MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT

NATIONAL INSTITUTE OF ANIMAL SCIENCE

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PRODUCTIVITY OF DVN1 AND DVN2 PIGS PRODUCED FROM CANADIAN DUROC GENE SOURCE

SUMMARY OF DOCTORAL THESIS

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HANOI – 2022

The study has been completed at: National institute of animal science

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LISTS OF RELATED PUBLICATIONS

1. Pham Thi Minh Nu, Pham Duy Pham, Trinh Quang Tuyen, Trinh Hong Son, and Nguyen Van Duc (2022). Effects of several factors on semen volume and sperm quality of DVN1 and DVN2 pigs produced from Canadian Duroc gene source through three selected generations. Journal of Animal Husbandry Sciences and Technics, No 273(01.22): 37-42.
2. Pham Thi Minh Nu, Pham Duy Pham, Trinh Quang Tuyen, Trinh Hong Son, and Nguyen Van Duc (2022). The growth performance and carcass yield of DVN1 and DVN2 pigs produced from Canadian Duroc gene source through three selected generations. Journal of Animal Husbandry Sciences and Technics, No 273(01.22): 43-47.
3. Pham Thi Minh Nu, Pham Duy Pham, Trinh Quang Tuyen, Trinh Hong Son, and Nguyen Van Duc (2021). Effect of some factors on reproductive performance of DVN1 and DVN2 sows from Canadian Duroc gene source. Journal of Animal Science and Technology, No 128(10.21): 23-33.

1. INTRODUCTION

1.1. The rationale of the study

Duroc is a well-known purebred and raised widely in commercial industrialized farms as the terminal sire in the commercial three-breed crossbreeding programs or crossed with Pietrain line to produce PiDu crossbreed for commercial four-breed crossbreeding programs.

The Duroc boars used in this study were originated from the Hypor company in Canada, including two lines: The Kanto line with good meat quality and high intramuscular fat content (namely high intramuscular fat content line), and the Magnus line with better growth performance (namely high growth performance line). These pig lines were imported by the Thuy Phuong Pig Research and Development Center in 2015 to improve the quality of current breeds raised in the centre and distribute the high-quality breeding boars to commercial farms in the Northern provinces of Vietnam.

Based on the Duroc pure breed originating from Canada with a high heritability potential of growth performance and intramuscular fat content, the center utilized the Duroc high growth performance line boars to cross with the Duroc high intramuscular fat content line dams to produce DVN1 crossbred line. Moreover, the Duroc high intramuscular fat content line boars were crossed with the Duroc high growth performance line dams to have the DVN2 crossbred line. These are excellent genes with a high heritability potential that can help improve the productivity, meat quality, and production efficiency of pig production in Vietnam. The evaluation of production performance of these crossbreeds under the farming condition in North Vietnam is of great importance because they are used as a terminal sire in three-and four-breed crossbreeding programs that strongly determines the growth performance and carcass quality of market pigs. However, when these pig lines are raised in the farming conditions in North Vietnam, their heritability potential can be achieved at the highest result or not? The utilization and expansion of these pig lines require more research and tests of their adaptative ability when raising under the local pig farming conditions in North Vietnam before transferring and distributing to other commercial farms.

In response to the concerns mentioned above, several research questions addressed in this study included: Are there any differences in growth performance between two lines DVN1 and DVN2? Are there any differences in reproductive performance between two lines DVN1 and DVN2? Are there any differences in ejaculate volume and sperm quality of Duroc boars between two lines DVN1 and DVN2? Will the production traits of growth, reproductive performance, and sperm quality of two DVN1 and DVN2 lines be improved by different generations during the progeny testing or not? Will the growth performance, carcass yield, and quality of market pigs be affected when these two DVN1 and DVN2 lines are used as a terminal line in the commercial crossbreeding programs?

The answers to the above questions are necessary for building up the scientific background for the development of a highly effective, productive, safe, sustainable, and comparative pig production to meet the food demand in the both domestic and exported market. From the above situation and rationale, the study on "Productivity of DVN1 and DVN2 pigs produced from Canadian duroc gene source" was conducted and presented in this thesis.

1.2 THE RESEARCH OBJECTIVES

The objectives of this study are:

To assess the growth performance, carcass characteristics, ejaculate volume and sperm quality, and reproductive performance of two crossbred lines DVN1, DVN2 produced from the Canadian Duroc gene source.

To assess the growth performance, carcass yield, and quality of the commercial crossbreeds TP1, TP2, TP3, and TP4 produced by crossing two lines DVN1, DVN2 boars with two crossbred parent sows PS1 and PS2.

1.3. THE NOVELTY OF THE STUDY

This is systematic and comprehensively scientific research covering different production parameters, including the growth, carcass characteristics, and reproductive performance of two crossbred lines DVN1, DVN2 produced from the Canadian Duroc gene source. It also contributes scientific information and database about the genes of boars in the Vietnamese pig breeding system.

The study has covered the assessment of the growth, carcass yield, and quality of four commercial crossbreeds TP1, TP2, TP3, and TP4 from two terminal sires DVN1 and DVN2 and two crossbred parent sows PS1 and PS2, providing the essential scientific evidence for the development of commercial pig crossbreeds with high productivity and meat quality and contributing to the sustainable development of an effective pig industry in our nation.

14. THE ACADEMIC AND PRACTICAL CONTRIBUTIONS OF THE STUDY

1.4.1. Academic contributions

This study supplemented the scientific information for the research and training on the productivity of two-terminal boar lines DVN1 and DVN2 produced from two Canadian Duroc gene sources when they are raising in Vietnam, and on the growth, carcass yield, and quality of market pigs produced from two crossbred sire lines DVN1, DVN2 and two crossbred parent sows PS1 and PS2, which were formed from two crossbred sows LVN and YVN.

1.4.2. Practical contributions

The present study covered comprehensively product traits, including the growth and reproductive performance of two crossbred sires, DVN1 and DVN2 when raising in the production conditions of pig farms in North Vietnam. The scientific-based evaluation of the growth and reproductive performance of these two crossbred lines DVN1 and DVN2, and their market pigs produced from these two sires with two crossbred parent sows PS1 and PS2 helped the pig producers to increase the production and economic efficiency when utilizing and exploiting these pig lines.

