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INFLUENCE OF GENOTYPE AND PARATYPE FACTORS ON THE REPRODUCTIVE QUALITIES OF MOTHER BREEDS OF PIGS

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Abstract

The object of the research was the study of the influence of the breed of pigs and methods of their breeding on the reproductive functions of sows. Manifestation of various forms of the effect of hybrid power during direct and reverse crossing of animals of these breeds, as well as the tightness and directionality of correlative relationships were studied. No significant difference was found in most parameters of reproductive capacity between Large White and Landrace sows of Irish origin for purebred breeding and crossing, except for individual piglet weight at weaning. The weight of one piglet at weaning was probably higher in purebred litters of the Landrace breed compared to other investigated genotypes. We found that the heterosis caused the advantages of crossbred litters over purebred litters in most traits of reproductive performance. But despite this, the mass of weaned piglets had an intermediate form of inheritance. It was established that there was a strong positive correlation between fertility indicators and litter weight of piglets at birth, as well as between the number of piglets in the nest at weaning and the weight of the litter of piglets at weaning, similarly as between the weight of the litter of piglets at birth and the number of piglets in the nest at weaning and the weight of the litter of piglets at weaning. A strong positive correlation was found between indicators of the number of piglets in the nest at weaning and their weight during this period, as well as between the individual weight of the piglet at weaning and the weight of the nest of piglets at the time of weaning. Between multifertility and the average weight of one piglet at weaning, an inverse moderate relationship was found, as well as between the indicator of survival of piglets before weaning and survival of piglets at the time of weaning. As a result of the research, it can be asserted that there is a medium-strength correlation between the weight of the litter of piglets at birth and their weight at weaning.

Key words**:** *pigs, Irish breeding, reproductive capacity, breeding methods, heterosis effect, industrial production pork production*

INTRODUCTION

Breeding of pigs in recent years has been carried out in the direction of creating specialized breeds or types, which, when combined, should provide the effect of heterosis for a number of traits. However, productivity traits in pigs have different degrees of heritability and different genetic conditioning, and therefore their improvement depends on a number of geno- and paratypic factors [9].

The pig breeding industry allows to produce a large amount of meat in a relatively short time due to the introduction of intensive technologies and rational use of the pig gene pool in purebred breeding and hybridization systems [11]. Inheritance of reproductive traits mainly occurs in a non-additive type, which makes it difficult to assess the breeding value of animals, but indicates the possibility of increasing fertility, improving the maternal qualities of sows through controlled heterozygosity and creating appropriate environmental conditions for animals [29].

The results of numerous studies indicate the effectiveness of interbreed crossings [12], breed-line hybridization, which leads primarily to an increase in fertility, the weight of piglets and the litter as a whole compared to purebred breeding [23]. To improve reproductive qualities in industrial pig breeding, two-breed F_1 crossbreeds from direct and backcrossing of animals of Large White and Landrace breeds are usually used, which allows to additionally use the effect of hybrid strength in terms of reproductive performance characteristics [18]. It has long been established that the degree of inheritance of reproductive qualities is noticeably low and selection for them does not differ in efficiency. Pigs of new specialized lines have high productivity, which was genetically determined [10]. However, increased productivity is the reason for their high dependence on negative environmental factors. The authors reported [14] that reproductive indicators of sows, such as multifertility, the proportion of piglets born dead, depended on the factors of their breeding method and the breed of pigs, the influence of which was higher.

The selection of the last 30 years, being aimed at a larger size of offspring in sows, led to its steady increase, which continues to this day [24, 34]. Piglet live weight at birth has a huge influence on the subsequent productivity of pigs [22]. Piglets with a low body weight at birth have a negative effect on the efficiency of pig farming. These piglets have lower organ development and lower productivity later on [15]. Scientists also reported [7] that heavier newborn piglets have better viability, which positively affects the growth of fattening and slaughter indicators compared to counterparts born lighter. According to the results of recent experiments [8, 17], the influence of piglet weight at birth on the reproductive qualities of pigs was determined. In particular, they [8, 17] showed that for every 0.1 kg decrease in the birth weight of piglets, pre-weaning mortality increased by 3%, post-weaning mortality increased by 2%, and market weight decreased by 1.63 kg [3]. Most studies show that if a live-born piglet is 0.45 kg heavier, then at weaning its weight will be 0.9 kg heavier than the average piglet weight. And at the end of the rearing period, heavier piglets at weaning gain from 1.8 kg to 3.6 kg in the same number of days of rearing compared to normal or lighter piglets. The weight of piglets is inversely dependent on the number of piglets born to a sow per farrowing [13]. According to the reports of other authors [33], there was a high statistically reliable correlation between indicators of fertility and nest weight at the time of weaning r = 0.64–0.89 and milk yield and fertility of sows under different breeding methods r = 0.65–0.81.

