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SELECTION FOR IMPROVING PERFORMANCE OF DUROC, LANDRACE AND YORKSHIRE PUREBREDS RAISED AT DABACO COMPANY

ABSTRACT OF PHD THESIS

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LIST OF PUBLISHED WORKS

1. Luu Van Trang, Tran Xuan Manh, Pham Van Hoc, Luu Quang Du, Nguyen Van Khoa and Dang Vu Binh **(2021).** SELECTION FOR IMPROVING GROWTH PERFORMANCE OF DUROC, LANDRACE AND YORKSHIRE PURBREDS AT DABACO NUCLEAR PIG BREEDING COMPANY. Journal of Animal Science and Technology – Institute of Animal Sciences, No. 123, May 2021, pages 41-52.

2. Luu Van Trang, Tran Xuan Manh, Pham Van Hoc, Luu Quang Du, Nguyen Van Khoa and Dang Vu Binh **(2021).** SELECTION TO IMPROVE NUMBER OF PIGLET BORN ALIVE OF PURE LANDRACE AND YORKSHIRE SOWS AT DABACO NUCLEAR PIG BREEDING COMPANY. Journal of Animal Science and Technology – Institute of Animal Sciences, No. 123, , May 2021, pages 53-64.

3. Luu Van Trang, Tran Xuan Manh, Pham Van Hoc, Luu Quang Du, Nguyen Van Khoa and Dang Vu Binh **(2019).** PRODUCTION AND REPRODUCTION PERFORMANCES AND SOME GENETIC PARAMETERS OF MAIN TRAITS OF DUROC, LANDRACE AND YORKSHIRE BREEDS RAISED AT DABACO NUCLEUS BREEDING PIG COMPANY Journal of Animal Science and Technology – Institute of Animal Sciences, No. 100, June 2019, pages 30-43

INTRODUCTION

1.1. URGENCY OF THESIS SUBJECT

Duroc (D), Landrace (L) and Yorkshire (Y) are 3 main pig breeds used in intensive farming systems in most countries around the world as well as in Vietnam. The three pig breeds also participate in all most of the crossbred formula in intensive, semi-intensive systems with different scales in our country. Y and L pigs not only create crossbred sows of these systems, but they are terminal boars to creat crossbreds in livestock smallholder farmers. Meanwhile, D and Piétrain pigs are used to create commercial hybrids of 3 or 4 different breeds.

Improving the growth rate of pure Dpigs, as well as reproductive performance of pure L and Y pigs are an important task in the pig production for exotic breeds in our country.

Over the years, some breeding centers or breeding companies in our country have built a 3-level breeding pig system, in which the GGP herds of the three pure breeds imported from abroad. Every year, most of these centers or companies have to import a certain number of pure boar and sow pigs from different countries in order to supply genetic resources and improve the quality of the nuclear herds. In recent years, a number of studies on pure exotic pig herds raised in our country have been conducted in order to assess the status of growth and reproductive performance, estimate some important genetic parameters, as well as carry out some selective methods for these breeding pigs (Nguyen Huu Tinh et al., 2013; Nguyen Van Duc, 2015; Trinh Hong Son, 2015; Le Van Sang et al., 2018; Tran Thi Minh Hoang). and cs., 2019a, 2019b, 2019c).

Dabaco Nuclear Pig Breeding Company (Dabaco Company) was established in 2010 with a scale of 3,400 sows. The D, L and Y pigs were bred in GGP, GP and PS herds. Researched by Doan Phuong Thuy cs. (2015 and 2016) have determined some genetic parameters of some growth and reproductive traits for 3 purebred breeds raised at Dabaco Company and built a selection orientation for these pure breeds. On the basis of some data from Dabaco Company and other breeding farms, Tran Thi Minh Hoang (2020) also estimated the breeding values of some basic reproductive traits of L and Y sows. However, these studies did not set a specific goal in improving the performance of pure D, L and Y herds raised at Dabaco Company.

As a nuclear pig breeder, over the years, Dabaco Company has built a data set with a complete pedigree and individual testing as well as the reproductive

performance of pureD, L and Y breeds. This study was carried out on the basis of the above data set to estimate some genetic parameters and based on EBV select to improve the performances of 3 pure breeds raised at Dabaco Company.

1.2. STUDY OBJECTIVES

General objective

To estimate genetic parameters of some growth and reproductive traits, use BLUP method to predicte estimated breeding value (EBV) and selection by EBV to improve the growth performance of pure D, L and Y pigs, improve the reproductive performance of pure L and Y pigs, contribute to meet the requirements of pig production in our country.

Specila objectives

- Evaluate the results of individual testing, reproductive performance of sows, estimate genetic parameters for some growth and reproductive traits of the GGP herds of D, L and Y breeds raised at Dabaco Company.

-Based on EBVselect to improve the growth performance of pure D, L and Y boars;

- Based on EBV selectto improve the reproductive perfomance of pure L and Y sows.

1.3. FINDINGS OF THE SUBJECT

- Using a large data set collected over a long period of time, estimating heritability, genetic and phenotypic correlation coefficients of some growth and reproductive traits of pureD, L and D pigs;

- Using the BLUP method and based on EBV selecting to improve the ADG of pure D, L and Y pigs, and improve the number of piglets born alive per litter (NBA) of pure L and Y sows raised at Dabaco Company.

1.4. SCIENTIFIC AND PRACTICAL VALUES OF THESIS

1.4.1. Scientific value

- Estimate some genetic parameters for growth and reproductive traits of pure D, L and Y pig breeds raised in our country;

- Use the BLUP method to select and improve the growth performance of D, L and Yboars, improve the reproductive performance of pure L and Y sows raised in our country.

1.4.2. Pratical value

- Contribute to improving the performances of pure D, L and Y pig breeds raised at Dabaco Company;

- Add materials for research and training on exotic pig breeds raised in our country.

The thesis included 99 pages, exception of the references and appendices, 34 tables, 8 figures, 130 references including 51 Vietnamese documents and 79 foreign language documents.

2. LITERATURE REVIEW

2.1. SCIENTIFIC BASIS OF THESIS

The research issues of the thesis were scientifically based on the characteristics of quantitative traits, genetic parameters, EBV by BLUP, growth and reproductive traits of pigs and other influence factor.

2.2. RESEARCH IN VIETNAM AND OTHER COUNTRIES

The thesis has evaluated domestic and foreign research on genetic parameters of growth and reproductive traits of 3 pure D, L and Y breedpigs raised in abroad and in our country.

The domestic research works were mainly refer to the reproduction and growth rate of hybrids, there were still few studies on evaluation of pure breeds, genetic characteristics and selection orientations. Therefore, evaluation of growth performance through ADG trait as well as reproductive performance of sows through NBA trait per litter, selection to improve the performances of 3 D, L and Y pig breeds in GGPherds raised at Dabaco Company in this study is very necessary that contribute to improving the genetic potential of exotic breed pigs, meeting the requirements of the pig production in our country.

3. CONTENTS AND METHODS

3.1. CONTENTS

The thesis was conducted with 3 research topics:

- Evaluate productivity and estimate some genetic parameters of main traits of pure D, L and Y pigs raised at Dabaco Company;

- Select to improve ADG trait of pure D, L and Y boars raised at Dabaco Company;

- Select to improve NBA per litter of pure L and Y sows raised at Dabaco Company.

3.2. MATERIALS AND METHODS

3.2.1. Evaluateproductivity and estimate some genetic parameters of main traits of pure D, L and Y pigs raised at Dabaco Company

3.2.1.1. Materials

Research materials were gilt and male pigs, sows in the GGP herd raised at Dabaco Company from 2011 to 2017.

3.2.1.2. Methods

Male and female in the period ofindividual testing

The males and females at the begining of the period of individual testinghad body weight of 25 - 40 kg, corresponding to 70 - 75 days of age, and the end of testing had body weight of 90 - 100 kg, corresponding to 130 - 150 days of age.

Pigs were raised in separate groups in closed housing with ventilation and cooling fans in the summer. The individual density was 12 – 15 pigs/barn; 1.5 - 1.8 m^2/pig. The pigs were feeding *ad libitum* and used automatic nipples.

