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Breeding value and productivity in sows of the Large White breed

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The article presents the results of research on the indicators of own productivity of replacement pigs and reproductive qualities of sows of different breeding value and determines the economic efficiency of research results. The study was conducted in agricultural formations of Dnipropetrovsk and Sumy regions, the livestock laboratory of the Institute of Grain Crops of NAAS, and the livestock and feed production laboratory of the Institute of Agriculture North-East of NAAS. The evaluation of replacement pigs on indicators of own productivity and sows on signs of reproductive qualities was carried out taking into account the following parameters: age of achievement of live weight of 100 kg, days; fat thickness at the level of 6-7 thoracic vertebrae, mm; the thickness of the fat at the midpoint of the back between the withers and buttocks, mm; thickness of lard on the sacrum, mm; torso length, cm; fertility, goal; nest weight at the time of weaning at the age of 28 days, kg, safety, %. The BLUP index (maternal line) was calculated according to the general model of a single animal (P.A. Vashchenko, 2019), the reproductive quality index (RQI) – according to the method of I.P. Sheiko and others. (2006), the index of alignment (homogeneity) of the sow's nest by live weight of piglets at the time of their birth (IVG_0) – according to the method of V.I. Khalak (2012), biometric processing of research results - according to the methods of G.F. Lakin (1990). It is established that replacement pigs of the Large White breed based on their productivity (age of reaching live weight 100 kg, days, fat thickness at the level of 6-7 thoracic vertebrae, mm) belong to the elite class. The number of sows, which by fertility, milk yield, and nest weight at the time of weaning at the age of 60 days (estimated) belong to the elite class is 71.73, 41.30, and 37.68%, respectively. A significant difference between replacement pigs of different breeding value (M^+, M^-) was established by the age of reaching a live weight of 100 kg (12 days, td = 4.58, P<0.001), the thickness of the fat at the level of 6-7 thoracic vertebrae (2.4 mm, td = 6.67, P<0.001), the thickness of the fat at the midpoint of the back between the withers and buttocks (1.1 mm, td = 3.14, P<0.01), the thickness of the fat on the buttocks (2.1 mm, td = 6.77, P<0.001) and body length - 1.9 cm (td = 4.14, P<0.001). Sows of group I (BLUP index is 109.78-128.75 points) outperformed peers of group III (BLUP index is 53.61-89.91 points) in the fertility by 27.13% (td = 10.60, P<0.001), milk yield - 27.86% (td = 10.86, P<0.001), the number of piglets at the time of weaning at the age of 28 days - 27.27% (td = 12.00, P<0.001), nest weight at the time of weaning at the age of 28 days - 21.37% (td = 10.57, P<0.001) and the index of reproductive qualities (RQI) - 24.52% (td = 11.50, P<0.001). According to the IVG_0 index, the difference between the groups M^- and M^+ is 28.15% (td = 9.82, P<0.001), which indicates greater homogeneity of sows of class M^-. According to the BLUP index for pigs of the Large White breed of the controlled herd, the criterion for selecting highly productive animals is the indicators 109.78-128.75, according to the index of reproductive qualities (RQI) - 101.43-161.72 points. The pairwise correlation coefficient between the absolute indicators of reproductive qualities of sows, the BLUP index (maternal line), the index "alignment (homogeneity) of the sow's nest by live weight of piglets at birth," and the index of reproductive qualities ranges from +0.648 to +0.984. M+ class sows provide additional products at the level of +13.08%, and its cost is +332.08 UAH/head.
Keywords: replacement pig, own productivity, sow, reproductive qualities, breeding value, index, variability, correlation, economic efficiency.

Introduction

Both individual sources of information and their combinations are used to assess the breeding value of pigs (Schiavo et al., 2015; Kramarenko, 2017; Martyshuk et al., 2019; 2020; Khalak et al., 2020; Khalak & Gutyj, 2020). Thus, according to the requirements of the Instruction on grading pigs (2003), take into account the absolute indicators of their productivity of

replacement young (live weight 100 kg, fat thickness at the level of 6-7 thoracic vertebrae, mm), reproductive qualities of sows and breeding boars (multiplicity, goal, milk yield, kg, the weight of nest and offspring at the time of weaning, kg), fattening and meat qualities of their offspring (age of reaching live weight 100 kg, feed consumption per 1 kg of grain, feed units, fat thickness at the level of 6-7 thoracic vertebrae, mm, length of the chilled carcass, cm).