2. LITERATURE REVIEW

2.1. THE SCIENTIFIC BACKGROUND

The scientific background of this study includes the principles of growth, reproductive performance, carcass yield, and quality of pigs and the factors influencing these traits

2.2. THE RELATED STUDIES IN VIETNAM AND IN THE WORLD

A number of studies on the growth, reproductive performance, ejaculate volume, sperm quality, carcass yield, and quality of pigs have been carefully reviewed from related studies published both in Vietnam and in the world.

The literature review of published references in Vietnam and the world showed that the productivity of pigs had been studied comprehensively. However, research on the productivity of Duroc pure breed originated from Canada, especially on the herd raised in the farming conditions in North Vietnam, is limited, insufficient, and nonsystematic. Besides that, previous studies on the growth, reproductive performance, sperm quality of the Duroc breed did not state clearly the origin of this breed used in their studies. Remarkably, there is no previous research on two boar lines produced in Vietnam from pure breed originated from Canada with high growth performance line and high intramuscular fat content line. There is also no study on the growth, carcass yield, and quality of the commercial crossbred pigs produced from two crossbred sires DVN1 and DVN2, and crossbred parent sows.

3. RESEARCH MATERIALS AND METHODS

3.1. RESEARCH MATERIALS

3.1.1. The production performance of DVN1 and DVN2 line pigs

The study was conducted on two-line pigs, DVN1 and DVN2, produced from Duroc pure breed belong to two lines, including Magnus line with high growth performance and the Kanto line with good meat quality and high intramuscular fat content, which are originated from Hypor company, Canada. The breeding diagram of these two sire lines are presented as below:

- The terminal DVN1 sire line:

♂ Duroc high growth performance x ♀ Duroc high intramuscular fat content

↓

DVN1

- The terminal DVN2 sire line:

♂ Duroc high intramuscular fat content x ♀ Duroc high growth performance

↓

DVN2

3.1.2. Production performance of commercial crossbreeds produced from DVN1 and DVN2 boars and crossbred parent sows PS1 and PS2

The two crossbred parent sow lines, PS1 and PS2, were produced from two grand-parent lines LVN and YVN, with high productivity and meat quality. The LVN line (Landrace) and YVN line (Yorkshire) were produced and selected from two gene sources from France and the USA. The breeding charts of two crossbred parent sows, PS1 and PS2, are shown as below:

♂ LVN x ♀ YVN → PS1

♂ YVN x ♀ LVN → PS2

The two crossbred line boars, DVN1 and DVN2, were crossed with two crossbred parent sow lines, PS1 and PS2, to produce the market pigs TP1, TP2, TP3, and TP4 as the following breeding charts:

♂ DVN1 x ♀ PS1 → TP1

♂ DVN1 x ♀ PS2 → TP2

♂ DVN2 x ♀ PS1 → TP3

♂ DVN2 x ♀ PS2 → TP4

3.2. CONTENTS OF THE STUDY

The study has two main contents:

- The production performance of DVN1 and DVN2 line sires
- The production performance of commercial crossbreeds produced from DVN1 and DVN2 line sires and parent sow lines PS1 and PS2.

3.2. METHODS

3.2.1. The production performance of DVN1 and DVN2 line pigs

3.2.1.1. Growth performance and carcass characteristics of DVN1 and DVN2 line

pigs

a. Materials

The study was conducted on a total of 1,800 pigs, of which 900 pigs (300 male pigs and 600 gilts) are DVN1 line, and 900 pigs (300 male pigs and 600 gilts) are DVN2 line, originated from Canada throughout three generations.

b. Research methods

Data about the growth performance of DVN1 and DVN2 pigs during the growing stage starting from 71.49 days of age (SD=2,36 days) to the end at 148.70 days of age (SD= 4.94 days) were collected at the Thuy Phuong Pig Research and Development Center from June 2017 to December 2020. The initial body weight of pigs was measured individually by a mechanical single face scale (Nhon Hoa scale, 100kg, ± 200g), and the final body weight of pigs was measured by an electronic weighing scale (Kelba, Australia). The daily body weight gain was calculated as the difference between the final and initial body weights of individual pigs divided by the total days from the beginning to the end of the growing phase. The backfat thickness (BFT) and depth of the *longissimus dorsal* were measured by ultrasound Agroscan AL using ALAL 350 probe (ECM, France) on the same day when measuring the final body weight according to the method by Youssao *et al.* (2002). The lean meat percentage was estimated based on backfat thickness and muscle thickness. The intramuscular fat content was determined at individual pigs on the same day when measuring the final body weight by the ultrasound Exago using L3130B probe (IMV, France) at the 10th ribs with 6.5cm away from the middle line of the back, and it was calculated by the Biosoft Toolbox II for Swine software version 3.0.

Data on feed consumption during the performance test period were collected on the male pig herd at the Thuy Phuong Pig Research and Development Center. The total feed provided to the pigs and the remaining amount of each day were weighed to calculate the feed intake as the difference between the provision amount and the residual amount. The feed conversion ratio (feed intake per body weight gain) was calculated by dividing the feed intake by cumulative body weight gain during the experiment.

The GLM procedure in SAS 9.4 software was used to examine the effects of variables on the growth traits, backfat thickness, depth of the *longissimus dorsal,* intramuscular fat content, and lean meat percentage according to this statistical model: $y_{ijkl} = \mu+H_i+G_j+S_k+H_i*G_j+H_i*S_k + G_j*S_k+\varepsilon_{ijkl}$, where yijk = growth performance, lean meat percentage, and intramuscular fat content; μ = overall mean; H_i = effect of line i (i= 2: DVN1 and DVN2); G_j = effect of generation j (j = 3: 1; 2; 3); S_k = effect of sex k (k = 2: male and female); H_i*G = interaction between line and generation; G_j*S_k = interaction between generation and sex; ε_{ijkl} = residual errors. The age at the beginning of the experiment was used as a covariate for the analysis of initial body weight. The age at the end of the experiment was used as the covariate for other traits, including final body weight, body weight gain, backfat thickness, depth of the *longissimus dorsal,* lean meat percentage, and intramuscular fat content. Estimation of LSM, standard error of the mean (SEM) was conducted by the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment.

