fluid concentration of estradiol-17β (Hansen et al., 2001). In the summer months (June, July, August and even September) reduced concentrations of LH in the blood serum of sows were observed (Bassett et al., 2001). Impaired development of follicles affects the lower ovulation rate and oocytes are not fully valuable, which can cause a higher embryo mortality (Einarsson et al., 1996; Bracken et al., 2003). The analogy may be used to interpret our reduced results. On the other hand, comparing the results with a tropical climate it is proposed that the same month is of importance (a period of year), rather than just temperature (Peltoniemi et al., 2000) or the interaction of temperature-humidity as is observed in cattle (Freitas et al., 2006).

The temperature-humidity configuration affects the number of piglets born alive. It was shown that the worst configuration is high temperature-high humidity, where fewer piglets are born alive than with both low temperature-high humidity ($P \leq 0.05$) and high temperature-low humidity ($P \leq 0.001$) (Suriyasomboon et al., 2006). In our study, the best results were recorded for insemination months with high humidity and low temperature.

Repeatable results were observed in other studies analysing the number of piglets born alive linked to parity number. Tummaruk et al. (2000) and Suriyasomboon et al. (2006) noted the highest number of piglets born for parity 4–6 and the lowest for primiparous sows, also in crossbred sows. This could be explained by more follicles ovulating, uterus capacity and the age of the sows. In our study, the period of insemination was divided into months. The first four months of the year were probably characterized by a greater number of fertilized oocytes, a consequence of which was a higher number of piglets born after the gestation time. In the next months this trend was not continued and similar results between primiparous and other parities were observed. On this basis it is possible to suggest that gilts reacted more to environmental conditions in the winter than in the summer-autumn. Therefore, low temperatures had a stronger influence on the young female body than was the case with high ones. Similarly, the bodies of older sows were more influenced by high temperatures during insemination, which resulted in a lower number of piglets born alive. This observation should be continued in future studies, particularly in relation to crossbred sows.

Similar results for primiparous and multiparous sows held in high temperatures were given by Prunier et al. (1997), where at temperatures of 27–30°C litter sizes were similar. Another study conducted by Gourdine et al. (2006) revealed the negative effect of climate only on primiparous sows and also a greater significance of season on insemination. The low number of piglets born alive after May insemination for sows in parity group 5–11 (9.90) could be explained by the highest level of prolactin blocking ovulation recorded in this month, as noted by Bassett et al. (2001). It can be deduced that older females are especially susceptible to the activity of this hormone.

The farrowing interval is determined mainly by the weaning to next insemination period. A prolonged period of the appearance of oestrus is characteristic for summer months (Tummaruk et al., 2001; Marchev and Szostak, 2007). One of the factors was probably feed intake, as reported by Prunier et al. (1997) and Škorjanc et al. (2008). However, it has been shown that the survival of embryos as a result of feeding and the progesterone-mediated mechanism is effective only for 3–4 days after copulation (Foxcroft, 1997) and does not affect vital embryonic survival (Hoving et al., 2012). A consequence of reduced feed intake is reduced release of LH which leads to impaired follicular development and thus disorders in the occurrence of oestrus after weaning (Bloemhof et al., 2008). Sows inseminated in January, March, April were distinguished by the longest farrowing interval. However, such a relationship was not reported in our study for February and this interval was one of the shortest. Farrowing interval may also depend on follicular populations before weaning and the rate of follicular development after weaning (Bracken et al., 2003).

The production potential of sows may be exploited only with a well-organized breeding system, taking the most limiting factors into account. In conclusion, the present study confirms that sow insemination month had a significant influence on some elements of reproductive performance. Summer insemination leads to a lower number of piglets born alive later (even 0.72 piglet). It can be also concluded that the month of insemination did not have much effect on the number of piglets weaned. However, farrowing interval was the longest after winter insemination. Gilts were more susceptible to the impact of low outdoor temperatures in contrast with older sows, which reacted to higher outdoor temperatures. This relationship was observed during analysis of the parity.

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