Based on these absolute productivity indicators, several indices have been developed and implemented, which are practical tools for evaluating and selecting highly productive animals (Bazhov & Komlatskiy, 1989; Bekenev, 2007; Getya, 2009, Tserenyuk et al., 2012). The topical issue is the use in the selection work of genotyping data on DNA markers and the BLUP model (Best Linear Unbiased Prediction - the best linear unbiased prediction) (Tserenyuk et al., 2010; Kovalenko, 2011; Khalak, 2015; Voloshchuk & Khalak, 2015; Girya et al., 2018).

The work aims to investigate the indicators of own productivity of replacement pigs and reproductive qualities of sows of different breeding value and determine the economic efficiency of research results. We identified the following tasks:
- to evaluate replacement pigs based on their productivity, sows - on indicators of reproductive qualities;
- based on the calculation of the BLUP index to determine the breeding value of pigs in the controlled herd;
- calculate the level of correlations between traits and economic efficiency of the use of pigs of different breeding values.

Materials and Methods

The study was conducted in agricultural formations of Dnipropetrovsk and Sumy regions, the livestock laboratory of the Institute of Grain Crops of NAAS and the livestock and feed production laboratory of the Institute of Agriculture of the North-East of NAAS. The study's object was replacement pigs and sows of the Large White breed (n = 138). The work was performed according to the research program of NAAS №30 "Pig breeding".

The BLUP index (maternal line) was calculated at the Main Breeding Center for Pig Breeding (Institute of Pig Breeding and AIP NAAS of Ukraine) according to the general model of a single animal (Vashchenko, 2010).

A comprehensive evaluation of sows reproductive qualities was performed according to the following mathematical models:

$$IVG_0 = \frac{n}{2.5 - (\frac{x_{max} - x_{min}}{\overline{X}})}, \qquad (1)$$

where: IVG_0 - index of alignment of the sow's nest by live weight of piglets at the time of their birth, score, n – fertility, goal; 2.5 – the maximum live weight of one piglet at birth, kg; x_{max} – the live weight of piglets in the nest with the maximum value, kg; x_{min} – the live weight of piglets in the nest with a minimum value, kg; $\overline{X}$ – the average live weight of piglets in the nest at birth (sow fertility), kg (Khalak, 2012);

$$IRQ = (1.1 \times X_1) + (0.3 \times X_2) + (3.3 \times X_3) + (0.67 \times X_4), \qquad (2)$$

where: IRQ – index of reproductive qualities of the sow, score; X_1 – fertility, goal; X_2 – the weight of piglets at 21 days of age (milk yield), kg; X_3 – the number of piglets at the time of weaning, ch.; X_4 – a mass of the nit at the time of weaning, kg (Shejko et al., 2008).

The economic research efficiency was evaluated by Methodology (1983).

The strength of the correlations between traits was performed on the Cheddock scale (Sidorova et al., 2003) (Table 1).

Table 1. Cheddock scale for grading the strength of the correlation

The value of the correlation coefficient	Correlation strength
0.1–0.3	Weak
0.3–0.5	Moderate
0.5–0.7	Noticeable
0.7–0.9	High
0.9–0.99	Very high

The results were processed by the method of variation statistics (Lakin, 1990).

Results and Discussion

Studies have shown that the age of reaching a live weight of 100 kg is 175.8 ± 0.88 days (Cv = 5.90%), the thickness of the fat at the level of 6–7 thoracic vertebrae – 22.9 ± 0.13 mm, (Cv = 6,80%), the thickness of the fat at the midpoint of the back between the withers and buttocks – 17.2 ± 0.12 mm (Cv = 8.76%), the thickness of the fat on the buttocks - 20.3 ± 0.10 mm, (Cv = 6,23%), body length – 116.7 ± 0.16 mm (Cv = 1.62%), fertility of sows – 11.1 ± 0.14 piglets per farrowing (Cv = 15.82%), high fertility – 1.41 ± 0.009 kg (Cv = 7.94%), the index of uniformity (homogeneity) of the sow's nest by live weight of piglets at the time of their birth – 5.23 ± 0.85 points (Cv = 17.16%), milk yield – 51.9 ± 0.81 kg (Cv = 18.44%), the number of piglets at weaning – 9.4 ± 0.13 goals (Cv = 16.57%), nest weight at weaning at the age of 28 days, kg – 74.4 ± 0.85 kg (Cv = 13.43%), safety - 84.9 ± 0.49%.