In order to intensify the use of brood stock, various technological methods are used, one of which is the reduction of the length of the suckling period [2, 5, 16]. The timing of weaning piglets also has an impact on the reproductive qualities of pigs. According to scientists [26], the development of pig farming is moving towards increasing the weaning age of piglets. This allows for higher pig weights and higher average daily gains, better survival and a higher number of piglets at birth, and especially ensures more efficient use of production facilities and, as a result, increases profits. According to scientists [28], early weaning of piglets has a positive effect on the further reproductive capacity of sows and promotes the development of genital organs and improves the reproductive qualities of their daughters. Piglets that were weaned at 35 days had better developed internal organs and a secretory system, which allowed them to be significantly ahead of their counterparts that were weaned at 60 days in terms of average daily gains and feed efficiency [28]. Early weaning of piglets can

provide certain advantages of higher growth intensity only if appropriate conditions are created, without which this measure will not be effective [4]. The main conditions for successful rearing of early-weaned piglets are good health and development of piglets at weaning, provision of piglets with sufficient and complete feeding, warm and dry premises. In addition, it should be taken into account that if piglets are weaned too early, the involution of the sow's reproductive system is delayed [6, 21], and the length of the service period increases [1]. It was reported that the time of weaning reliably influenced the time of onset of heat in sows. In particular, sows from which piglets were weaned at 60 days old came to the farrowing house 5-7 days after weaning on average. Their counterparts, whose piglets were weaned at 45 days after the end of the suckling period, gave birth in 13-17 days. In this way, the reduction of the suckling period led to an increase in the period of arrival of sows in heat by 7-10 days [30].

Since it was found that there are ambiguous views of scientists on the strength of the relationship between the reproductive qualities of sows and the method of their breeding taking into account the length of the suckling period, we consider it urgent to continue researching this problem.

The purpose of our experiment was to establish the influence of the breed, pig breeding technology, litter size and piglet weaning period on their growth intensity and on the reproductive qualities of the sow.

MATERIALS AND METHODS

Four groups of sows were selected to study the influence of the breed and breeding method, the number of piglets in the nest at birth and the length of the suckling period on the productive qualities of sows of the Large White and Landrace breeds of the Irish selection of the genetic company Hermitage Genetics and their combining ability (according to the main indicators of reproductive ability). Each group included 10 sows (Table 1).

The first and third groups were made up of purebred sows of the Large White breed. The second and fourth groups included their purebred Landrace counterparts.

Table 1. Scheme of the experiment on the study of the influence of genotypic and paratypic factors on the reproductive qualities of pigs of maternal breeds

Group	Sows		Boars	
	Breed	Number	Breed	Number
I	Large White (GW)	10	Large White (GW)	3
II	Landrace (L)	10	Landrace (L)	3
III	Large White (GW)	10	Landrace (L)	3
IV	Landrace (L)	10	Large White (GW)	3

Source: Own calculation.

Sows of groups I and IV were inseminated with the sperm of boars of the Large White breed of the Irish company Hermitage Genetics. Their peers from II and III groups were inseminated with the sperm of Landrace boars of the same selection. Maintenance of sows in all periods of the reproductive cycle was identical according to the norms of the PIC company. The feed was also identical, full-rational and balanced, compound feed of our own production. The study evaluated the total number of piglets born, fertility, litter weight of piglets and their individual weight at birth, number, individual weight and nest weight of piglets at weaning, duration of suckling period of sows, survival of piglets until weaning.

