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Analysis of Reproduction Performance Traits in Sows of the CG36 Hybrid Line, Including the Effect of Selected Factors and Phenotypic Correlations

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Abstract: In Poland, despite a decline in the pig population, pork consumption invariably remains high. For this reason, it is important to search for a potential reduction in pig production costs. One of the feasible solutions is to use sows of hybrid lines. Currently, several sow lines are available on the Polish market, such as CG36 (Choice Genetics). The aim of this study was to determine the level of reproduction performance in this line considering the effect of parity and farrowing season. Additionally, coefficients of phenotypic correlations between analysed reproduction performance parameters were determined. The experimental material comprised 112 females inseminated with semen of a boar of the Excelium line (Choice Genetics), which produced 336 litters. The investigated population was characterised by a high level of reproduction traits and young age at first farrowing (AFF), while the number of piglets born alive (NBA), the number of piglets weaned per litter (NW), and the number of piglets weaned per sow per year (PWSY) reached high, economically advantageous levels. Primiparous sows produced and reared lower numbers of piglets than multiparous sows, which indicates the need to maintain an adequate herd structure, with a maximum share of gilts at 30%. No effect of the season on values of reproduction traits was found, which shows optimal environmental conditions in the animal housing where the pigs were kept. Dependencies between the analysed traits confirmed the results reported by other authors, where NBA was highly positively correlated with LW, although LW increased with an increase in NBA. No correlations were found between PWSY and the other traits. In turn, the observed coefficients of phenotypic correlations indicate that in order to reduce AFF in CG36 sows, it is necessary to control FI.

Keywords: hybrid pig; sow; reproductive traits; correlations

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1. Introduction

Poland is a European country in which pig production is a traditional branch of animal production. However, for over 10 years, we have observed a continuous decline in the pig population. In 2010, the population was estimated at 14,775.7 thousand animals [1]. In December 2022, it was only 9624.3 thousand, with the number having decreased by 6% from December 2021 [2]. There are many reasons for such a situation, e.g., increased production costs, persistent low slaughter pig prices, or the ASF epidemic in Poland. The situation was additionally deteriorated by the COVID-19 pandemic. As a result, due to the low profitability of production, many producers ceased to rear pigs. Nevertheless, despite the observed reduction in the pig population, pork consumption in Poland remains at a stable, high level. In 2010, a statistical Pole consumed 42.2 kg of this meat annually, while in 2020, pork consumption amounted to 43.4 kg, which indicates the continued interest of consumers in this meat [3]. For this reason, these producers, which are still operating in the market, are striving to maximally reduce costs in order to improve their profitability. Factors affecting the profitability of slaughter pig production include those independent of producers and those which may be controlled by them. One of the latter is connected to reproduction traits [4,5].

Since the heritability of reproduction traits is low [6–8], breeding work aiming at improving their levels generally brings unsatisfactory results. This is confirmed by the analysis of changes in reproduction traits in Polish Landrace (PL) and Polish Large White (PLW) sows kept in nucleus herds. In 2012, the mean number of live-born piglets per litter was 11.81 and 11.70 head for PL and PLW, respectively. According to data for the year 2022, the mean litter size at birth for the above-mentioned breeds amounted to 12.81 and 13.08 head [9,10]. In view of problems with gaining genetic progress through selection, it has become necessary to find alternative methods to improve reproduction traits. One of the approaches known for decades is crossbreeding using the phenomenon of heterosis [11–13].

In view of the considerable role played by the prolificacy index (reproductive rate) of sows in the profitability of pig production, it is assumed that maternal heterosis is of greater importance than paternal or progeny heterosis [12,13]. It has a positive effect not only on increasing conception rates, but also on further piglet survival rates [12,14,15]. Sows coming from two-way crossings of the Landrace and Large White breeds, as well as sows of commercial hybrid lines, e.g., PIC1050, Camborough (Pig Improvement Company, Hendersonville, TN, USA), TN70 (Topigs Norsvin, Burnsville, MN, USA), Naïma, and CG36 (Choice Genetics, West Des Moines, IA, USA), are used as dams of fatteners [12,15–28]. Since their popularity has been steadily increasing in Poland, it is necessary not only to monitor the level of reproduction traits but also to determine the effects of various factors on these traits. This facilitates the selection of optimal conditions for their maintenance, i.e., those promoting the development of their potential.