The index of reproductive qualities of the sow (IRQ) is equal to 108.77 ± 1.375 points (Cv = 14.86%), the index of breeding value (index BLUP, maternal line) – 99.82 ± 1.246 points (Cv = 14.67%).

We found that the difference between replacement pigs of different breeding value (M^+, M^-) at the age of reaching a live weight of 100 kg is 12 days (td = 4.58, P<0.001), the thickness of the fat at the level of 6–7 thoracic vertebrae – 2.4 mm (td = 6.67,

P<0.001), the thickness of the fat at the middle point of the back between the withers and buttocks – 1,1 mm (td = 3.14, P<0.01), the thickness of the fat on the buttocks – 2.1 mm (td = 6.77, P<0.001), body length – 1.9 cm (td = 4.14, P<0.001).

Studies of signs of own productivity of replacement pigs and indicators of reproductive qualities of sows of the Large White breed of different breeding value are given in Table 2.

Table 2. Indicators of signs of own productivity of replacement pigs and indicators of reproductive qualities of sows of the Large White breed of various pedigree value

Indicators, units of measurement	Biometric Indicators	Distribution class by index "BLUP" (mother line), X ± (0.67 × σ)		
		M⁺	M⁰ index gradation	M⁻
		109.78-128.75	90.35-109.51	53.61-89.91
			Group	
		I	II	III
Age of reaching live weight 100 kg, days	n	30	73	35
	$\overline{O} \pm S_{\overline{x}}$	189.0 ± 2.21	181.9 ± 1.18	177.0 ± 1.42
	$\sigma \pm S_G$	12.11 ± 15.645	10.16 ± 0.841	8.41 ± 1.005
	$Cv \pm S_{Cv}$,%	6.40 ± 0.826	5.58 ± 0.461	4.75 ± 0.568
The thickness of the fat at the level of 6-7 thoracic vertebrae, mm	$\overline{O} \pm S_{\overline{x}}$	24.8 ± 0.27	23.1 ± 0.18	22.4 ± 0.25
	$\sigma \pm S_G$	1.47 ± 0.189	1,57 ± 0.129	1.62 ± 0.193
	$Cv \pm S_{Cv}$,%	5.92 ± 0.683	6.79 ± 0.562	7.23 ± 0.873
The thickness of the fat at the midpoint of the back between the withers and buttocks, mm	$\overline{O} \pm S_{\overline{x}}$	18.1 ± 0.27	17.3 ± 0.18	17.0 ± 0.23
	$\sigma \pm S_G$	1.50 ± 0.193	1.56 ± 0.129	1.38 ± 0.165
	$Cv \pm S_{Cv}$,%	8.28 ± 1.069	9.01 ± 0.745	8.11 ± 0.970
The thickness of the fat on the buttocks, mm	$\overline{O} \pm S_{\overline{x}}$	21.2 ± 0.22	20.3 ± 0.14	19.1 ± 0.23
	$\sigma \pm S_G$	1.22 ± 0.157	1.27 ± 0.105	1.31 ± 0.156
	$Cv \pm S_{Cv}$,%	5.75 ± 0.742	6.25 ± 0.517	6.82 ± 0.815
Body length, cm	$\overline{O} \pm S_{\overline{x}}$	117.8 ± 0.33	116.5 ± 0.22	115.9 ± 0.32
	$\sigma \pm S_G$	1.83 ± 0.236	1.91 ± 0.158	1.92 ± 0.229
	$Cv \pm S_{Cv}$,%	1.55 ± 0.200	1.63 ± 0.134	1.65 ± 0.197
Multiplicity, heads	$\overline{O} \pm S_{\overline{x}}$	12.9 ± 0.21	11.1 ± 0.13	9.4 ± 0.26
	$\sigma \pm S_G$	1.20 ± 0.155	1.14 ± 0.094	1.57 ± 0.187
	$Cv \pm S_{Cv}$,%	9.29 ± 1.281	10.26 ± 0.849	16.76 ± 2.004
IVG₀, points	$\overline{X} \pm S_{\overline{x}}$	6.11 ± 0.112	5.26 ± 0.075	4.39 ± 0.135
	$\sigma \pm S_G$	0.61 ± 0.078	0.64 ± 0.052	0.80 ± 0.095
	$Cv \pm S_{Cv}$,%	10.10 ± 1.304	12.18 ± 1.008	18.27 ± 2.185
Milk yield, kg	$\overline{X} \pm S_{\overline{x}}$	62.8 ± 1.46	50.5 ± 0.96	45.3 ± 0.69
	$\sigma \pm S_G$	8.03 ± 1.037	8.24 ± 0.682	4.09 ± 0.489
	$Cv \pm S_{Cv}$,%	12.78 ± 1.651	16.31 ± 1.350	9.04 ± 1.081
Number of piglets at the time of weaning, heads	$\overline{X} \pm S_{\overline{x}}$	11.0 ± 0.19	9.4 ± 0.15	8.0 ± 0.17
	$\sigma \pm S_G$	1.00 ± 0.129	1.30 ± 0.107	1.05 ± 0.125
	$Cv \pm S_{Cv}$,%	9.84 ± 1.271	13.80 ± 1.142	13.10 ± 1.566
The weight of the nest at the time of weaning at the age of 28 days, kg	$\overline{X} \pm S_{\overline{x}}$	85.6 ± 1.54	73.3 ± 1.00	67.3 ± 0.79
	$\sigma \pm S_G$	8.46 ± 1.093	8.55 ± 0.707	4.68 ± 0.559
	$Cv \pm S_{Cv}$,%	9.88 ± 1.276	11.67 ± 0.966	6.96 ± 0.832
Preservation of piglets before weaning, %	$\overline{X}$	85.27	84.68	85.10
	Lim	101.43-161.72	87.46-147.56	84.46-113.86
IRQ, Score	$\overline{X} \pm S_{\overline{x}}$	126.7 ± 2.27	107.7 ± 1.56	95.63 ± 1.48
	$\sigma \pm S_G$	12.44 ± 1.607	13.36 ± 1.105	8.78 ± 1.050
	$Cv \pm S_{Cv}$,%	9.82 ± 1.268	12.41 ± 0.027	9.19 ± 1.099