Reproductive characteristics of pigs were calculated using the evaluation index of reproductive qualities (*I*) [25]:

$$I = B + 2W + 35G \quad \text{.....(1)}$$

where:

B is the number of piglets at birth, head;

W is number of weaned piglets, head;

G is average daily growth of piglets before weaning, kg.

The selection index of reproductive qualities of sows (SIRQS) was determined according to the methodology [31]:

$$(SIRQS) = 6X_1 + 9.34\left(\frac{X_2}{X_3}\right) \text{.....(2)}$$

where:
SIRQS is the selection index of reproductive qualities of sows;
X_1 is multifertility, goal;
X_2 is weight of the nest at weaning, kg;
$X_3$is weaning period, days;
6 and *9.34* are coefficients.
Heterosis indices were determined according to the formulas proposed by the methodology [32]:

$$Ht = \left(\frac{Hs}{Sb} \times 100\right) - 100 \text{ .....(3)}$$

where:
Ht is heterosis true;
*Hs*is hybrid sign;
*Sb*is sign of better parental form;

$$Hh = \left(\frac{2 \times Hs}{Sp + Sm} \times 100\right) - 100 \text{ .....(4)}$$

where:
Hh is heterosis hypothetical;
*Hs*is hybrid sign;
Sp is sign of the parent form;
Sm is sign of the mother form;

$$Hg = \left(\frac{Hs}{Sm} \times 100\right) - 100 \text{ .....(5)}$$

where:
Hg is heterosis general;
*Hs*is hybrid sign;
Sm is a sign of the mother form;

$$Hsp = \left(\frac{Hs}{Sp} \times 100\right) - 100 \text{ .....(6)}$$

where:
Hsp is heterosis specific;
*Hs*is hybrid sign;
Sp is sign of the parent form.

Statistical processing of data from experimental studies was carried out by biometric methods using Microsoft Excel software. The results were considered statistically significant at the first – $P<0.05$, the second – $P<0.01$, and the third – $P<0.001$ thresholds. To assess the closeness of the relationship between indicators of the reproductive capacity of sows, a correlation analysis was conducted using Statistica 10.
The methodological part of the experiment was approved by the Bioethical Commissions of Animal Care and Use during scientific (experimental) research of Sumy National Agrarian University (ethical approval number BT-22-110822-01).

RESULTS AND DISCUSSIONS

The analysis of the data showed that when using direct and reciprocal crossing, there was a tendency to increase the multifertility rate of sows by 0.2–0.6 piglets compared to counterparts that were bred by the purebred method. Landrace sows had a higher rate of multifertility compared to peers of the Great White breed at purebred breeding by 0.2 piglets.
We did not find any statistically significant discrepancies in the reproductive performance of sows of the experimental groups in terms of high fertility, although a tendency to its decrease with increasing multifertility was observed.
Number of weaned piglets turned out to be 0.9–1.4 more in crossbreed nests compared to purebred nests, but due to the small size of the sample, it turned out to be improbable.
The average weight of 1 piglet at weaning turned out to be the highest in sows of the Landrace breed when purebred breeding them. The piglets of this group were probably ($p<0.01$) heavier by 0.4 kg compared to the analogues of the control group and by 0.3 kg ($p<0.05$) heavier compared to peers of the III experimental group, and by 0.6 kg ($p<0.001$) heavier in comparison with the animals of the IV experimental group.

Table 2. Reproductive qualities of sows

Indicators	Group I (♀LW × ♂LW)	Group I (♀L × ♂L)	Group III (♀LW × ♂L)	Group IV (♀L ×♂LW)
Multifertility, heads	15.8±0.62	16.0±0.36	16.4±0.72	16.2±0.56
Weight of piglets at birth, kg	1.29±0.02	1.28±0.03	1.25±0.01	1.24±0.02
The nest weight of piglets at birth, kg	20.4±0.78	20.5±0.57	20.5±0.96	20.1±0.85
Number of weaned piglets, heads	13.9±0.43	13.5±0.34	14.4±0.51	14.8±0.49
The average weight of piglets at weaning, kg	7.5±0.15	8.1±0.10**	7.8±0.09*2	7.5±0.08***2
The weight of the nest of piglets at weaning, kg	104.3±4.62	108.4±4.78	111.5±4.72	110.7±3.96
Preservation of piglets,%	88.1±1.59	84.2±2.06	87.6±1.69	91.6±1.73
Index of reproductive qualities (I)	51.4	51.4	53.3	53.7
Selection index of reproductive qualities of sows(SIRQS)	129.6	132.2	135.6	134.1

* – P <0.05; ** – P <0.01; *** – P <0.001.
Source: own calculations.