Body weigh was weighed on thestartand end date oftesting, lean meat percentage (LM) was determined on the enddate oftesting by indirect method through back fat, loin thickness measured by EXAGO equipment at position P2.

Reproductive sows

The sows were selected according to the regulations of Dabaco Company, artificially inseminated by double mating method. The diets were according to the technical process of Dabaco Company.

Reproductive performance of each sow was considered by the following criteria: date of birth, date of farrowing, mating boar, total number of piglets born per litter (TNB), number of piglets born alive (NBA), body weight of NBA, number of piglets raised per litter, weaning date, number of piglets weaned per litter (NW) and litter weight at birth (LWB) and at weaning (LWW).

Calculating methods

The monitoring data were imported into Excel 2010 software, excluding values outside the range of Mean ± 3 SD.

Statistical model to evaluate the influence of breeds on idividual testing traits:

$Y_{ijklm} = \mu + G_i + S_j + YS_k + W_l + e_{ijklm}$

in which, Y_{ijklm}: phenotypic value of the trait; μ: population mean; G_i: influence of breed; S_j: influence of sex; YS_kinfluence of year – season; W_l: influence of body weight atthe test starting; e_{ijklm}: random error.

Statistical model to evaluate the influence of breeds on reproductive performance traits:

$Y_{ikmno} = \mu + G_i + YS_k + B_m + L_n + e_{ikmno}$

in which, Y_{ikmno}: phenotypic value of the trait; μ: population mean; G_i: influence of breed; YS_k: influence of year - season; B_m: influence of the breed of mating boars; L_n: influence of litter; e_{ikmno}: random error.

Statistical model was used to evaluate the influencing factors for 2 traits of ADG

during the testing period and back fat at the end of the testing period:

$Y_{jklm} = \mu + S_j + YS_k + W_l + e_{jklm}$

in which, Y_{jklm}: phenotypic value of the trait; μ: population mean; S_j: influence of sex; YS_k: influence of year - season; W_l: influence of body weight at the test starting; e_{jklm}: random error.

Statistical model was usd to evaluate the influencing factors for 3 traits of litter size of reproductive sows for each breed:

$Y_{kmno} = \mu + YS_k + B_m + L_n + e_{kmno}$

in which, Y_{kmno}: phenotypic value of the trait; μ: population mean; YS_k influence of year - season; B_m: influence of the breed of mating boar; L_n: influence of litter; e_{kmno}: random error.

For the above statistical models, GLM procedure of SAS 9.1.3 using to evaluate the influence of factors, calculate LSM, SE parameters and compare by Tukey.

The pedigree and data files were used PEST to encode data and VCE6 to estimate genetic parameters.

3.2.2. Select to improve ADG of pure D, L and Y breeding boars raised at Dabaco Company

3.2.2.1. Materials

The research materials were males and females of 3 pure D, L and Y breds raised for the individual testing at Dabaco Company from 2015 to 2021.

3.2.2.2. Methods

- *Male and female in the period ofindividual testing*

The individual testing was in the content of the first study.

- *The males were selected through 3 stages*

The selected stages presented in figure 1.

In each stage, the best males after individual testing were kept with the percentage of 5% for the next stage. After semen quality checking and mating training, the trained boars were used for insemination in the next stage.

- *Selection methods*

Data sets of individual testing were entered into Excel 2010 software, excluding excluding values outside the range of Mean ± 3 SD.

The pedigree and data files were used PEST to encode data and VCE6 to estimate genetic parameters. The EBV of ADG was predicted using PEST, then the males which had highest EBV were selected with the percentage of 5%.

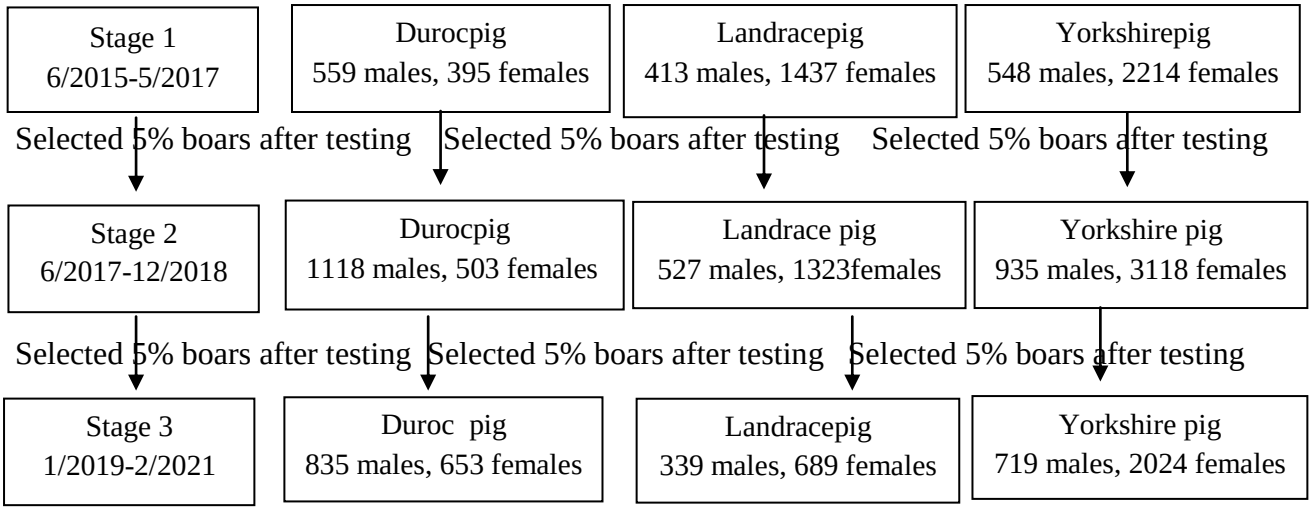

Figure 1. Diagram of selection stages for males

- *Evaluating selective results*

Selection results were evaluated through phenotypic value, EBV, accuracy of EBV and genetic tendency of the ADG trait over the selection periods.

3.2.3. Select to improve the NBA of pure L and Y sows raised at Dabaco Company

3.2.3.1. Materials

The research materials were L and Y sows raised at Dabaco Company from 2015 to 2021. The sows were evaluated and selected through 2 stages with the number of sows and the number of litters according to the diagram in figure 2.

In each phase, 40% of the sows with the highest breeding value on NBA were selected for the next stage.

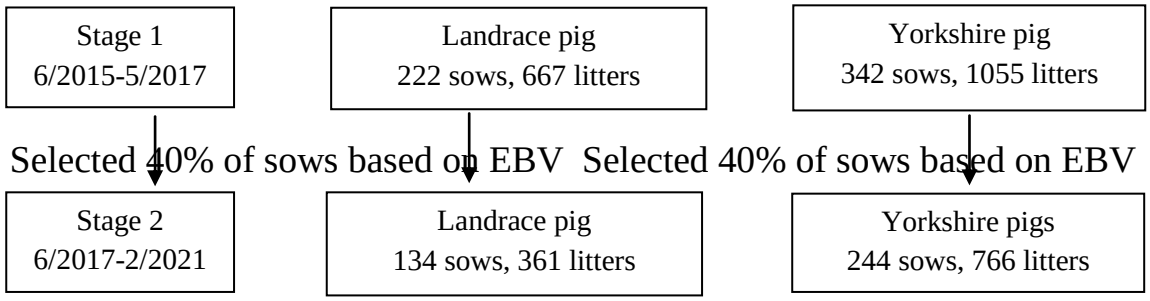

Figure 2. Diagram of selection stages for sows

3.2.3.2. Methods

- *Sow selection method*

The data on litter size traits of each sow were entered into Excel 2010 software, excluding values outside the range of Mean ± 3 SD.

The pedigree and data files were used PEST to encode data and VCE6 to estimate genetic parameters. The EBV of NBA was predicted using PEST, then the

sows which had highest EBVs were selected with the percentage of 40%.

- *Evaluated slection results*

The selection results were evaluated through phenotypic value, EBV, accuracy of EBV and genetic tendency of the NBA trait over the selection periods.