The analysis of the reproductive qualities of sows show that the animals of group I outnumbered their peers of group III in terms of fertility by 3.5 piglets per farrowing (td = 10.60, P<0.001), milk yield - 17.5 kg (td = 10.86, P<0.001), the number of piglets

at weaning at the age of 28-35 days - 3.0 goals (td = 12.00, P<0.001), the weight of the nest at weaning at the age of 28 days – 18.3 kg (td = 10.57, P<0.001) and the index of reproductive qualities (IRQ) - 31.07 points (td = 11.50, P<0.001). According to the IVG_0 index, the difference between the groups M^- and M^+ is equal to 1.72 points (td = 9.82, P<0.001), which indicates greater homogeneity of sows of class M^-.

The calculation of the coefficients of pairwise correlation between the characteristics of reproductive qualities and evaluation indices in sows of the Large White breed is shown in Table 3.

Table 3. The pairwise correlation coefficient between the characteristics of reproductive qualities and evaluation indices in pigs of Large White breed

Feature		Biometric indicators		Correlation strength
x	y	r ± Sr	tr	
	1	0.710 ± 0.0422***	16.81	High
	2	0.648 ± 0.0492***	13.12	Noticeable
	3	0.667 ± 0.0471***	14.11	Noticeable
Index BLUP (maternal line), points	4	0.657 ± 0.0471***	13.58	Noticeable
	5	-	-	-
	6	0.665 ± 0.0474***	14.02	Noticeable
	7	0.685 ± 0.0452***	15.16	Noticeable
	1	0.947 ± 0.0088***	107.80	Very high
	2	0.751 ± 0.0371***	20.23	High
	3	0.872 ± 0.0204***	42.75	High
Index "uniformity (homogeneity) of the sow's nest by live weight of piglets at birth", points	4	0.764 ± 0.0354***	21.56	High
	5	0.665 ± 0.0474***	14.02	Noticeable
	6	-	-	-
	7	0.900 ± 0.0162***	55,64	High
	1	0.899 ± 0.0163***	55,06	High
	2	0.978 ± 0.0037***	264,00	Very high
	3	0.975 ± 0.0042***	231,36	Very high
Index of reproductive qualities (IRQ), points	4	0.984 ± 0.0086***	109,93	Very high
	5	0.685 ± 0.0452***	15,16	Noticeable
	6	0.842 ± 0.0248***	33,98	High
	7	-	-	-