3.2.1.2. Reproductive performance of DVN1 and DVN2 sows

a. Materials

The study was conducted on a total of 300 sows with 900 litters, of which 150 sows (450 litters) of the DVN1 line and 150 sows (450 litters) of the DVN2.

b. Methods

Data on the reproductive performance of Duroc sows were reviewed and traced from the recorded data at the Thuy Phuong Pig Research and Development Center from January 2017 to June 2017. The reproductive performance of Duroc sows was also measured and recorded directly from July 2017 to December 2020. Duroc sows were housed in the closed facilities at the Thuy Phuong Pig Research and Development Center.

The age at first farrowing was recorded in the gilt herd. The reproductive performance of sows was determined by different measures, including total number of piglets born per litter, number of piglets born alive per litter, number of weaned piglets per litter, percentage of piglets born alive, percentage of piglets weaned alive, born weight per piglet, born weight per litter, weaned weight per piglet, weaned weight per litter, and farrowing interval. Piglets were weaned at 28 days of age. Ear notching was conducted at birth, and ear tags were used at the weaning age. Total number of piglets born per litter, number of piglets born alive per litter, number of weaned piglets per litter were counted at each respective time point. Born weight per piglet and weaned weight per piglet were measured by weighing individual pigs by mechanical single face scale at each respective time point. Born weight per litter and weaned weight per litter were the sum of weights of all piglets in each litter at born and weaning age. Percentage of piglets born alive = (number of piglets born alive per litter/ Total number of piglets born per litter) x100. Percentage of piglets weaned alive = (number of weaned piglets per litter/ number of piglets born alive per litter) x100.

The GLM procedure in SAS 9.0 software was used to analyze the factors affecting the variables according to this statistical model: $y_{ijkl} = \mu + B_i + G_j + L_k + \varepsilon_{ijkl}$, where: y_{ijkl}: Reproductive performance of sows; μ: overall mean; B_i= effect of line i (i= 2: DVN1 and DVN2); G_j = effect of generation j (j = 3: 1; 2; 3); L_k= effect of parity k (k = 3: parity 1, 2, 3); ε_{ijkl} = residual errors. Estimation of LSM, standard error (SE) was conducted by the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment.

3.2.1.3. Ejaculate volume and sperm quality of DVN1 and DVN2 boars

a. Materials

The study was conducted on a total of 180 boars with 1,800 ejaculates, of which 90 boars (900 ejaculates) of the DVN1 line and 90 boars (900 ejaculates) of the DVN2.

b. Methods

Data on ejaculate volume and sperm quality of Duroc boars were reviewed and traced from the recorded data at the Thuy Phuong Pig Research and Development Center from January 2017 to June 2017. The ejaculate volume and sperm quality of Duroc boars was recorded directly from July 2017 to December 2020. Duroc boars were housed in individual pens equipped with automatic feeders and drinkers and fed 2.5-3.0kg per day. Boars were raised in the closed facilities. The young male pigs were trained to artificial mating at 225-240 days of age (or 7.5-8 months of age), and the total working life was less than 36 months (or three years of age). Ejaculate volume and sperm quality of boars mentioned in this thesis included boars passing the performance test and mating training and were at 10 to 12 months of age during the working period. Each boar was ejaculated 10 times for sperm quality assessment.

The semen was collected by mounting in the dummy sow, and the equipment for semen collection was pasteurized before usage. The semen was collected in the morning with 4-5 days of interval between consecutive collections. The ejaculate volume (V, ml) was measured by cups with measurement units. Spermatozoa motility (A, $0 \leq A \leq 1$ was evaluated microscopically (100-300 times of magnification) to count the number of sperm moves with flagellar movement compared with total sperm can be seen in a given volume. Sperm concentration (C, millions/ml) was measured by a sperm concentration machine (SDM5, Minitube, Germany). The total number of progressively motile spermatozoa (VAC, billions/ejaculate) was calculated from three parameters (V, A, and C). Percentage of abnormal sperm count (K, %) was identified by staining and counting in a microscope with 400-600 times of magnification. Semen pH was measured by pH meter (Toledo MP 220).

The GLM procedure in SAS 9.0 software was used to analyze the factors affecting the variables according to this statistical model: $y_{ijk} = \mu + B_i + G_j + B_i*G_j + \varepsilon_{ijk}$., where: y_{ijkl}: the sperm quality of boars; μ: overall mean; B_i= effect of sire line i (i= 2: DVN1 and DVN2); G_j = effect of generation j (j = 3: 1; 2; 3); B_i*G_j = Interaction between sire line and generation; ε_{ijkl} = residual errors. The LSM, standard error (SE) was estimated using the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment.

3.2.2. Production performance of market pigs produced from DVN1 and DVN2 sire lines and parent sows PS1 and PS2

3.2.2.1. Growth performance of market pigs from TP1, TP2, TP3, and TP4 crossbreeds

a. Materials

The study was conducted on a total of 360 growing pigs, of which TP1 crossbreed: 90 pigs (45 male and 45 female pigs), TP2 crossbreed: 90 pigs (45 male and 45 female pigs), TP3 crossbreed: 90 pigs (45 male and 45 female pigs), TP4 crossbreed: 90 pigs (45 male and 45 female pigs)

b. Methods

Data about the growth performance of TP1, TP2, TP3, and TP4 pigs during the growing stage starting from 71.32 days of age (SD=1,11 days) to the end at 148.90 days of age (SD= 1.47 days) were collected. The initial body weight, final body weight, daily body weight gain (g/day), backfat thickness, depth of the *longissimus dorsal*, and lean meat percentage was determined by the same methods presented previously at 3.2.1.1.

The GLM procedure in SAS 9.4 software was used to examine the effects of variables on the growth trait, backfat thickness, depth of the *longissimus dorsal,* and lean meat percentage according to this statistical model: $y_{ijkl} = \mu + G_i + S_j + F_k + \varepsilon_{ijkl}$, where y_{ijkl} = growth performance and lean meat percentage; μ = overall mean; G_i = effect of commercial crossbreed i (i= 4: TP1, TP2, TP3, and TP4); S_j= effect of sex j (k = 2: male and female); F_k= effect of studied farms in province k (k=3: Bac Ninh, Ninh Binh, Thai Nguyen); ε_{ijkl} = residual errors. Estimation of LSM, standard error of the mean (SEM) was conducted by the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment. The age at the beginning of the experiment was used as a covariate for the analysis of initial body weight. The age at the end of the experiment was used as the covariate for final body weight, body weight gain, backfat thickness, depth of the *longissimus dorsal,* lean meat percentage.