The aim of this study was to establish the level of reproduction performance in sows of the CG36 hybrid line (Choice Genetics) considering the effect of farrowing parity and season. Additionally, coefficients of phenotypic correlations were determined between the analysed reproduction traits.

2. Material and Methods

The experimental material comprised sows of the CG36 synthetic line (Choice Genetics). Investigations were carried out in the years 2020–2023 over three production cycles. Analyses were conducted on data concerning 112 sows, which produced a total of 336 litters. Females were kept in a floor management system in mechanically ventilated buildings. For all the technological groups, individual dry feeding was used, with the composition and amount of the feed mix being adapted to the age and physiological conditions of the female (Table 1). All sows were inseminated with the semen of Excelium boars (Choice Genetics).

Table 1. Basic composition of feeds for individual technological groups.

Technological Group	Dry Matter (%)	Crude Ash (%)	Crude Protein (%)	Crude Fibre (%)	Crude Fat (%)
Pregnant sows	89.07	4.78	13.58	3.57	2.15
Nursing sows	90.47	7.72	17.73	3.61	3.30
Prestarters	91.13	6.45	19.65	2.69	4.32

Sows were transferred to farrowing houses 5 days before farrowing. The maternal nursing period lasted 28 days, with the piglets being supplementally fed with Prestarter feed starting from day 5 of life.

The following reproduction traits were analysed:

- Age at first farrowing AFF (days);
- Farrowing interval FI (days);
- Number of piglets born alive NBA (head);
- Number of stillborn piglets NBS (head);
- Number of piglets weaned per litter NW (head);

- Loss of piglets to weaning LW (%);
- Number of piglets weaned per sow per year PWSY (head).

Data were collected and aggregated using MS Excel 2016. The accumulated data were analysed using the SAS 9.4 2019 software package (SAS Institute Inc., Cary, NC, USA). The MEANS and UNIVARIATE procedures were applied to calculate elements of descriptive statistics (the mean, minimum, maximum, standard deviation, coefficient of variation, number of observations in the dataset). The GLM-SAS procedure was used to estimate the effect of the year and season of farrowing, as well as the effect of parity based on the multivariate analysis of variance according to the following linear model:

$$Y_{ijklmn} = \mu + R_i + S_j + M_k + e_{ijklm}$$

where

Y_{ijklmn}—phenotypic value of the investigated trait;
μ—population mean;
R_i—fixed effect of farrowing year (j = 1, 2, 3, 4);
S_j—fixed effect of farrowing season (k = 1, 2, 3, 4);
M_k—fixed effect of parity (j = 1, 2, 3);
e_{ijk}—random error.

Tukey's test was applied to conduct a detailed comparison of means. The significance of differences was established at $p \leq 0.05$. In order to estimate Spearman's phenotypic correlations between the investigated traits, the CORR-SAS procedure was applied.

3. Results

Table 2 presents the general characteristics of reproduction performance in sows of the CG36 hybrid maternal line.

Table 2. General characteristics of reproduction performance in CG36 hybrid line sows.

Trait	*n*	Min	Max	$\bar{x}$	SD	CV
[1] AFF (days)	112	350.00	360.00	354.32	2.19	0.62
[2] FI (days)	224	148.00	158.00	152.34	2.20	1.44
[3] NBA (head)	336	9.00	21.00	14.83	2.10	14.19
[4] NBS (head)	336	0.00	3.00	0.69	0.79	114.67
[5] NW (head)	336	9.00	16.00	13.31	1.52	11.42
[6] LW (%)	336	0.00	35.29	9.64	7.16	74.28
[7] PWSY (head)	112	10.00	48.00	31.77	10.67	35.37

[1] AFF—age at first farrowing; [2] FI—farrowing interval; [3] NBA—number of piglets born alive; [4] NBS—number of stillborn piglets; [5] NW—number of piglets weaned per litter; [6] LW—loss of piglets to weaning; [7] PWSY—number of piglets weaned per sow per year.