We did not establish statistically confirmed differences in the weight index of weaned piglets, although a tendency to increase it by 3.3–7.2 kg was found in crossbred litters compared to purebred litters.

The preservation of piglets was lower in nests with high multiple fertility, and there was no probable difference between the groups.

The index of reproductive qualities of pigs (*I*) in the group where piglets were obtained by purebred breeding method was equivalent. In groups of piglets obtained from direct crossing, the Index of reproductive qualities of sows (*I*) was higher by 1.9 points compared to counterparts obtained using purebred breeding. The specified index (*I*) in pigs obtained from reciprocal crossing was 2.3 points higher compared to piglets obtained from purebred breeding. The Selection index of reproductive qualities of sows (SIRQS) was also higher by 2.0–6.0 points in crossbred animals compared to purebred breeding. For the latter, it turned out to be 2.6 points higher in sows of the Landrace breed compared to their Large White counterparts (Table 2).

We did not find statistically confirmed differences in most reproductive indicators of Great White and Landrace sows obtained using purebred breeding. The only exception was the piglet mass index at weaning, which was higher in Landraces. It was also noted that the use of the crossbreeding method compared to purebred breeding had a positive effect on the tendency towards growth of most reproductive indicators of pigs. However, the weight of piglets at weaning was outside the boundaries of the influential breeding method and did not differ when using different breeding methods. The weight of one piglet at weaning was probably higher in purebred litters of the Landrace breed compared to other investigated genotypes.

We conducted a study of the influence of various types of heterosis effect on increasing the productive qualities of sows when crossing maternal breeds. As can be seen from Table 3 when crossing sows of the Large White breed with boars of the Landrace breed, the total and true effect of heterosis was at the level of 12.33%, the hypothetical heterosis was 7.19%, and the specific heterosis was 7.19%.

In the reverse variant of the combination of these breeds, the manifestation of the effect of heterosis in any of its forms has not been established.

According to the indicator of the weight of piglets at birth, the manifestation of the effect of hybrid strength was not established either in the direct or in the reciprocal variants of the combination of these breeds.

At weaning, the manifestation of the heterosis effect was established for almost all signs (Table 4). Thus, in terms of the survival of piglets, the manifestation of general heterosis was the highest (8.79%) when sows of the Landras breed were combined with boars of the Large White breed. At the same time, the hypothetical heterosis was 6.33%, and the specific and real heterosis were 3.97% each.

In the reverse variant of the combination of these breeds, the manifestation of the general and true forms of heterosis was not established, while the specific and hypothetical forms were found at the level of 4.04 and 1.68%.

Table 3. Effect of heterosis on indicators of reproductive quality of sows during farrowing

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Multifertility, heads					
♀LW × ♂LW	15.8				
♀L × ♂L	16.0				
♀LW × ♂L	16.4	7.19	12.33	12.33	2.50
♀L ×♂LW	16.2	-7.19	-11.25	-2.74	-2.74
Weight of piglets at birth, kg					
♀LW × ♂LW	1.29				
♀L × ♂L	1.28				
♀LW × ♂L	1.25	-2.72	-3.10	-2.34	-2.34
♀L ×♂LW	1.24	-3.50	-3.13	-3.13	-3.88

Source: own calculations.

Table 4. Effect of heterosis on indicators of reproductive quality of sows during weaning

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Preservation of piglets,%					
♀LW × ♂LW	88.1				
♀L × ♂L	84.2				
♀LW × ♂L	87.6	1.68	-0.57	-0.57	4.04
♀L ×♂LW	91.6	6.33	8.79	3.97	3.97
Number of weaned piglets, heads					
♀LW × ♂LW	13.9				
♀L × ♂L	13.5				
♀LW × ♂L	14.4	5.11	3.60	3.60	6.67
♀L ×♂LW	14.8	8.03	9.63	6.47	6.47
The average weight of piglets at weaning, kg					
♀LW × ♂LW	7.5				
♀L × ♂L	8.1				
♀LW × ♂L	7.8	0	4.0	-3.70	-3.70
♀L ×♂LW	7.5	-3.85	-7.41	-7.41	0
The weight of the nest of piglets at weaning, kg					
♀LW × ♂LW	104.3				
♀L × ♂L	108.4				
♀LW × ♂L	111.5	4.84	6.90	6.90	2.86
♀L ×♂LW	110.7	4.09	2.12	6.14	6.14

Source: own calculations.