3.2.2.2. Carcass yield of market pigs from different crossbreeds

a. Materials

The study was conducted on a total of 40 market pigs, of which TP1 crossbreed: 10 pigs (5 male and 5 female pigs), TP2 crossbreed: 10 pigs (5 male and 5 female pigs), TP3 crossbreed: 10 pigs (5 male and 5 female pigs), TP4 crossbreed: 10 pigs (5 male and 5 female pigs).

b. Methods

The live body weight of individual pigs was recorded before slaughter by electronic scale (Kelba, Australia). The hot carcass weight was determined by a mechanical single face scale (100kg maximum) after deducting the weight of bristles, blood, and internal organs. The killing-out percentage was then calculated based the live weight and the hot carcass weight. The dressed carcass weight was measured after removing the head and four hooves. The dress carcass percentage was calculated from hot carcass weight and the live weight. The carcass length was measured by the tapeline from the first cervical vertebra (*Atlas* vertebrae) to the pubis (*symphysis*). The area of *longissimus dorsi* muscle (cm^2) was identified by the conventional method using plastic paper to print the transected surface of the muscle at the rib number 13 and 14, then transfer this printed plastic paper into the graph paper. The area of *longissimus dorsi* muscle was calculated from the weight of $100cm^2$ graph paper (a, gram) and the weight of printed transect surface graph paper (b, gram) as this formula: b (g) x100 cm^2/a (g).

Data were analyzed by SAS 9.4 software. The GLM procedure was used to examine the effects of crossbreed and sex variables on the carcass yield parameters according to this statistical model: $y_{ijk} = \mu + G_i + S_j + \varepsilon_{ijk.}$, where y_{ijkl} = Carcass yield parameters; μ = overall mean; G_i = effect of commercial crossbreed i (i= 4: TP1, TP2, TP3, and TP4); S_j= effect of sex j (k = 2: male and female); ε_{ijkl} = residual errors. Estimation of LSM, standard error of the mean (SEM) was conducted by the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment.

3.2.2.3. Carcass quality of market pigs from different crossbreeds

a. Materials

The study was conducted on a total of 40 *longissimus dorsi* muscle samples, of which TP1 crossbreed: 10 pigs (5 male and 5 female pigs), TP2 crossbreed: 10 pigs (5 male and 5 female pigs), TP3 crossbreed: 10 pigs (5 male and 5 female pigs), TP4 crossbreed: 10 pigs (5 male and 5 female pigs) .

b. Methods

The *longissimus dorsi* muscle samples were collected at the slaughterhouse immediately after the slaughter at rib number 13 and 14. The pH value was measured by pH meter (Testo 230, Germany) at 45 minutes post-mortem (pH45) and 24 hours post-mortem (pH24). Meat color was determined by Minolta CR-410 machine (Japan) with three parameters: L* (lightness), a* (redness) and b* (yellowness) at 24 hours post-mortem (L*24, a*24, b*24). The drip loss percentage (%) was identified by the differences between the weight of muscle samples before and after cold storage during 24 hours. The cooking loss percentage (%) was calculated from the differences between the weight of muscle samples before and after cooking by steaming in the Waterbatch Memmert bath at 75^{o}C for 50 minutes. The shear force of the muscle (N) was determined by Warner Bratzler 2000D machine (USA) at 24 hours post-mortem.

Data were analyzed by SAS 9.4 software. The GLM procedure was used to examine the effects of crossbreed and sex variables on the carcass quality parameters according to this statistical model: $y_{ijk} = \mu + G_i + S_j + \varepsilon_{ijk.}$, where y_{ijkl} = Carcass quality parameters; μ = overall mean; G_i = effect of commercial crossbreed i (i= 4: TP1, TP2, TP3, and TP4); S_j= effect of sex j (k = 2: male and female); ε_{ijkl} = residual errors. Estimation of LSM, standard error of the mean (SEM) was conducted by the LSMeans compute with a pairwise comparison using Tukey test with pdiff adjustment.

4. RESULTS AND DISCUSSION

4.1. PRODUCTION PERFORMANCE OF DVN1 AND DVN2 PIGS

4.1.1. Growth performance and carcass yield of DVN1 and DVN2 pigs

4.1.1.1. Effects of factors on the growth performance and carcass yield of DVN1 and DVN2 pigs

Results on the effects of different factors on the growth and carcass yield of DVN1 and DVN2 pigs are presented in Table 4.1

Table 4.1 Effects of different factors on the growth and carcass yield of DVN1 and DVN2 pigs

Parameters	D	TH	TB	D*TH	D*TB	TH*TB
Initial body weight (kg)	0.446	0.110	0.716	0.833	0.619	<0.0001
Final body weight (kg)	0.522	<0.0001	0.075	0.003	<0.0001	<0.0001
Daily body weight gain (g/day)	0.205	<0.0001	0.016	0.013	<0.0001	0.002
Backfat thickness (mm)	<0.0001	<0.0001	<0.0001	0.004	0.0003	0.004
Depth of the *longissimus dorsal* (mm)	<0.0001	<0.0001	<0.0001	<0.0001	0.586	<0.0001
Lean meat percentage (%)	<0.0001	<0.0001	<0.0001	0.630	0.007	<0.0001
Intramuscular fat content (%)	<0.0001	<0.0001	<0.0001	0.081	0.099	0.415
Feed conversion ratio (kg)	<0.0001	<0.0001	-	0.062	-	-

*Note: - Not measured; D is line; TH is generation; TB is sex; interation D*TH; D*TB; TH*TB*

The generation has a significant effect on all studied parameters about the growth and carcass yield of DVN1 and DVN2 pigs (P<0.0001), except the initial body weight (P>0.05). The pig line also has a significant effect on measured indicators about growth performance of DVN1 and DVN2 pigs (P<0.0001), except the initial body weight and final body weight and daily body weight gain (P>0.05). The sex of the pig has a significant effect on the backfat thickness, depth of the longissimus dorsal, lean meat percentage, intramuscular fat content (P<0.0001), and the daily body weight gain (P<0.05), except the initial body weight and final body weight (P>0.05). The interaction between the pig line and generation has a significant effect on parameters of daily body weight gain (P<0.05), final body weight, backfat thickness (P<0.01), depth of the longissimus dorsal (P<0.001), except the initial body weight, lean meat percentage, intramuscular fat content, and the feed conversion ratio (P>0.05). The difference between the results of the present study and other previous reports comes from the differences in gene frequency among pig populations, in data sources, and the calculation methods.