AFF was 354.32 ± 2.19 days. FI was short and amounted to 152.34 ± 2.20 days. Sows of the investigated population on average produced 14.83 live-born piglets per litter, with a minimum litter size of 11 piglets and a maximum litter size of 22 piglets. The mean number of stillborn piglets per litter was 0.69 ± 0.79. Piglet losses during maternal nursing on average amounted to 9.64 ± 7.16%. The latter trait, nevertheless highly important from an economic point of view, was connected with the number of piglets reared by the sow per year. Sows on average reared 31.77 ± 10.67 piglets annually.

Table 3 presents reproduction performance data considering the effect of parity. Statistical analysis showed that parity had a significant effect on the number of live-born and stillborn piglets per litter, as well as the number of piglets weaned per litter.

Table 3. Reproduction performance of CG36 hybrid line sows considering the effect of parity.

Traits	Effect of the Litter P	Parity								
		1			2			3		
		N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
[1] NBA (head)	0.0023	112	14.07 A	1.89	112	15.06 B	2.09	112	15.36 B	2.12
[2] NBS (head)	0.0013	112	0.95 A	0.84	112	0.54 B	0.78	112	0.58 B	0.68
[3] NW (head)	0.0012	112	12.78 A	1.53	112	13.53 B	1.51	112	13.63 B	1.39
[4] LW (%)	0.4834	112	8.81	6.08	112	9.57	7.75	112	10.55	7.49

A, B: Means denoted with different letters differ statistically at $p \leq 0.05$. [1] NBA—number of piglets born alive; [2] NBS—number of stillborn piglets; [3] NW—number of piglets weaned per litter; [4] LW—loss of piglets to weaning.

The lowest NBA was recorded in the first litters (14.07 ± 1.89 head). It differed from the values recorded for the second and third litters, for which it amounted to 15.06 ± 2.09 and 15.36 ± 2.12 head, respectively. In litters of primiparous sows, the highest NBS was observed, at the mean of 0.95 ± 0.84. Significantly fewer stillborn piglets were found in the second and third litters (0.54 ± 0.78 and 0.58 ± 0.68, respectively). Significant differences were also recorded in the number of weaned piglets per litter. In the first litters, the value of this trait was 12.78 ± 1.53 head and it differed from the levels for the second and third litters (13.53 ± 1.51 and 13.53 ± 63, respectively). In contrast, no effect of parity on LW was observed. Only a slight trend towards greater piglet wastage was found in litters of multiparous sows compared to those of primiparous sows. Nevertheless, the observed differences were statistically non-significant.

Table 4 presents the reproduction performance depending on the farrowing season. No effect of the season on the level of the analysed traits was found. The mean number of piglets born alive per litter ranged from 15.87 ± 1.86 head in the autumn litters to 15.38 ± 1.81 in those born in the summer. Also, NBS levels in individual seasons were comparable. They amounted to 0.58 head in the litters born in the summer and 0.75 head in litters from the winter season. No statistical differences were recorded in the levels of piglet losses to weaning; for litters born in the spring, it was 9.10 ± 6.66%, while for autumn litters, it was 11.08 ± 7.94.

Table 4. Reproduction performance of CG36 hybrid line sows considering the effect of farrowing season.

Traits	Effect of Season P	Farrowing Season											
		Winter (Dec–Feb)			Spring (Mar–May)			Summer (Jun–Aug)			Autumn (Sept–Nov)		
		N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD
[1] NBA (head)	0.5889	109	14.63	2.16	75	14.81	2.00	84	14.80	2.10	68	15.21	2.12
[2] NBS (head)	0.8562	109	0.75	0.83	75	0.73	0.72	84	0.58	0.82	68	0.66	0.75
[3] NW (head)	0.5360	109	13.20	1.61	75	13.39	1.46	84	13.31	1.57	68	13.41	1.40
[4] LW (%)	0.5633	109	9.27	6.24	75	9.10	6.66	84	9.44	7.98	68	11.08	7.94

[1] NBA—number of piglets born alive; [2] NBS—number of stillborn piglets; [3] NW—number of piglets weaned per litter; [4] LW—loss of piglets to weaning.