The pairwise correlation coefficient between the absolute indicators of reproductive qualities of sows, the BLUP index (maternal line), the index "alignment (homogeneity) of the sow's nest by live weight of piglets at birth," and the index of reproductive qualities ranges from +0.648 to +0.984. Significant relationships were established between the following pairs of traits: BLUP index (maternal line) × fertility (r = +0.710), BLUP index (maternal line) × milk yield (r = +0.648), BLUP index (maternal line) × number of piglets per weaning time (r = +0.667); BLUP index (maternal line) × nest weight at the time of weaning at the age of 28 days (r = +0.657), BLUP index (maternal line) × index of alignment (homogeneity) of the sow's nest by live weight of piglets at the time of birth (r = +0.665); index of alignment (homogeneity) of the sow's nest by live weight of piglets at the time of birth × multiplicity (r = +0.947); index of alignment (homogeneity) of the sow's nest by live weight of piglets at the time of birth × nest weight at the time of weaning at the age of 28 days (r = +0.764), reproductive quality index (IRQ) × fertility (r = +0.899), reproductive index qualities (IRQ) × milk yield (r = +0.978), index of reproductive qualities (IRQ) × number of piglets at the time of weaning (r = +0.975), index of reproductive qualities (IRQ) × weight of the nest at the time of weaning at the age of 28 days (r = +0.984), index of reproductive qualities (IRQ) × index of alignment (homogeneity) of the sow's nest by live weight of piglets at birth (r = +0.842).

Table 4. Economic efficiency of using sows of different breeding value, evaluated by the BLUP method (maternal line)

Class distribution according to the BLUP index (maternal line)	n	The weight of the nest at the time of weaning at the age of 28 days, kg	Addition of additional products,%	Cost of additional products, UAH / head *
General sample	138	74.4 ± 0.82	-	-
M^-	35	67.3 ± 0.79	-9.54	-242.21
M^0	73	73.3 ± 1.00	-1.47	-37.32
M^+	30	85.6 ± 1.54	+13.08	+332.08

Note: * **-** the average sale price of young pigs at processing enterprises is 45.5 UAH/kg

Calculations of economic efficiency of research results show that the maximum increase in additional products was obtained from sows of class M$^+$ +13.08%, and its cost is +332.08 UAH/head.

Conclusions

Studies show that the Large White breed replacement pigs belong to the elite class due to productivity (age of live weight 100 kg, days, fat thickness at the level of 6-7 thoracic vertebrae, mm). The number of sows, which by fertility, milk yield, and nest weight at the time of weaning at the age of 60 days (estimated) belong to the elite class is 71.73, 41.30, and 37.68%.

A significant difference between replacement pigs of different breeding value (M$^+$, M$^-$) was established by the age of reaching a live weight of 100 kg (12 days, td = 4.58, P<0.001), the thickness of the fat at the level of 6-7 thoracic vertebrae (2.4 mm, td = 6.67, P<0.001), the thickness of the fat at the midpoint of the back between the withers and buttocks (1.1 mm, td = 3.14, P<0.01), the thickness of the fat on the buttocks (2.1 mm, td = 6.77, P<0.001) and body length - 1.9 cm (td = 4.14, P<0.001).

Sows of group I (BLUP index is 109.78-128.75 points) outperformed peers of group III (BLUP index is 53.61-89.91 points) in the fertility by 27.13% (td = 10.60, P<0.001), milk yield – 27.86% (td = 10.86, P<0.001), the number of piglets at the time of weaning at the age of 28-35 days - 27.27% (td = 12.00, P<0.001), nest weight at the time of weaning at the age of 28 days – 21.37% (td = 10.57, P<0.001) and the index of reproductive qualities (CPI) - 24.52% (td = 11.50, P<0.001). According to the IVG$_0$ index, the difference between the groups M$^-$ and M$^+$ is 28.15% (td = 9.82, P <0.001), which indicates greater homogeneity of sows of class M$^-$.

According to the BLUP index for pigs of the Large White breed of the controlled herd, the criteria for selecting highly productive animals are within 109.78-128.75, according to the index of reproductive qualities (IRQ) 101.43-161.72 points.

The coefficient of pair correlation between the absolute indicators of reproductive qualities of sows, the index BLUP (maternal line), the index "alignment (homogeneity) of the sow's nest by live weight of piglets at birth," and the index of reproductive qualities ranges from +0.68 to +. The use of sows of class M$^+$ provides additional products at the level of +13.08%, and its cost is +332.08 UAH/head.
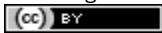
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