4.1.1.2. The growth performance and carcass yield of DVN1 and DVN2 pigs

Results on the growth performance and carcass yield of DVN1 and DVN2 pigs are shown in table 4.2

Table 4.2. Growth performance and carcass yield of DVN1 and DVN2 pigs

Parameters	n	DVN1	DVN2	SEM
Initial body weight (kg)	900	31.52	31.57	0.04
Final body weight (kg)	900	100.14	100.25	0.11
Daily body weight gain (g/day)	900	893.48	890.30	1.78
Backfat thickness (mm)	900	10.34[b]	10.49[a]	0.01
Depth of the *longissimus dorsal* (mm)	900	57.42[a]	56.95[b]	0.04
Lean meat percentage (%)	900	62.10[a]	61.83[b]	0.02
Intramuscular fat content (%)	900	2.92[b]	3.03[a]	0.01
Feed conversion ratio (kg)	300	2.47[b]	2.49[a]	0.002

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.2, the growth performance and carcass yield of DVN1 and DVN2 pigs were moderately high, where daily body weight gain was 893.448 and 890.30g/day, the lean meat percentage was high at 62.10 and 61.83%, the intramuscular fat content was 2.92 and 3.03%, the feed conversion ratio was low at 2.47 and 2.49kg, respectively. The daily weight gain of DVN1 pigs (893.48g/day) was higher than the DVN2 pigs (890.30g/day) (P<0.05). The DVN1 pigs have a higher backfat thickness (10.34mm), and a lower intramuscular fat content (2.92%) than the DVN2 pigs (10.49mm and 3.03%), but a higher depth of the *longissimus dorsal* and lean meat percentage than DVN2 pigs. The differences in these parameters are statistically significant (P<0.0001). Besides that, the feed conversion ratio of DVN1 pigs (2.47kg) was lower than the DVN2 pigs (2.49kg), and the difference in feed conversion ratio between DVN1 and DVN2 boars is statistically significant (P<0.0001). Therefore, the use of DVN1 pigs can help improve the depth of the *longissimus dorsal,* lean meat percentage, and feed conversion ratio compared with the DVN2 pigs, whereas the DVN2 pigs can contribute better to the intramuscular fat content compared with DVN1 pigs.

The daily weight gain of two DVN1 and DVN2 pig lines is higher than the standard level of nucleus Duroc breeders ((≥ 800 g/day) according to Decision number 675/QĐ-BNN-CN issued by the Ministry of Agriculture and Rural Development (2014).

4.1.1.3. The growth performance and carcass yield of DVN1 and DVN2 pigs through three generations

Results on the growth performance and carcass yield of DVN1 and DVN2 pigs through three generations are shown in table 4.3

Table 4.3. Growth performance and carcass yield of DVN1 and DVN2 pigs through three generations

Parameters	n	1st generation	2nd generation	3rd generation	SEM
Initial body weight (kg)	600	31.56	31.47	31.62	0.05
Final body weight (kg)	600	98.22^{b}	101.24^{a}	101.13^{a}	0.14
Daily body weight gain (g/day)	600	858.97^{b}	905.42^{a}	911.27^{a}	2.22
Backfat thickness (mm)	600	10.67^{a}	10.47^{b}	10.12^{c}	0.02
Depth of the *longissimus dorsal* (mm)	600	56.08^{c}	56.95^{b}	58.52^{a}	0.05
Lean meat percentage (%)	600	61.45^{c}	61.86^{b}	62.59^{a}	0.02
Intramuscular fat content (%)	600	2.84^{c}	2.95^{b}	3.14^{a}	0.01
Feed conversion ratio (kg)	200	2.51^{c}	2.49^{b}	2.46^{a}	0.03

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.3, the daily body weight gain, depth of the *longissimus dorsal,* lean meat percentage, and intramuscular fat content of DVN1 and DVN2 pigs were at the lowest level in the first generation (858.97 g/day, 56.08 mm, 61.45%, and 2.84%) and at the highest level in the third generation (911.27 g/day, 58.52 mm, 62.59% and 3.14 %), while the backfat thickness and feed conversion ratio were at the controversial trend, at the highest level in the first generation (10.67 mm and 2.51 kg) and the lowest level in the third generation (10.12 mm and 2.46 kg). The differences in these parameters among the three generations are statistically significant ($P<0.001$).

Results on the growth performance and carcass yield of DVN1 pigs through three generations are shown in table 4.4

Table 4.4. Growth performance and carcass yield of DVN1 pigs through three generations

Parameters	n	1st generation	2nd generation	3rd generation	SEM
Initial body weight (kg)	300	31.50	31.46	31.61	0.08
Final body weight (kg)	300	98.14^{b}	101.04^{a}	101.13^{a}	0.19
Daily body weight gain (g/day)	300	852.91^{c}	903.03^{b}	948.67^{a}	3.72
Backfat thickness (mm)	300	10.62^{a}	10.39^{b}	10.01^{c}	0.02
Depth of the *longissimus dorsal* (mm)	300	56.46^{c}	57.22^{b}	58.58^{a}	0.07
Lean meat percentage (%)	300	61.58^{c}	62.01^{b}	62.72^{a}	0.03
Intramuscular fat content (%)	300	2.80^{c}	2.89^{b}	3.06^{a}	0.01
Feed conversion ratio (kg)	100	2.50^{c}	2.47^{b}	2.45^{a}	0.004

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

Results on the growth performance and carcass yield of DVN2 pigs through three generations are shown in table 4.5