4. RESULTS AND DISCUSSION

4.1. GROWTH, REPRODUCTIVE PERFORMANCES AND SOME GENETIC PARAMETERS OF MAJOR CHARACTERISTICS OF PURE D, L, AND Y PIGS RAISED AT DABACO COMPANY

4.1.1. Growth performance and influent factors

Table 1. Results of individual testing for D, L and Y

	D			L			Y		
	n	LSM	SE	n	LSM	SE	n	LSM	SE
Age at starting to test (day)	2799	79.11^{a}	0.12	3586	76.77^{c}	0.11	5766	77.51^{b}	0.09
Body weight at starting to test (kg)	2799	32.11^{c}	0.08	3586	33.88^{a}	0.07	5766	33.28^{b}	0.06
Number of days to test (day)	2799	76.97^{a}	0.16	3586	72.37^{b}	0.14	5766	72.49^{b}	0.12
Body weight at the end to test (kg)	2799	94.35^{a}	0.17	3586	93.89^{ab}	0.15	5766	93.53^{b}	0.12
ADG (g/day)	2799	812.83^{b}	1.92	3586	832.95^{b}	1.68	5766	834.36^{a}	1.43
Back fat (mm)	1071	11.42^{b}	0.44	1551	12.18^{a}	0.44	2584	12.21^{a}	0.44
Loin muscle thickness (mm)	1071	58.01^{a}	0.86	1551	55.43^{b}	0.86	2584	55.27^{b}	0.85
LM (%)	1071	60.32^{a}	0.41	1551	59.12^{b}	0.41	2584	59.06^{b}	0.41

Note: LSM values in the same row with different a, b superscripts were statistically different (P<0.05)

The individual testing data (Table 1) showed that: The ADG was highest in Y pig, the difference was statistically significant (P<0.05) in comparision with L and D pigs. The BF of Dpigs was the lowest, their loin thickness and lean percentage were also the highest, the differences were statistically significant (P<0.05). Both of these indicators were at a much better level than the economic-technical norm for exotic boars checked by the MARD, as well as higher than the recent publications on the growth performances of exotic pigs raised in our country.

However, the ADGs of all three pig breeds raised in Dabaco were still lower

than many published documents in developed countries.

The data in table 2 showed that: The heritabilities for ADG and LM were 0.35 – 0.43 and 0.48 – 0.52, respectively. The heritabilityerrors for these two traits was relatively low. The heritabilites of these 2 traits were relatively high compared to some research by the domestic and foreign authors.

According to Ha Xuan Bo et al. (2014), heritabilities for ADG and LMof stress resistant Piétrain pigs were 0.31 and 0.19, respectively. Ngo Thi Kim Cuc et al. (2015) showed that the heritabilites of D, Piétrain and L breeds on ADG were 0.30; 0.29 and 0.32, respectively.

Table 2. Genetic parameters for ADG and LM

Breed	Traits	n	ADG	LM
D	ADG	2799	0.43 ± 0.06	0.18 ± 0.09
	LM	1071	-0.08	0.50 ± 0.08
L	ADG	3586	0.41 ± 0.05	0.08 ± 0.10
	LM	1551	0.09	0.52 ± 0.06
Y	ADG	5766	0.35 ± 0.04	0.31 ± 0.09
	LM	2584	0.09	0.48 ± 0.05

Note: The diagonal elements were the heritability (h^2 ± SE), the elements above the diagonal were the genetic correlation coefficient (r_A ± SE), the elements below the diagonal were the phenotypic correlation coefficient (r_P)

Tomka et al. (2010) suggested that the heritability for ADG was ranged from 0.13 to 0.23. Radović et al. (2013) confirmed that the heritability for ADG of L pigs raised in Serbia was low (0.11) and lean percentage was high (0.63). However, there have also been some publications showing that the heritability for these two traits was fluctuated in a wide range and in many cases at a high level.

Cluster (2010) collected 19 published papers on the heritability for ADG in pigs with *ad libitum* and semi-restricted feeding regimes were 0.03 and 0.49, respectively and the average was 0.29, and the heritabilities of8 documents of restricted diets were 0.14 - 0.76; the average was 0.30. Szyndler-Nędza et al. (2010) reported that heritability for ADG of D, L and Large White boars raised in the Netherlands were 0.472; 0.421 and 0.345, respectively. Radović cs. (2013) reported that the heritability for LMof L pigs raised in Serbia was 0.63. According to the National Swine Improvement Federation of America (2019), the heritability for ADG was 0.30. Dong et al. (2019) reported that Large White pigs at the age of 100 kg reached the heritability of 0.22.

The reason for the large difference between the research results was that the

populations had different gene frequencies, data sources and different calculation methods.

The genetic correlation coefficient between ADG and LM was low, ranged from 0.08 to 0.31 and error was larger than the ones of the heritability. There was not almost phenotypic correlation between the two traits (the phenotypic correlation coefficient only ranged from -0.08 to 0.09). The reason may be due to the LM was estimated by the formula from the data of back fat and loin thickness using Exago ultra-sound equipment.

The data in Table 3 show that: In general, most of the traits in a litter of D sows were lower than that of L and Yorkhire sows, especially number of newborn piglets, NBA, NW ($P<0.05$). the Y sows were superior to L sows in terms of NBA, but the difference in the NW was not statistically significant. The number of weaned piglets/sow/year of these 3 sows were 21.96; 24.34 and 24.66, respectively.

Table 3. Reproductive performance of D, L and Ysows

	D				L				Y			
	n	LSM	±	SE	n	LSM	±	SE	n	LSM	±	SE
Age at first farrowing (days)	802	377.33^{a}	±	0.86	1097	365.81^{b}	±	0.76	1405	365.19^{b}	±	0.66
Parity interval (days)	1908	149.59^{b}	±	0.94	4256	151.45^{a}	±	0.89	4554	150.06^{b}	±	0.89
TNB	2779	9.85^{c}	±	0.06	5847	11.58^{b}	±	0.04	6252	12.02^{a}	±	0.04
NBA	2779	9.02^{c}	±	0.06	5847	10.41^{b}	±	0.04	6252	10.70^{a}	±	0.04
Number of weaned days (days)	1482	22.72^{b}	±	0.06	3673	22.99^{a}	±	0.04	4227	23.06^{a}	±	0.03
NW	1482	9.00^{b}	±	0.04	3673	10.10^{a}	±	0.02	4227	10.14^{a}	±	0.02
Body weight of piglet at birth	2757	1.51^{a}	±	0.003	5791	1.49^{b}	±	0.002	6205	1.40^{c}	±	0.002
Body weight of piglet at weaning (kg)	1482	5.77^{c}	±	0.03	3673	6.21^{a}	±	0.02	4227	5.93^{b}	±	0.02

Note:Lowest mean square values (LSM) values in the same row with different a, b superscripts were statistically different ($P<0.05$).

Exception of NBA for D sows, in general, the reproductive performance of these sows exceed the requirements of economic and technical norms for original breed pigs, as well as higher than reproductive performance of exotic sows raised in our

country which has been recently published by studies.

Paura cs. (2014) reported that the first farrowing ages of Latvian L and Ypigs were 359.0 and 375.9 days, respectively; NBA in litter 1 was 9.3 and 10.1, respectively; in litter 2, 10.4 and 10.2, respectively. Meanwhile, Ye et al. (2018) evaluated 14097 Y sows with 40262 litters in Guangdong province, China, and showed that number of newborn piglets and NBA were 13.84 and 12.22 pigs, respectively.

Estimation of the heritabilities and repeatabilities for the number of newborn piglets, NBA and number of weaned piglets per litter of the sows of all three breeds (Table 4) had low values and to the extent that virtually all literature has confirmed.

The results of heritability estimation of L and Y pigs for NBA were: 0.12 and 0.14 respectively (Nguyen Huu Tinh and Nguyen Thi Vien, 2011). Trinh Hong Son et al. (2014) reported that the heritabilities for NBA and weaned piglet of VCN03 pigs were 0.19 and 0.11, respectively. Le Van Sang et al. (2018) reported that the heritabilities of VCN03 for number of newborn piglets and NBA were 0.26 and 0.13, respectively.