Additionally, Table 5 presents phenotypic correlations for the investigated traits. A significant correlation was found between AFF and FI amounting to −0.28 at $p < 0.01$. A negative correlation was recorded between the number of piglets born alive per litter and the number of stillborn piglets (−0.52, $p < 0.01$).

Table 5. Phenotypic correlations between reproduction performance parameters in CH36 hybrid line sows.

Traits		AFF (Days)	FI (Days)	NBA (Head)	NBS (Head)	LW (%)	NW (Head)	PWSY (Head)
[1] AFF (days)	r_p		−0.28	0.04	0.02	0.09	<0.01	−0.04
	P		<0.01	0.46	0.70	0.11	0.95	0.61
[2] FI (days)	r_p	−0.28		0.02	0.04	0.03	−0.02	−0.09
	P	<0.01		0.70	0.49	0.64	0.73	0.43
[3] NBA (head)	r_p	0.04	0.02		−0.52	0.50	0.80	0.14
	P	0.46	0.70		<0.01	<0.01	<0.01	0.06
[4] NBS (head)	r_p	0.02	0.04	−0.52		−0.21	−0.44	−0.01
	P	0.70	0.49	<0.01		<0.01	<0.01	0.93
[5] LW (%)	r_p	0.09	0.03	0.50	−0.21		−0.06	0.01
	P	0.11	0.64	<0.01	<0.01		0.30	0.86
[6] NW (head)	r_p	<0.01	−0.02	0.80	−0.44	−0.06		0.13
	P	0.95	0.73	<0.01	<0.01	0.30		0.07
[7] PWSY (head)	r_p	−0.04	−0.09	0.14	−0.01	0.01	0.13	
	P	0.61	0.43	0.06	0.93	0.86	0.07	

[1] AFF—age at first farrowing; [2] FI—farrowing interval; [3] NBA—number of piglets born alive; [4] NBS—number of stillborn piglets; [5] LW—loss of piglets to weaning; [6] NW—number of piglets weaned per litter; [7] PWSY—number of piglets weaned per sow per year.

In turn, NBA was positively correlated with the piglet loss percentage until weaning (0.50) and the number of piglets weaned from the litter (0.80). Additionally, the number of stillborn piglets had a significant effect on the percentage of piglet losses during maternal nursing (r_p −0.21, $p < 0.01$) and litter size at weaning (r_p −0.44, $p < 0.01$).

4. Discussion

Improved reproduction performance is crucial for the profitability of pig production. As mentioned in the introduction, an effective method to attain this objective is to utilise the effect of maternal heterosis, which is observed in female hybrid lines. An example of such a line is CG36 (early Naïma), created by crossing two grandparent lines of Redone (Tia Meslan × Carelie) and Gallia [23,29].

Sows of the CG36 line evaluated in this study exhibited a high level of reproduction performance traits. AFF was 354 days and it was younger than that observed by Szulc [30] for Redone sows by 9 days. It was also better than the reported AFF for Polish Landrace and Polish Large White sows, which produced their first litters at the age of 367 and 375 days, respectively [10]. In turn, Kasprzyk and Łucki for Danhybryd LY recorded a comparable AFF, amounting on average to 355 days [31]. FI in the investigated population was only 152 days, which was similar to the levels reported for Danhybryd LY sows by Pietruszka et al. [20] and Kasprzyk and Łucki [31]. Additionally, this was higher than that recorded for Redone sows [30] as well as Polish Landrace and Polish Large White sows [10]. The results of this study are advantageous in terms of production profitability, since a short farrowing interval reduces the number of non-productive days that generate excessive costs [13,30].