In terms of the number of piglets at weaning, the nests of sows of the Landrace breed differed by their combination with boars of the Large White breed, and their true and specific forms of heterosis were at the level of 6.47%. The general and hypothetical heterosis wereat the levels of 9.63 and 8.03% respectively.

In the reverse variant of the combination of these breeds, lower rates of heterosis were established in all its forms.

According to the average weight of one piglet at weaning, it was found that there was no manifestation of the effect of hybrid power when crossing Landrace sows with boars of the Large White breed, while in the case of backcrossing, only its general form was established.

According to nest weight of weaned piglets, the manifestation of the effect of hybrid power was established both in direct and backcrossing. Somewhat higher values of hypothetical, general and true forms of

heterosis were obtained for the combination of Large White breed sowsand Landrace boars. The specific heterosis turned out to be higher during the reverse combination.

Manifestation of different forms of the heterosis effect according to a set of traits was compared using the comparison of two indices (Table 5).

Table 5. The effect of heterosis on a set of indicators of reproductive quality

Breeds combination	Indicators	Heterosis hypothetical, %	Heterosis general, %	Heterosis true, %	Heterosis specific, %
Selection index of reproductive qualities of sows(SIRQS)					
♀LW × ♂LW	129.6				
♀L × ♂L	132.2				
♀LW × ♂L	135.6	3.59	4.63	4.63	2.57
♀L ×♂LW	134.1	2.44	1.44	3.47	3.47
Index of reproductive qualities (I)					
♀LW × ♂LW	51.4				
♀L × ♂L	51.4				
♀LW × ♂L	53.3	3.70	3.70	3.70	3.70
♀L ×♂LW	53.7	4.47	4.47	4.47	4.47

Source: own calculations.

Thus, according to the selection index of reproductive qualities, higher levels of hypothetical, general and true forms of heterosis were noted in sows of the Large White breed when they were combined with boars of the Landrace breed, while specific heterosis was 0.90% higher than in the reciprocal variant of the combination of these breeds.

Thus, the advantages of crossbred nests over purebred litters in most characteristics were due to the manifestation of the heterosis effect, while the average weight of piglets at weaning, in our opinion, had an intermediate form of inheritance.

The relationship between individual indicators of reproductive characteristics of sows was evaluated using correlation analysis. Correlations were found between the multifertility indicator and the weight of newborn piglets, r = 0.92 ($p<0.001$). Correlation analysis also showed a relationship between multiple fertility and the number of weaned piglets r = 0.89 ($p<0.001$). Also, multifertility was correlated with the mass of weaned piglets r = 0.81 ($p<0.001$). The correlation between multifertility and the weight of weaned piglets was of medium strength r = -0.45 ($p<0.01$), Multifertility and piglet survival were connected by an inverse relationship of medium strength r = -0.44 ($p<0.05$).

The weight of newborn piglets was correlated only with the weight of weaned piglets.

The weight of the nest of newborn piglets was directly correlated with the indicator of the number of weaned piglets r = 0.84 ($p<0.001$), as well as with the weight of the nest of weaned piglets r = 0.81 ($p<0.001$).

A close correlation was found between the indicator of the number of weaned piglets and the nest weight of newborn piglets, r = 0.84 ($p<0.001$). Also, the number of weaned piglets was related to the indicator of the weight of the nest of weaned piglets by a strong correlation r = 0.82 ($p<0.001$), similarly to the indicator and the number of newborn piglets r = 0.92 ($p<0.001$).

The weight of weaned piglets had a close direct correlation r = 0.80 ($p<0.001$) with the weight of weaned piglets. However, the weight of weaned piglets was negatively correlated with the multifertility index r = -0.45 ($p<0.01$).