Table 4. Genetic parameters for liter size traits

Breed	Traits	Number of newborn piglets	NBA	Number of weaned piglets
D	TNB (n = 2779)	*0.14* 0.11±0.02	0.92±0.02	0.88±0.05
	NBA (n = 2779)	0.83	*0.13* 0.09±0.02	0.91 ± 0.03
	NW (n = 1482)	0.69	0.85	*0.12* 0.10 ± 0.02
L	TNB (n = 5847)	*0.20* 0.09±0.03	0.94±0.03	0.76±0.17
	NBA (n = 5847)	0.88	*0.16* 0.06±0.02	0.80±0.17
	NW (n= 3673)	0.54	0.66	*0.05* 0.03±0.01
Y	TNB (n= 6252)	*0.24* 0.17±0.10	0.89±0.04	0.60±0.12
	NBA (n = 6252)	0.87	*0.20* 0.12+0.14	0.81 ± 0.19
	NW (n = 4227)	0.54	0.66	*0.10* 0.06±0.09

Note: The diagonal elements were the repeatability (in italic) and the heritability (h^2 ± SE), the elements above the diagonal were the genetic correlation coefficient (r_A ± SE), the elements below the diagonal were the phenotypic correlation coefficient (r_P)

Pholsing et al. (2009) reported that NBA of Large White pigs raised in Thailand was 0.11. According to Chansomboon et al. (2010) heritability for litter size traits of L pigs raised in Thailand was ranged from 0.05 to 0.06; repeatabilities of these traits was ranged from 0.15 to 0.18. According to Ye et al. (2018), the heritability for TNB and NBA of Y sow was 0.07 and 0.06, respectively; and repeatabilities were 0.17 and 0.14, respectively.

Genetic correlation coefficients between litter size traits were positive values and higher than phenotypic correlation coefficients. Thus the influence of raising environment reduced the values of genetic correlation. Some studies in domestic as welll as foreign also obtained similar results.

4.2. SELECTION TO INCREASEBODY WEIGHT OF D, L, AND Y BOARS

4.2.1. Selection to increase ADGof D boars

The data in table 5 showed that: At different stages of selection, ADG and LM of D pigs were relatively high level for male and female.

In general, the ADG as well as LM in the latter period were higher than that of the previous period. The individual testing data at each stage were used to estimate genetic parameters and EBV for each stage.

Table 5. Results of individual testing of Dpigs through selected stages

Stage	Indexes	Paramatters	Female	Male	Total
1	ADG (g/pig/day)	n	395	559	954
		Mean±SE	806.83±4.86	820.96±4.25	815.11±3.20
	LM (%)	n	252	361	613
		Mean±SE	60.33±0.16	60.52±0.12	60.44±0.10
2	ADG (g/pig/day)	n	503	1118	1621
		Mean±SE	807.77±2.33	828.20±2.07	822.17±1.57
	LM (%)	n	455	817	1272
		Mean±SE	60.45±0.08	60.51±0.06	60.49±0.05
3	ADG (g/pig/day)	n	653	835	1488
		Mean±SE	823.47±3.84	838.99±3.74	832.18±2.71
	LM (%)	n	255	528	783
		Mean±SE	60.92±0.11	61.04±0.07	61.00±0.06

The results of the selection for ADG over the stages (Table 6) showed that the BLUP selection had given an accuracy ranging from 77 to 86% for D boar. If only based on the phenotypic value for the trait, selection accuracy only achieved from 73 to 75% for D boar. Thus, using BLUP had increased the accuracy of selection by 4 to 11% for D boar.

Table 6. Results of D male selection through selection stages

Stage	Indexes	Selective rate (%)			
		5	10	15	100
1	The phenotypic value of ADG (g/pig/day)	940.68	903.20	881.70	820.96
	EBV of ADG	80.70	66.04	56.17	9.81
	Accuracyof EBV (%)	83.46	83.32	83.28	83.20
2	The phenotypic value of ADG (g/pig/day)	941.52	908.39	888.99	828.20
	EBV of ADG	89.57	79.33	72.96	15.22
	Accuracyof EBV (%)	77.20	77.47	77.24	77.15
3	The phenotypic value of ADG (g/pig/day)	1006.03	913.43	892.14	838.99
	EBV of ADG	98.14	73.09	61.56	16.21
	Accuracyof EBV (%)	85.98	85.94	85.88	85.75

The genetic tendency for male with selective rate of 5% as well as for the whole herd was in an increasing trend through the selection stages, that was clearly shown in Figure 3. Annual genetic tendency for ADG in D maleswas 4.71 g/head/day.

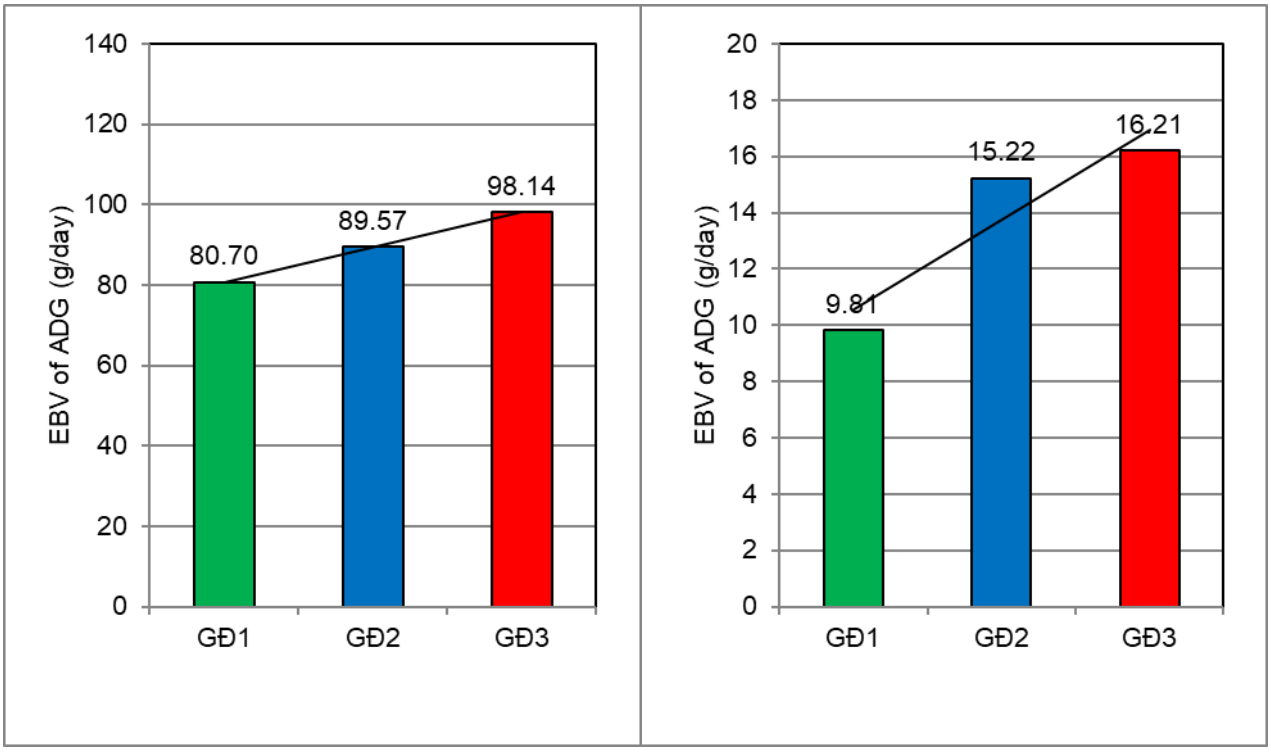

Figure 3. Genetic tendency ofADG over the selective stages of D males (left: 5% selective rate, right: whole herd of boar)

Table 7. LSM values of ADG for Dpig over the selection stages

Selection stages	Statistical parameters	Female	Male
1	n	395	559
	LSM±SE (g/day)	807.07^{b} ± 5.77	819.97^{c} ± 4.25
2	n	503	1118
	LSM±SE (g/day)	810.08^{b} ± 3.95	830.53^{b} ± 2.07
3	n	653	835
	LSM±SE (g/day)	824.71^{a} ± 4.99	836.87^{a} ± 3.74

Note: Least square mean (LSM) in the same column with different a, b superscripts were statistically different (P<0.05)

The LSM of ADG for D pig in table 7 provided a more accurate evaluation of selective efficiency over the three stages. Overall, ADG at stage 3 in both male and female was always highest and the difference was statistically significant compared with stages 1 and 2 for the males. Particularly for the females, the difference between stage 2 and stage 1 was not statistically significant, because the selection was done only for the males.