Litter size was large both at birth and at weaning, as on average, sows produced 14.83 piglets born alive per litter, and they reared 13.31 piglets to weaning. These values were slightly higher than those reported for the CG36 line by Urbaniak [32]. In contrast, they exceeded the values recorded in a study by Hoha et al. for PIC1050 and Camborough. PIC1050 and Camborough sows investigated by those authors produced 10.62 and 11.43 piglets at birth and reared 10.15 and 11.06 piglets to weaning, respectively [18]. These levels also exceeded the data shown for the Camborough-15 and Danhybryd LY lines [17,31], Polish Landrace and Polish Large White [10,33], as well as Korean Landrace and Yorkshire breeds [34]. In this study, significant differences were recorded in the numbers of piglets born alive and reared to weaning in successive litters. The lowest prolificacy was reported for the first litters (14.07 head). From those litters, the lowest numbers of piglets were also reared, amounting to a mean of 12.78 head. The effect of parity on litter size was found by many authors [15,31,33,35–40]. Knecht et al. [33], when analysing the reproduction performance of the Naïma and Redone lines, stated that primiparous sows produced on average 10.9 and 12.0 piglets per litter, respectively. In successive litters, this number increased to 12.9 in Naïma and 12.2 in Redone. The same authors found a significant effect of parity on NBA ($p \leq 0.01$) and NW ($p \leq 0.05$) in sows of the Polish Landrace, Polish Large White breeds, and their crosses [40]. Similar observations were made by Kasprzyk and Łucki [31] for the Danhybryd LY line. In their study, females produced on average 13.0 live-born piglets in their first litters, and this was significantly lower than the respective number recorded in successive litters. Those authors also observed that the number of piglets weaned from litters of primiparous sows was lower than that recorded for multiparous sows. The results reported in this study indicate that even in the case of genotypes characterised by high reproduction performance parameters, such as line CG36, it is important to maintain an appropriate herd structure. Primiparous sows, due to their significantly lower reproduction performance, should constitute a maximum of 30% of herd structure.

In turn, NBS amounted to 0.69 head. A similar result was reported by Păsărin et al. for Camborough sows [22]. The same researchers recorded a greater number of stillborn piglets in the case of the PIC1050 line, whereas McGlone and Hicks observed NBS of 0.8 head for Camborough-15 [7]. Also, Corredor et al. [41] found a greater number of stillborn piglets in litters produced by Yorkshire sows. Here, it ranged from 0.7 to 1.2 head. In turn, Szulc et al. [42] showed only 0.44 stillborn piglets in the litters of PIC sows. In the analysed population, a significantly higher number of stillborn piglets was recorded in the first litters (0.95 head) compared to the second and third litters. Similar results were obtained for Polish Large White × Polish Landrace crosses [36]. However, no significant effect of farrowing season was observed in the value of this trait.

In CG36 sows, the loss of piglets during the maternal nursing period was on average 9.64%. Similar losses were reported in the case of the PIC1050 and Camborough lines [22]. In turn, a markedly higher level of piglet losses to weaning was found by Kramarenko et al. [43] for Large White (11.6%) and Large White × Landrace sows (12.1%). In this study, no effect of parity and farrowing season on LW was observed. Also, Klimas et al. [38] in Large White sows observed no effect of parity on piglet rearing losses. Opposing results were recorded for the Danhybryd LY line, as losses were not only greater, amounting to 12.62%, but also, a significant effect of parity on their level was found. Here, the smallest losses were recorded in the first litters [31]. Also, Knecht et al. observed the effect of parity on the level of piglet losses in sows of the Naïma and Redone lines [33].

PWSY in CG36 sows was on average 31.77 head. This value was only slightly lower than that recorded for the CG36 line in a study by Urbaniak, where it amounted to 32.76–33.69 piglets weaned per sow per year [32]. In turn, values observed in this study exceeded those recorded for the Polish Landrace and Polish Large White breeds, for which in 2022, the mean number of piglets reared per sow per year was 25.1 and 25.96 head, respectively [10]. The results in this study were also higher than those given by Declerck et al. [44] for sows of the Danbred, Topigs Hypor, and PIC lines, as well as the Landrace breed. The high prolificacy observed in this study resulted from high fertility and high farrowing frequency. On average, the analysed sows produced 2.4 litters per year. This result was identical to that recorded by other authors for Landrace and Large White sows [31,33,36,45].

This study showed no effect of farrowing season on the level of discussed reproduction traits, in contrast to the findings of Holm et al., who stated such an effect for the Norwegian Landrace breed [46]. In a study by Nowak et al. [47], a significant effect ($p \leq 0.05$) of farrowing season was found on the length of the reproduction cycle in crossbred sows. In turn, Knecht et al. [39] in Polish Landrace, Polish Large White, and PL x PLW crossbred sows showed a significant effect of the season on NBA, NW, and body weight of piglets at birth and at weaning. Similar results were recorded in a study by Ek et al. [48].