Table 4.5. Growth performance and carcass yield of DVN2 pigs through three generations

Parameters	n	1st generation	2nd generation	3rd generation	SEM
Initial body weight (kg)	300	31.61	31.48	31.61	0.07
Final body weight (kg)	300	98.43^{c}	101.50^{a}	100.83^{b}	0.19
Daily body weight gain (g/day)	300	836.15^{c}	894.31^{b}	936.68^{a}	3.38
Backfat thickness (mm)	300	10.71^{a}	10.55^{b}	10.22^{c}	0.02
Depth of the *longissimus dorsal* (mm)	300	55.70^{c}	56.68^{b}	58.48^{a}	0.08
Lean meat percentage (%)	300	61.32^{c}	61.71^{b}	62.47^{a}	0.03
Intramuscular fat content (%)	300	2.89^{c}	3.03^{b}	3.19^{a}	0.01
Feed conversion ratio (kg)	100	2.52^{c}	2.50^{b}	2.47^{a}	0.003

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.4 and 4.5, the final body weight, daily body weight gain depth of the *longissimus dorsal,* lean meat percentage, and intramuscular fat content of DVN1, and DVN2 pigs were increased from the first generation to the third generation, except the backfat thickness with the decreased trend from the first generation to the third generation. The differences in these parameters are statistically significant (P<0.001). Therefore, the growth performance indicators of two pig lines DVN1 and DVN2, after selection through three generations, showed a greater improvement compared with previous generations. It indicates that two pig lines DVN1 and DVN2 can adapt well to the local conditions, and all the growth traits were well and stably selected through three generations

The results of the present study on the growth performance of two pig lines, DVN1 and DVN2, through three generations are consistent with the previous study reported by Nguyen Huu Tinh et al. (2020b), who examined the growth performance of terminal pig sire TS3 (Duroc) and found that the daily body weight gain was improved through four-generation selection (original pig herd: 843 g/day, first generation: 923 g/day, second generation: 929 g/day, and the fourth generation: 932 g/day). Research results by Trinh Hong Son et al. (2013a) on the growth performance of the crossbred VCN03 pig line found that the daily body weight gain (829.80 g/day), the killing-out percentage (84.30%), lean meat percentage (61.14%) of pigs in the first generation after selection were higher than the original pig herd (769.51 g/day, 84.12% and 59.74%). The carcass quality of pigs in the original herd and the first generation was at a good standard level.

4.1.1.4. The growth performance and carcass yield of DVN1 and DVN2 by sex of pigs

The results of growth performance and carcass yield of DVN1 and DVN2 by sex of pigs are presented in table 4.6

Table 4.6. Growth performance and carcass yield of DVN1 and DVN2 by sex of pigs (LSM ± SE)

Parameters	**Female pigs** (n=1,200)	**Male pigs** (n = 600)
Initial body weight (kg)	31.54±0.03	31.56±0.05
Final body weight (kg)	100.34±0.09	100.05±0.13
Daily body weight gain (g/day)	888.21^{b}±1.67	902.37^{a}±2.37
Backfat thickness (mm)	10.59^{a}±0.01	10.25^{b}±0.02
Depth of the *longissimus dorsal* (mm)	56.81^{a}±0.04	57.56^{b}±0.05
Lean meat percentage (%)	61.70^{b}±0.01	62.23^{a}±0.02
Intramuscular fat content (%)	3.04^{a}±0.01	2.92^{b}±0.01

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.6, DVN1 and DVN2 female pigs had a lower daily body weight gain (888.21 g/day) and lean meat percentage (61.70%) than the male pigs, but a higher backfat thickness (10.59mm) and intramuscular fat content (3.04 %) than the male pigs (902.37 g/day; 10.25 mm; 2.92 % and 62.23%) with statistically significant differences (P<0.0001).

4.1.2. The reproductive performance of DVN1 and DVN2 sows

4.1.2.1. Effects of factors on the reproductive performance of DVN1 and DVN2 sows

The results of effects factors on the reproductive performance of DVN1 and DVN2 sows are shown in table 4.7

Table 4.7. Effects of factors on the reproductive performance of DVN1 and DVN2 sows

Parameters	**Pig lines**	**Generations**	**Parities**
Age at first mating (day)	<0.0001	<0.0001	-
Age at first farrowing (day)	<0.0001	<0.0001	-
Farrowing interval (day)	0.653	<0.0001	<0.0001
Number of litters/sow/year	0.881	<0.0001	<0.0001
Number of weaned piglets/sow/year (head)	0.068	<0.0001	<0.0001

Number of piglets born (head)	0.072	0.032	0.063
Number of piglets born alive (head)	0.013	0.315	0.028
Number of piglets selected (head)	0.009	0.182	0.141
Percentage of piglets born alive (%)	0.188	0.0007	0.497
Born weight per piglet (kg)	0.316	<0.0001	0.018
Born weight per litter (kg)	0.0009	0.011	0.004
Weaning age (day)	0.425	0.0057	0.070
Number of weaned piglets (head)	0.013	0.039	<0.0001
Percentage of piglets weaned alive (%)	0.439	0.540	<0.0001
Weaned weight per piglet (kg)	0.375	<0.0001	0.086
Weaned weight per litter (kg)	0.021	0.0001	<0.0001

Note: - Not tested

The pig line has a significant effect on the age at first mating, age at first farrowing, weaned weight per litter (P<0.001), Number of piglets selected (P<0.01), number of piglets born alive per litter, number of weaned piglets per litter (P<0.05). The generation has a significant effect on the age at first mating, age at the first farrowing, farrowing interval, number of litters/sow/year, number of weaned piglets/sow/year, percentage of piglets born alive, born weight per piglet, born weight per piglet, weaned weight per litter (P<0.001), number of piglets born, born weight per litter, number of weaned piglets (P<0.05). The parity of sows has a significant effect on the farrowing interval, number of litters/sow/year, number of weaned piglets, percentage of piglets weaned alive, weaned weight per litter (P<0.001), number of piglets born alive, born weight per piglet (P<0.05).

3.1.2.2. Reproductive performance of DVN1 and DVN2 sows

The parameters of reproductive performance of DVN1 and DVN2 sows are presented in table 4.8.