3.2.2. Selection to increase ADGfor L pigs

Table 8 showed the different growth performance of L pig through selection stages 1,2 and 3. Similar to the results of individual testing in D pig, both ADG and LM of L pig were gradually increased through the selection stages.

Table 8. Results of performance testing of L pigs through selected stages

Stage	Indexes	Paramatters	Female	Male	Total
1	ADG (g/pig/day)	n	1437	413	1850
		Mean±SE	833.29±2.83	842.57±3.25	835.36±2.49
	LM (%)	n	646	227	873
		Mean±SE	59.14±0.10	59.17±0.10	59.15±0.09
2	ADG (g/pig/day)	n	1323	527	1850
		Mean±SE	846.85±2.38	862.71±2.51	851.37±3.23
	LM (%)	n	561	362	923
		Mean±SE	60.13±0.10	60.52±0.09	60.28±0.12
3	ADG (g/pig/day)	n	689	339	1028
		Mean±SE	860.98±3.91	876.27±3.91	866.02±5.82
	LM (%)	n	344	196	540
		Mean±SE	60.50±0.10	60.81±0.12	60.61±0.14

Table 9. Results of L male selection through selection stages

Stage	Indexes	Selective rate (%)			
		5	10	15	100
1	The phenotypic value of ADG (g/pig/day)	923.25	918.05	907.24	842.57
	EBV of ADG	71.73	61.46	54.59	0.17
	Accuracyof EBV for ADG (%)	69.13	68.66	68.62	68.18
2	The phenotypic value of ADG (g/pig/day)	927.82	922.50	910.38	862.71
	EBV of ADG	76.64	51.91	14.36	7.25
	Accuracyof EBV for ADG (%)	71.75	71.67	71.79	70.85
3	The phenotypic value of ADG (g/pig/day)	932.26	925.91	918.39	876.27
	EBV of ADG	120.99	131.55	125.20	10.42
	Accuracyof EBV for ADG (%)	73.61	73.27	73.20	71.96

The data in table 9 showed thatthe phenotypic values and EBVs of ADG for L males was keptfor breeding increased through each selection stage. The accuracy of EBV wasranged from 68 to 74%. If only based on phenotypic value to selection, the accuracy of EBV achieved only from 57 to 62%. Thus, using BLUP had increased the accuracy of EBV by 11 - 12% for L males.

The EBV of ADG in stage 3 compared with stage 1 given an annual genetic tendency for this trait was 13.31 g/pig/day in L pigs.

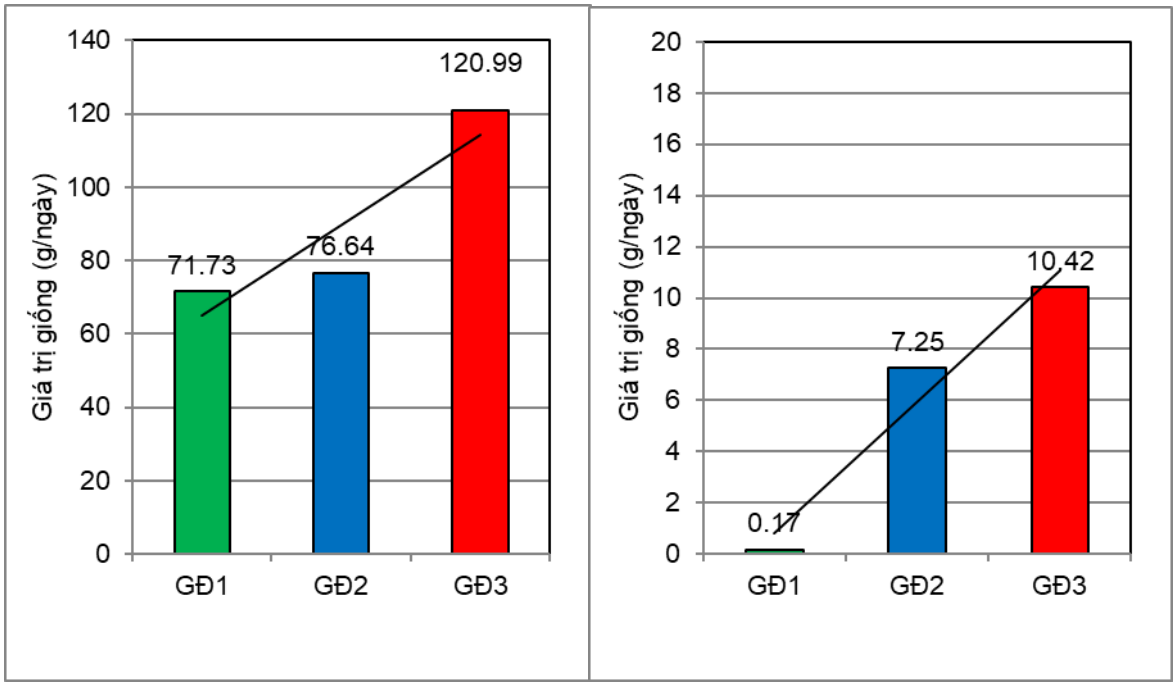

Figure 4. Genetic tendency of ADGthrough selection of L males (left: 5% selection rate, right: whole herd)

The genetic tendency for selected males to be kept for breeding at the rate of 5%, as well as for the whole individual testing herd for productivity was on an increasing trend through the selection stages, that clearly showed in figure 4.

Table 10. LSM ofADG for L pigs over the selection stages

Selection stages	Statistical parameters	Female	Male
1	n	1437	413
	LSM±SE (g/day)	835.24^{c} ± 3.34	844.07^{c} ± 6.39
2	n	1323	527
	LSM±SE (g/day)	849.90^{b} ± 3.02	860.31^{b} ± 4.56
3	n	689	339
	LSM±SE (g/day)	865.79^{a} ± 4.28	878.30^{a} ± 6.60

Note: Least square mean (LSM) values in the same column with different a, b superscripts were statistically different (P<0.05).

The data in table 10 provided a more accurate evaluation of selection efficiency through the selection stages. The LSM values on body weight gain of males as well as females were always highest at stage 3, the difference was statistically significant compared with stage 1 and stage 2 (P<0.05).

The LSM of ADG for L males and females were increased gradually from stage 1 to stage 3, the difference was statistically significant (P<0.05).

4.2.3. Selection to increase ADG of Ypigs

Results of individual testing for Ypigs through selection stages were presented in table 11.

Table 11. Results of performance testing of Y pig through selection satges

Stage	Indexes	Paramatters	Female	Male	Total
1	ADG (g/pig/day)	n	2214	548	2762
		Mean±SE	849.06±2.22	856.38±4.80	850.51±2.03
	LM (%)	n	1229	313	1542
		Mean±SE	58.82±0.08	59.50±0.13	58.96±0.07
2	ADG (g/pig/day)	n	3118	935	4053
		Mean±SE	864.36±1.75	873.17±2.95	866.39±1.53
	LM (%)	n	879	451	1330
		Mean±SE	60.16±0.07	60.27±0.10	60.20±0.06
3	ADG (g/pig/day)	n	2024	719	2743
		Mean±SE	876.50±2.27	884.64±4.21	878.63±2.06
	LM (%)	n	945	447	1392
		Mean±SE	60.30±0.06	60.45±0.11	60.35±0.05

Similar to the results of individual testing forr D and L pigs, both ADG and LM of Y female and male were increased gradually through selectionstages.