The weight of the nest of weaned piglets was closely related to the multifertility indicator r = 0.81 ($p<0.001$). The weight of the nest of weaned piglets was closely correlated with the indicator of the weight of the nest of newborn piglets r = 0.81 ($p<0.001$), similarly to the indicator of the number of weaned piglets r = 0.82 ($p<0.001$) and similarly to by the weight of weaned piglets, r = 0.80 ($p<0.001$).

The correlation between piglet survival rate and sow fertility was moderate and inverse r =

-0.44 ($p<0.05$). With the rest of the reproducible signs, the probable strength of the connections was not revealed.

Table 6. Correlation coefficients between the main indicators of reproducibility

Indicators	Multifertility	Weight of piglets at birth	The nest weight of piglets at birth	Number of weaned piglets	The average weight of piglets at weaning	The weight of the nest of piglets at weaningi	Preservation of piglets	The duration of the sucking period
Multifertility		-0.09	0.92***	0.89***	-0.45**	0.81***	-0.44*	0.22
Weight of piglets at birth	-0.09		0.12	-0.09	0.28	0.16*	0.002	-0.13
The nest weight of piglets at birth	0.92***	0.12		0.84***	0.47	0.81***	-0.35	0.23
Number of weaned piglets	0.89***	-0.09	0.84***		0.35	0.82***	-0.01	0.19
The average weight of piglets at weaning	-0.45**	0.28	0.47	0.35		0.80***	-0.30	-0.10
The weight of the nest of piglets at weaning	0.81***	-0.16*	0.81***	0.82***	0.80***		-0.18	0.02
Preservation of piglets	-0.44*	0.002	-0.35	-0.01	-0.30	-018		-0.18
The duration of the sucking period	0.22	-0.13	0.23	0.19	-0.10	0.02	-0.18	

* – P <0.05; ** – P <0.01; *** – P <0.001.
Source: own calculations.

Probable relationships between the duration of the subsucking period and other signs of reproductive performance have not been established.

The absence of a significant difference between the indicators of the reproductive qualities of pigs under different breeding methods was similar to similar results [19], which also showed the absence of any influence of the breeding method on the reproductive functions of pigs. In contrast to the reports [20], which indicated a reliable dependence of the number of weaned piglets on the breed of their closest ancestors, we did not detect the influence of the breed factor on the maternal qualities of lactating sows.

Similar to reports [14], in which the authors claimed that there is a negative strong correlation (r = – 0.70) between fertility and survival of piglets, we also established a negative inverse relationship between these indicators, but of medium strength. Similar to the results of the experiment [14], we found a correlation between the survival rate and the number of weaned piglets, but in our results it was weak and inverse (r = – 0.01), contrary to the average positive relationship found by the authors [14] (r = 0 ,52).

Also, the strength of the relationship established by us between the preservation of piglets and their number at the time of weaning (r = – 0.01) was significantly lower and reversed than in the mentioned experiment [14], where the correlation between the indicated indicators was average and positive (r = 0.52).

Survival in lower birth weight piglets tended to exceed survival in groups with higher birth weight piglets. This partially contradicts the findings of [8], which indicated that losses during rearing of piglets before weaning were highest in the group of piglets with the lowest birth weight.

We also found, similar to other scientists [27], that the duration of lactation did not have a reliable correlation relationship with the reproductive qualities of sows. From which we can conclude that there is no production need to make the lactation period longer.

CONCLUSIONS

The reproductive qualities of sows had a tendency to increase during their crossbreeding compared to purebred breeding, with the exception of the weight of one piglet at weaning. Both for the use of purebred breeding and for the use of crossbreeding, the weight of weaned piglets was higher in Landrace sows compared to counterparts born from Great White sows and compared to peers.

The effect of heterosis was confirmed on almost all reproductive characteristics of sows, including the weight of weaned piglets. It was found that the index of multiple fertility and the weight of the nest of newborn piglets were in a close direct correlation. Multifertility was also closely correlated with the number of weaned piglets and the weight of the nest of weaned piglets. Fertility and weight of weaned piglets were inversely correlated, as well as fertility and survival of piglets.

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