Table 4.8. Reproductive performance of DVN1 and DVN2 sows

Parameters	n	DVN1	DVN2	SEM
Age at first mating (day)	150	218.85[b]	229.43[a]	0.69
Age at first farrowing (day)	150	333.57[b]	343.89[a]	0.70
Farrowing interval (day)	300	158.37	157.95	0.66
Number of litters/sow/year	300	2.32	2.32	0.01
Number of weaned piglets/sow/year (head)	300	22.82	22.22	0.23
Number of piglets born (head)	450	11.23	10.95	0.11
Number of piglets born alive (head)	450	10.76[a]	10.42[b]	0.10
Number of piglets selected (head)	450	10.34[a]	10.03[b]	0.08
Percentage of piglets born alive (%)	450	96.41	95.80	0.33

Born weight per piglet (kg)	450	1.54	1.53	0.01
Born weight per litter (kg)	450	16.64[a]	15.95[b]	0.15
Weaning age (day)	450	22.48	22.54	0.06
Number of weaned piglets (head)	450	9.70[a]	9.44[b]	0.07
Percentage of piglets weaned alive (%)	450	94.29	94.70	0.37
Weaned weight per piglet (kg)	450	6.87	6.89	0.01
Weaned weight per litter (kg)	450	66.67[a]	65.02[b]	0.51

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

The reproductive performance of DVN1 sows raised in the Thuy Phuong Pig Research and Development Center was at the moderate level with the number of piglets born alive, number of piglets selected per litter, born weight per litter, number of weaned piglets, and weaned weight per litter were 10.76 piglets, 10.34 piglets, 16.64 kg, 9.7 piglets and 66.67 kg, respectively (table 4.8). The number of piglets born alive per litter, number of piglets selected per litter, weaned weight per litter, number of weaned piglets, and weaned weight per litter of DVN2 sows were 10.42 piglets, 10.03 piglets, 15.95 kg, 9,44 piglets and 65.02 kg (table 4.8). The DVN1 and DVN2 sows were produced from Duroc pure breed originated from Canada, which is known as the "male line" thus, they have a moderate level of reproductive performance.

4.1.2.3. Reproductive performance of DVN1 and DVN2 sows through three generations

The reproductive performance results of DVN1 and DVN2 sows through three generations were shown in table 4.9.

Table 4.9. Reproductive performance of DVN1 and DVN2 sows through three generations

Parameters	n	1st generation	2nd generation	3rd generation	SEM
Age at first mating (day)	100	221.71[b]	230.20[a]	220.51[b]	0.85
Age at first farrowing (day)	100	336.46[b]	345.00[a]	334.72[c]	0.86
Farrowing interval (day)	200	161.53[a]	159.33[a]	153.62[b]	0.81
Number of litters/sow/year	200	2.28[b]	2.30[b]	2.39[a]	0.01
Number of weaned piglets/sow/year (head)	200	21.62[b]	22.39[b]	23.54[a]	0.28
Number of piglets born (head)	300	10.83[b]	11.12[ab]	11.32[a]	0.13
Number of piglets born alive (head)	300	10.45	10.61	10.70	0.12
Number of piglets selected (head)	300	10.04	10.23	10.30	0.10

Percentage of piglets born alive (%)	300	97.07	96.32	94.93	0.40
Born weight per piglet (kg)	300	1.51^{b}	1.55^{a}	1.55^{a}	0.01
Born weight per litter (kg)	300	15.85^{b}	16.49^{a}	16.54^{a}	0.18
Weaning age (day)	300	22.39^{b}	22.46^{ab}	22.68^{a}	0.07
Number of weaned piglets (head)	300	9.40^{b}	9.59^{ab}	9.72^{a}	0.09
Percentage of piglets weaned alive (%)	300	94.21	94.39	94.89	0.45
Weaned weight per piglet (kg)	300	6.79^{b}	6.92^{a}	6.94^{a}	0.02
Weaned weight per litter (kg)	300	63.79^{b}	66.36^{a}	67.38^{a}	0.62

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

The number of litters/sow/year, number of weaned piglets/sow/year, number of piglets born, weaned weight per piglet, weaned weight per litter of DVN1 and DVN2 sows were at the lowest level in the first generation (2.28; 21.62 piglets; 10.83 piglets, 1.51 kg; 15.85 kg; 9.40 con; 6.79 kg and 63.79 kg) and the highest level in the third generation (2.39; 23.54 piglets; 11.32 piglets; 1.55 kg; 16.54 kg; 9.72 piglets; 6.94 kg and 67.38 kg). The differences in these parameters among different generations were statistically significant (P<0.01)

4.1.2.4. Reproductive performance of DVN1 and DVN2 sows through three parities

The results of reproductive performance of DVN1 and DVN2 sows through three parities were presented in table 4.10.

Table 4.10. Reproductive performance of DVN1 and DVN2 sows through three parities

Parameters	n	1st parity	2nd parity	3rd parity	SEM
Farrowing interval (day)	150	-	160.84^{a}	155.48^{b}	0.66
Number of litters/sow/year	150	-	2.28^{b}	2.36^{a}	0.01
Number of weaned piglets/sow/year (head)	150	-	21.73^{b}	23.31^{a}	0.23
Number of piglets born (head)	150	10.88	11.07	11.32	0.13
Number of piglets born alive (head)	150	10.37^{b}	10.59^{ab}	10.81^{a}	0.12
Number of piglets selected (head)	150	10.03	10.22	10.32	0.10
Percentage of piglets born alive (%)	150	96.05	96.47	95.80	0.40
Born weight per piglet (kg)	150	1.52^{b}	1.54^{a}	1.55^{a}	0.01
Born weight per litter (kg)	150	15.85^{b}	16.34^{ab}	16.70^{a}	0.18
Weaning age (day)	150	22.43	22.47	22.64	0.07
Number of weaned piglets (head)	150	9.32^{b}	9.52^{ab}	9.88^{a}	0.09

Percentage of piglets weaned alive (%)	150	93.43^{b}	93.79^{b}	96.27^{a}	0.45
Weaned weight per piglet (kg)	150	6.86	6.89	6.91	0.02
Weaned weight per litter (kg)	150	63.81^{b}	65.49^{ab}	68.24^{a}	0.62