The data in table 12 showed that: phenotypic values of selected Y males at the rate of 5% to keep for breeding in the next stage.

The selection process was carried out for 3.7 years, the breed value of ADG of stage 3 compared with stage 1 of selected males at the rate of 5% giving annual genetic tendency for this trait in Y pigs obtained 16.79 g/pig/day.

Table 12. Results of Y male selection for breeding through selection stages

Stage	Indexes	Selective rate (%)			
		5	10	15	100
1	The phenotypic value of ADG (g/pig/day)	891.37	889.54	880.52	850.51
	EBV of ADG	57.74	49.32	43.31	9.45
	Accuracy for EBV of ADG	74.96	74.49	73.93	71.85
2	The phenotypic value of ADG (g/pig/day)	896.22	894.85	890.08	866.39
	EBV of ADG	64.26	50.70	12.68	9.91
	Accuracy for EBV of ADG	74.94	74.80	74.77	75.00
3	The phenotypic value of ADG (g/pig/day)	930.87	903.10	890.93	878.63
	EBV of ADG	119.87	82.40	57.73	14.27
	Accuracy for EBV of ADG	75.39	75.44	75.42	73.59

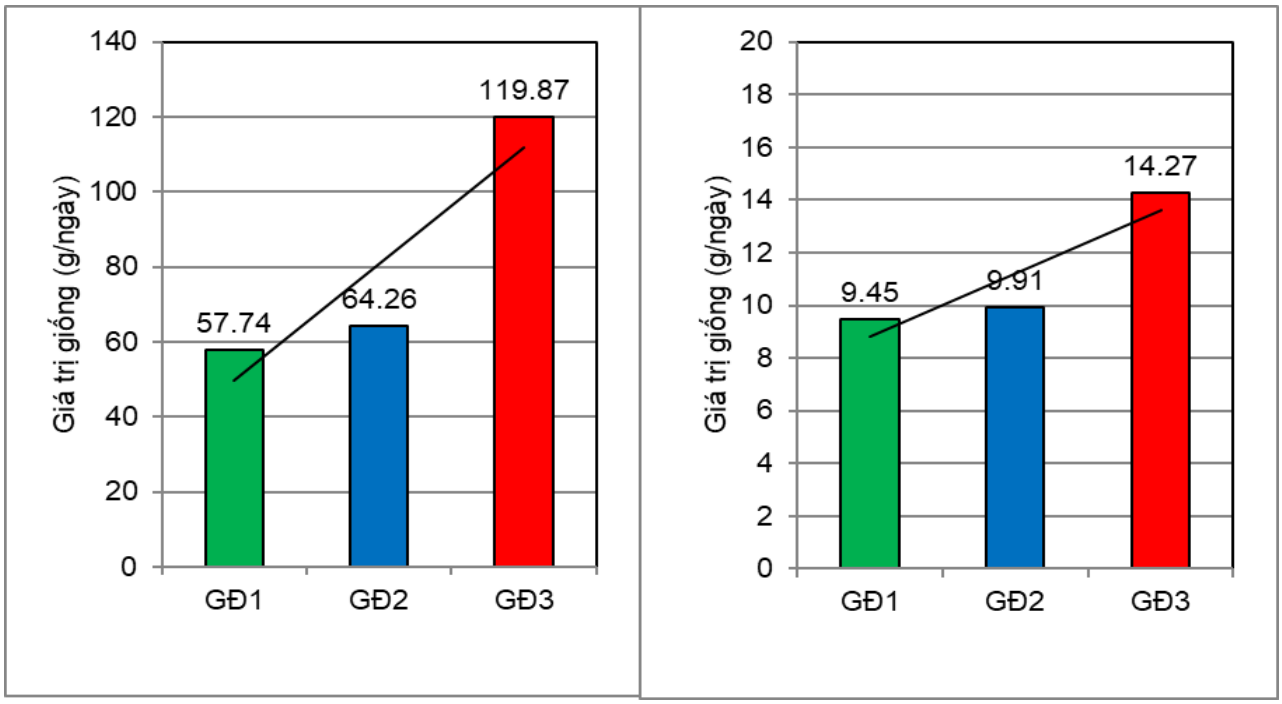

Figure 5. Genetic tendency of ADG over the selection stages for Y males (left: 5% selection rate, right: whole herd)

The genetic tendency tended to increase through selection stages showed clearly in figure 3. For selected males kept for breeding at the rate of 5%, the genetic tendency increased gradually at each stage. The increasing genetic tendency through the stages was also present for all herd of the individual testing.

Table 13. LSM values of ADG for Y pigs through selection stages

Selection stages	Statistical parameters	Female	Male
1	n	2214	548
	LSM±SE (g/day)	$850.25^{c} \pm 2.67$	$856.60^{c} \pm 5.50$
2	n	3118	935
	LSM±SE (g/day)	$864.90^{b} \pm 2.24$	$875.03^{b} \pm 3.72$
3	n	2024	719
	LSM±SE (g/day)	$875.88^{a} \pm 2.76$	$885.09^{a} \pm 4.70$

Note: Least square mean (LSM) values in the same column with different a, b superscripts were statistically different (P<0.05).

The data on the accuracy of EBV for ADG through selection stages showed that BLUP selection reached a relatively high accurate, ranging from 72 to 75% for Y boars. If only based on phenotypic values to select, the accuracy of selection was only between 63 and 66%. Thus, using BLUP increased the accuracy of selection for Y males by about 9%.

LSM values of ADG for Y males and females (Table 13) increased gradually from stage 1 to stage 3, the difference was statistically significant (P<0, 05).

4.3. SELECT TO IMPROVE NBA FOR PURE L AND Y SOWS RAISED AT DABACO COMPANY

4.3.1. Select to improve NBA of L sows

Table 14. Reproductive performance of L sows at stage 1

Indexes	n	Mean	SE
Parity interval (day)	1021	147.03	0.34
TNB (piglet)	1573	11.83	0.07
NBA (piglet)	1542	10.62	0.07
NW at birth (piglet)	1428	10.49	0.04
LW (kg)	1542	15.75	0.11
Body weight of piglet at birth (kg)	1542	1.50	0.01
Lactation period (day)	1520	22.24	0.12
LW at weaning(kg)	1428	72.69	0.40
Body weight of piglet at weaning (kg)	1428	6.94	0.03

The data in table 14 showed that: Due to the selection of sows with higher EBV in selection stage 1, in general the reproductive performance of L sows in stage 1 was higher than that of the whole L herd at the initial point of the selection stages (Table 3). The number of number of newborn piglet, NBA, number of weaned piglets/litter and weight of weaned piglets at selection stage 1 were all higher, and the parity interval was shorter than the corresponding number of the whole sow herd without the effect of selection.

The results of selection based on EBV for NBA in stage 1 showed that if using only one individual phenotype value, the selection accuracy was only 33%. As the EBV predicted on the basic of the influence of thepermanent environment and the phenotypic values of the relative animals in the pedigree, the accuracy of EBV reached 57 – 58%. Thus, the accuracy of breed selection increased by 24-25%, contributing to increasing genetic progress at the selection stage 2 of this trait.

With the selection rate based on EBV, 40% of the selected individuals with the highest EBVs and the reproductive performance in offspring during the selection stage 2 was evaluated.

Table 15. Results of selection of L sows at stage 1

Indexes	Selection rate (%)	40	60	100
	Number of sows	222	333	554
	Number of parities	667	965	1542
Phenotypic value for NBA (piglet)		11.94	11.52	10.62
EBV for NBA (piglet)		0.55	0.38	0.04
Aaccuracy of EBV for NBA (%)		58.28	57.55	57.11

Table 16. Reproductive performance of L sow at stage 2

Indexes	n	Mean	SE
Parity interval (day)	662	154.54	0.77
TNB (piglet)	880	12.34	0.10
NBA (piglet)	880	11.11	0.11
NW at birth (piglet)	776	10.62	0.08
LW (kg)	880	15.65	0.17
Body weight of piglet at birth (kg)	880	1.48	0.01
Lactation period (day)	831	23.39	0.15
LW at weaning(kg)	776	67.58	0.63
Body weight of piglet at weaning (kg)	776	6.36	0.03

The data in table 16 showed that the reproductive performance of L sows at selection stage 2 was relatively high. The trait for TNB, NBA, LW and body weight

of piglet at weaning at selection stage at the selection stage 2 were all higher than the corresponding data for these traits at stage 1.