It seems that in this study, the lack of any effect of farrowing season on levels of reproduction traits resulted from the fact that sows were provided optimal environmental conditions. Changing seasons of the year probably had no effect on the animal housing microclimate. This is essential, since many earlier studies indicate an adverse effect of elevated temperature on pig reproduction [40,49–51].

In this study, analyses were also conducted on phenotypic correlations between reproduction traits. A negative correlation was found between AFF and FI. A similar dependence was recorded by Plaengkaeo et al. in Landrace and Large White sows [52]. It also needs to be stated here that those authors observed dependencies between AFF and other reproduction traits, e.g., the total number of piglets born and reared by a sow over the entire productive life and farrowing interval. Also, Yu et al. [53] reported correlations (positive ones) between age at first farrowing and the number of live-born piglets per litter, body weight of the piglet at birth, and litter weight at weaning. In this study, no correlation was observed between the age of the sow at first farrowing and other reproduction traits. Also, Ziedina et al. [54] found no correlation between AFF and NBA as well as NW. The obtained results confirm the observations of other authors and indicate that too-young gilts should not be used in breeding. The organism of such animals has not been adequately prepared for the strain of pregnancy and piglet rearing, and as a result, it has a negative effect on the length of the production cycle, causing its extension, which in turn has a negative influence on the economic results of production.

A negative correlation was recorded between NBA and NBS. In contrast, a positive correlation was found between the percentage of piglet losses during maternal nursing and the number of piglets reared from the litter. In contrast, no correlation was observed between the number of live-born piglets and the number of piglets weaned from the sow per year. The same results were reported by Abell et al. [45]. Those authors found no phenotypic correlations between the number of piglets born and prolificacy in Landrace and Large White sows. In turn, Zhang et al. [55] observed positive phenotypic and genetic correlations between the number of live-born piglets per litter and litter weight at birth and at weaning. Positive and high phenotypic correlations between NBA and NW were also reported by Van and Duc [56] for the Large White and Mong Cai breeds. However, correlations between litter size at birth or at weaning and the corresponding weights of piglets were moderate. The same correlations were observed by Dube et al. [57] for South African Large White sows and Lukač [58] for sows of different breeds. Similar to the findings of this study, these results indicate that an increase in the number of piglets per litter at birth was connected with an increase in the number of piglets per litter at weaning. Moreover, it was connected with a reduction in the body weight of an individual piglet; however, this aspect was not analysed in this study. Positive correlations between the number of piglets per litter at birth and at weaning were also found by Oh et al. [59] in Duroc, Landrace, and Yorkshire sows.

5. Conclusions

In this study, it was shown that sows of the CG36 hybrid line (Choice Genetics), in accordance with breeding practice assumptions, showed a high level of reproduction traits. They produced their first litters before reaching one year of age. They produced and reared numerous litters. Moreover, a short farrowing interval was also reported. This made it possible to obtain high prolificacy, which is economically advantageous. Primiparous sows gave birth and reared until weaning fewer piglets than multiparous sows, which confirmed the results of other authors. This indicates the need to maintain an adequate herd structure, where the share of gilts is max. 30%. In turn, the analysis of variance showed no effect of the season on values of reproduction traits, which confirms optimal environmental conditions in animal housing, where the animals were kept.

Phenotypic correlations between the investigated traits confirmed the results of earlier studies. NBA was highly, positively correlated with NW, despite the fact that LW increased with an increase in NBA. No correlation was found between PWSY and the other traits. In turn, the observed coefficients of phenotypic correlations indicate that aiming to reduce AFF in CG36 sows, it is necessary to control FI. In the investigated population, sows showed a short farrowing interval; however, the above-mentioned correlation suggests that too early inclusion of CG36 sows in reproduction may result in decreased PWSY, which not only reflects the levels of the other reproduction parameters but is also of high economic importance.

Due to the small number of animals used in the study, the results obtained should be interpreted with caution. This is because the CG36 line was introduced into swine production on the analysed farm in 2020. The data regarding the level of reproductive performance were collected on a regular basis. Such an approach allows a more thorough analysis of the issue.

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