Table 17. Results of selection of L sows at stage 2

Indexes	Selection rate (%)	40	60	100
	Number of sows	134	201	337
	Number of parities	361	546	880
Phenotypic value for NBA (piglet)		12.20	11.73	11.11
EBV of NABP (piglet)		0.61	0.44	0.08
Accuracy of EBV for NBA (%)		54.41	54.00	52.88

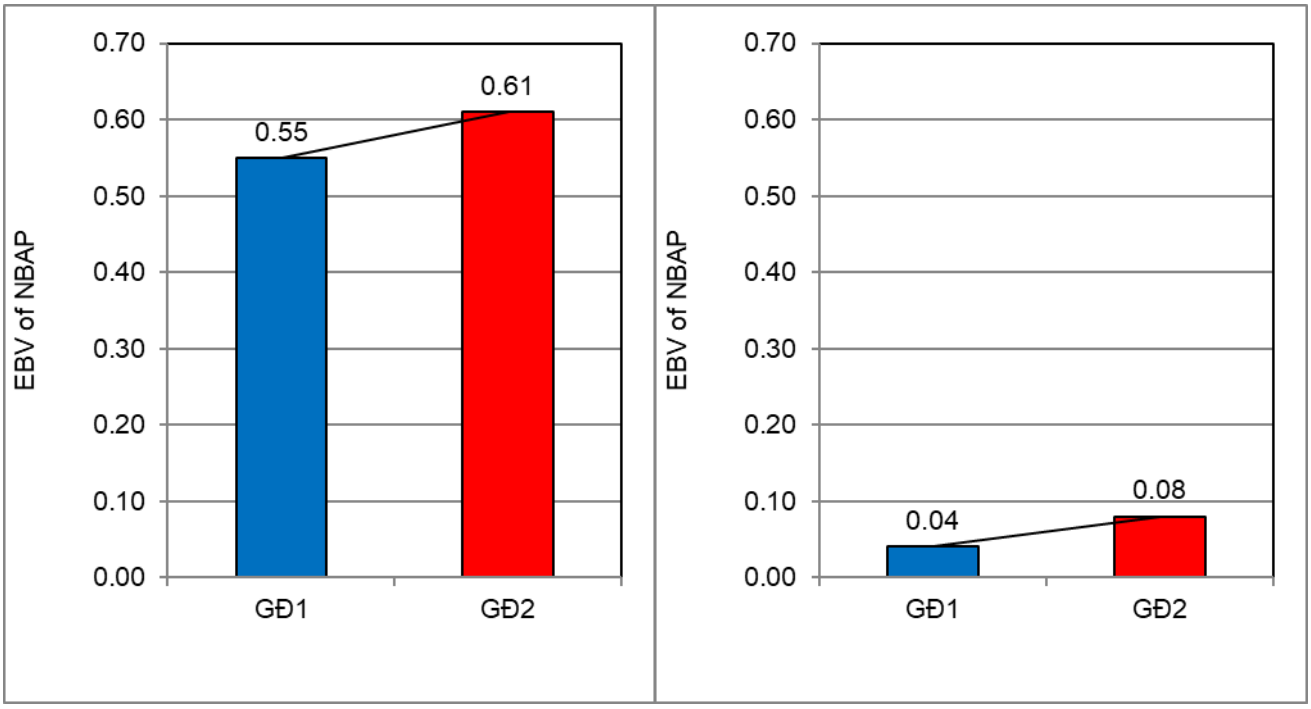

Figure 6. Genetic tendency of NBA over the selection stage of L sows (left: 5% selection rate, right: whole herd)

The results of selection in stage 2 showed that: if only the selection based on the individual phenotypic value for this trait, the accuracy of EBV would be less than 40%.

Due to using repeatable model of BLUP, the accuracy of EBV was 54.41 - 58.28%, an increased more than 14 - 18%. This result was similar to that in the selection stage 1. The repeatable model improved the accuracy of EBV and which was an important factor to improving NBA of L sows.

The results of evaluation of genetic tendency through 2 selection stages (Figure 6) showed that: For the herd of selected sows to keep for breeding in the next generation, the difference in EBV for NBA in L sows of stage 2 compared with stage 1 was 0.06 piglet/litter. Favorable genetic tendency was also obtained for the whole

herd of sows at 2 stages: the difference between stage 2 and stage 1was 0.04 piglet/litter. Genetic tendency for NBA of selected L sows at the rate of 40% was 0.016 piglets/year.

Table 18. LSM of NBA of L sows through selection stages

Stages	Traits	n	LSM ± SE
1	TNB (piglet)	1573	11.69^{b} ± 0.15
	NBA (piglet)	1542	10.42^{b} ± 0.15
	NW (piglet)	1248	10.35 ± 0.09
2	TNB (piglet)	880	12.30^{a} ± 0.17
	NBA (piglet)	880	11.06^{a} ± 0.17
	NW (piglet)	776	10.47 ± 0.10

Note: Least square mean (LSM) values in the same trait and column with different a, b superscripts were statistically different (P<0.05).

Table 18 shows that: The difference in LSM of the stage 2 compared with the stage 1 was 0.61 piglets/litter (P<0.05) for TNB, 0.54 piglets/litter for NBA. The genetic correlation between these two traits was at a very close level, TNB had higher heritability. Thus, the selection to improve NBA made an increasing of TNB witth a larger difference. This is in contrast to LW, selection to improve NBA had not much effect on LW, the difference between the two stages of this trait was not statistically significant (P>0.05).

3.2.2. Select to improve NBA of Y sows

Table 19. Reproductive performance of Y sowsat selected stages 1

Indexes	n	Mean	SE
Parity interval (day)	1713	145.28	0.20
TNB (piglet)	2566	12.29	0.06
NBA (piglet)	2535	10.93	0.06
NW at birth (piglet)	2370	10.60	0.03
LW (kg)	2533	15.02	0.08
Body weight of piglet at birth (kg)	2532	1.39	0.00
Lactation period (day)	2456	22.83	0.07
LW at weaning(kg)	2370	67.69	0.32
Body weight of piglet at weaning (kg)	2370	6.37	0.02

Table 19 showed: As selected sows with higher EBVs for stage 1, in general the reproductive performance of sows in stage 1 was higher than that of Y sows without selection (Table 3).

Based on the selection by EBV for NBA, the results of selected sows in stage 1 for this trait presented in table 20.

Table 20. Results of selection of Y sows at stage 1

Indexes	Selection rate (%)	40	60	100
	Number of sows	342	513	856
	Number of parities	1055	1573	2535
Phenotypic value for NBA (piglet)		12.39	11.93	10.93
EBV for NBA (piglet)		0.45	0.24	-0.17
Accuracy for NBA (%)		63.85	64.00	64.17

The results of selection were based on EBV for stage 1 (Table 20) showed that the accuracy of EBV for NBA ranged from 63.85% to 64.17%. If the selection based only on individual performance, the accuracy was only 36%. Thus, in the case of selection by EBV for Y sows, the accuracy of EBV was 1.8 times in higher. The modelused in the experiment brought a relatively high accuracy, contributed importantly to improving the genetic progress of sows.

Table 21 showed that in general, the reproductive performance ofY sows in stage 2 was higher than that of stage 1. The NBA in stage 2 was higher than stage 1 by 0.43 piglets/litter.

Due to the high genetic and phenotypic correlations between litter size traits, the selection based on NBA also increased TNB as well as NW.

Table 21. Reproductive performance of Y sowsat selected stages2

Indexes	n	Mean	SE
Parity interval (day)	1483	151.68	0.51
TNB (piglet)	1853	12.72	0.07
NBA (piglet)	1853	11.08	0.07
NW at birth (piglet)	1752	23.78	0.08
LW (kg)	1674	10.75	0.06
Body weight of piglet at birth (kg)	1825	15.13	0.11
Lactation period (day)	1825	1.37	0.00
LW at weaning(kg)	1674	65.57	0.40
Body weight of piglet at weaning (kg)	1674	6.09	0.02

The results of selection based on EBV in stage 2 (Table 22) showed that if the selection only based on the phenotypic value of the individual, the accuracy of EBV would be 33%. Due to the use of a repeat model, the accuracy of EBV was 54.41 - 58.56%, an increasing more than 11 - 15%. This result was similar to that in the selection stage 1. The repeatable model improved the accuracy of EBV and was a main cause contributing importantly to improve NBA of Y sows.

Table 22. Results of selection of Y sows at stage 2

Indexes	Selection rate (%)	40	60	100
	Number of sows	244	366	612
	Number of parities	766	1113	1826
Phenotypic value for NBA (piglet)		12.70	12.20	11.08
EBV for NBA (piglet)		0.49	0.29	-0.10
Accuracy for NBA (%)		58.56	58.39	58.41

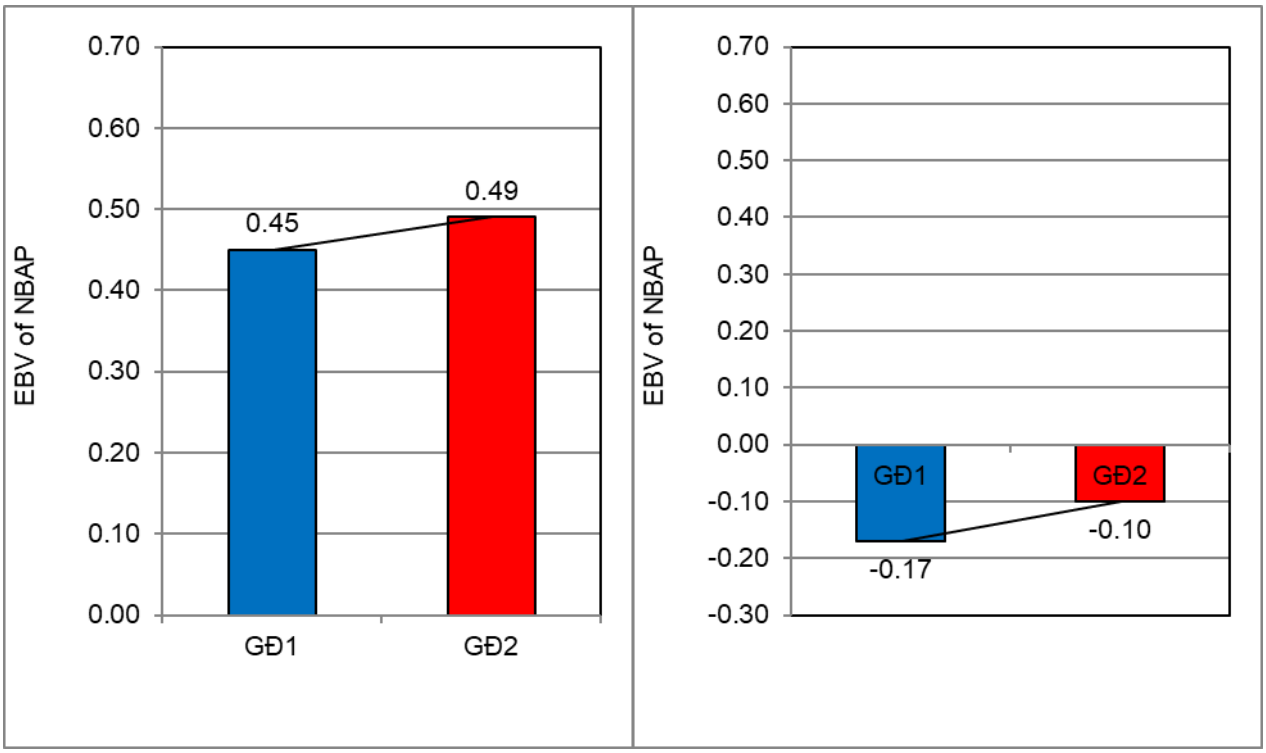

Figure7. Genetic tendency of NBA over the selection stage of Y sows (left: 5% selection rate, right: whole herd)

The results of genetic tendency evaluation on the trait of NBA for Y sows through 2 selection stages presented in figure 7.

The difference in EBV of NBA of the best sows with a selection rate of 40% in stage 2 compared with stage 1 was 0.04 pig per litter. For the whole herd of sows, the EBV of NBA increased at selection stage 2 compared to stage 1 which was 0.07 piglets/litter. The genetic tendency of NBA for the selected sows at a rate of 40% for breed value was 0.011 piglets/litter/year.

Thus, although the heritability values were very low, the use of a repeatable model to select by EBV increased genetic progress of NBA for Y sows.

Table 23 shows that: The difference in LSMs of the selection period 2 and 1 for NBA was 0.63 piglets/litte ($P<0.05$).

Table 23. LSM of litter size traits for Y sows through selection stages

Stages	Traits	n	LSM ± SE
1	TNB (piglet)	2566	12.61^{b} ± 0.24
	NBA (piglet)	2535	11.20^{b} ± 0.17
	NW (piglet)	2370	10.47 ± 0.14
2	TNB (piglet)	1853	13.02^{a} ± 0.24
	NBA (piglet)	1826	11.83^{a} ± 0.16
	NW (piglet)	1674	10.60 ± 0.15

Note: Least square mean (LSM) values in the same trait and column with different a, b superscripts were statistically different (P<0.05).

Because of a fairly close positive genetic correlation between TNB and NBA, the difference between LSM at the selection stage 2 compared with the selection stage 1 on TNB was 0.41 with P<0.05. Thus, the selection by EBV to improve NBA contributed to improving TNB. However, this difference was lower than that of NBA.

The selection to improve NBA was not significantly influenced the NW, the difference between the two stages was only 0.13 piglets/litter and not significantly statistical (P>0.05). There was not a close genetic relationship between these two traits. That was one of the reasons for the above situation.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

1. The individual testing traits of male and female for pure D, L and Y breeds were quite high: the ADGs were 812.83; 832.95 and 834.36 g/day, respectively, the lean meat percentages at the end of the testing were 60.32; 59.12 and 59.06%, respectively. The heritability of ADG and LM of these breeds were 0.35 – 0.43 and 0.48 – 0.52, respectively.

The reproductive performance of pure Y and L sows was quite high. The TNB, NBA and NW for Y and L sows were 12.02 and 11.58, respectively; 10.70 and 10.41; and 10.14 and 10.10 piglets/litter. The D sows had lower litter size.

The heritability of the traits for the litter size traits of pure D, L and Y sows were low, in the range of 0.12 - 0.14 and 0.05 - 0.20 and 0.10 - 0.24, respectively. The genetic correlation coefficiences of between these traits in all three breeds were quite high, ranging from 0.60 to 0.94, but the phenotypic correlation coefficiencies between these traits were at a low level.

2. The selected males by BLUP through 3 stages according to their EBVs of ADG at the rate of 5% increased the mean phenotypic values of 16.90; 34.23 and

28.49 g/day, respectively, created a continuously increasing genetic tendency from selection stage 1 to stage 3 for males kept as breeding for all pure D, L and Y breeds.

3. The selected sows by BLUP repeatable model through 2 stages according to their EBVs of NBA at the rate of 40% improved the number of newborn piglets per litter and NBA of 0.41 and 0.40; 0.63 and 0.64, respectively, increased genetic tendency from stage 1 to stage 2 of the NBA for both pure L and Y breeds.

5.2 RECOMMENDATIONS

- Applying BLUP method to estimate EBV and selection based on EBV to improve growth and reproductive performances for the whole pure herd for D, L and Y breeds raised at Dabaco Company.

- In order to achieve a good selection effect, it is recommended to apply a selection rate of 5% for males and 40% for sows.

- Dabaco Nuclear Pig Breeding Company needs to strengthen linkages and exchange of breeding data as well as good genetic resources with other pig breeders in order to contribute to increasing the productivity and efficiency of pig production in our country.