Note: - means not tested; In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.10, the number of piglets born, number of piglets born alive, born weight per piglet, number of weaned piglets, percentage of piglets weaned alive and weaned weight per litter of DVN1 and DVN2 sows were at the lowest level in the first parity (10.88 piglets; 10.37 piglets, 1.52 kg; 9.32 piglets; 93.43 % and 63.81 kg) and at the highest level in the third parity (11.32 piglets; 10.81 piglets; 1.55 kg; 9.88 piglets; 96.27 % and 68.24 kg). The differences in these parameters among different parities were statistically significant (P<0.01), except the number of piglets born (P>0.05). Therefore, the parameters of reproductive performance of DVN1 and DVN2 sows showed an increasing trend from the lowest level in the first parity to the higher level in the second parity and the highest level in the third parity. The reproductive parameters of DVN1 and DVN2 sows had a similar trend of general changing through parities of the sows.

4.1.3. The ejaculate volume and sperm quality of DVN1 and DVN2 boars

4.1.3.1. Factors that affect the ejaculate volume and sperm quality of DVN1 and DVN2 boars

The effects of several factors on the ejaculate volume and sperm quality of DVN1 and DVN2 boars are shown in table 4.11.

Table 4.11. Effects of several factors on the ejaculate volume and sperm quality of DVN1 and DVN2 boars

Parameters	Line	Generation	Line*Generation
Ejaculate volume (V, ml)	0.120	<0.0001	0.245
Spermatozoa motility (A, %)	0.0002	<0.0001	<0.0001
Sperm concentration (C, million/ml)	0.138	0.036	0.048
Total number of progressively motile spermatozoa per ejaculate (VAC, billion/ejaculate)	0.007	<0.0001	0.003
Percentage of abnormal sperm count (%)	0.004	<0.0001	<0.0001
pH	<0.0001	0.225	0.036

The pig lines had a significant effect on the spermatozoa motility (P<0.001) and pH value (P<0.001), the total number of progressively motile spermatozoa per ejaculate, and percentage of abnormal sperm count (P<0.01), except the ejaculate volume and sperm concentration (P>0.05). The generation influenced most parameters of volume and quality of semen of DVN1 and DVN2 pigs, except the pH value (P>0.05). The interaction between line and generation significantly affected most of the parameters of sperm quality of DVN1 and DVN2 pis, except the ejaculate volume

(P>0.05).

4.1.3.2. The ejaculate volume and sperm quality of DVN1 and DVN2 boars

The results of ejaculate volume and sperm quality of DVN1 and DVN2 boar lines were presented in table 4.12.

Table 4.12. Ejaculate volume and sperm quality of DVN1 and DVN2 boars

Parameters	n	DVN1	DVN2	SEM
Ejaculate volume (V, ml)	900	229.77	227.39	1.08
Spermatozoa motility (A, %)	900	86.78^{a}	86.29^{b}	0.09
Sperm concentration (C, million/ml)	900	255.95	254.44	0.72
Total number of progressively motile spermatozoa per ejaculate (VAC, billion/ejaculate)	900	51.07^{a}	49.97^{b}	0.29
Percentage of abnormal sperm count (%)	900	6.45^{b}	6.65^{a}	0.05
pH	900	7.36^{b}	7.43^{a}	0.01

In the same parameter, the LSM with different superscripts shows statistically significant differences

The DVN1 pigs had a higher ejaculate volume (229.77 ml), spermatozoa motility (86.78%), sperm concentration (255.95 triệu/ml), and the total number of progressively motile spermatozoa per ejaculate (51.07 billion/ejaculate) than the DVN2 pigs (227.39 ml; 86.29%; 254.44 million sperms/ml and 49,97 billion/ ejaculate), but the percentage of abnormal sperm count of DVN1 pigs was lower than DVN2 pigs. The differences in these parameters between two pig lines DVN1 and DVN2 were statistically significant (P<0.01), except the ejaculate volume and sperm concentration (P>0.05). Therefore, the utilization of DVN1 pigs in semen collection for artificial insemination can help improve the spermatozoa motility, total number of progressively motile spermatozoa, and percentage of abnormal sperm count compared with the DVN2 pigs.

Parameters of volume and sperm quality of both DVN1 and DVN2 pig lines are equivalent to the standard level according to the national standard number TCVN 9111:2011 exotic breeding pigs– technical requirements by Ministry of Science and Technology (2011) about the standard for exotic boars using in artificial insemination to meet the demand of breeding program in animal production in North Vietnam.

4.1.3.3. Ejaculate volume and sperm quality of DVN1 and DVN2 boars through three generations

Results on the ejaculate volume and sperm quality of DVN1 and DVN2 boars through 3 generations are indicated in table 4.13.

The DVN1 and DVN2 boars had the lowest level of ejaculate volume, spermatozoa motility, sperm concentration, and the total number of progressively motile spermatozoa in the first generation (223.79 ml; 84.59%; 253.68 million/ml and 48,06 billion/ ejaculate), better results in the second generation and at the highest level in the third generation (232.53 ml; 87.40%; 256.88 million/ml and 52.20 billion/ejaculate).

Table 4.13. ***Ejaculate volume and sperm quality of DVN1 and DVN2 boars through three generations***

Parameters	n	1st generation	2nd generation	3rd generation	SEM
Ejaculate volume (V, ml)	600	223.79^{b}	229.42^{a}	232.53^{a}	1.32
Spermatozoa motility (A, %)	600	84.59^{b}	87.62^{a}	87.40^{a}	0.11
Sperm concentration (C, million/ml)	600	253.68^{b}	255.03^{ab}	256.88^{a}	0.88
Total number of progressively motile spermatozoa per ejaculate (VAC, billion/ejaculate)	600	48.06^{b}	51.30^{a}	52.20^{a}	0.35
Percentage of abnormal sperm count (%)	600	6.82^{a}	6.56^{b}	6.28^{c}	0.06
pH	600	7.38	7.40	7.39	0.01

In the same parameter, the LSM with different superscripts shows statistically significant differences

However, the percentage of abnormal sperm count had a controversial trend, where the highest level was in the first generation, then decreased and at the lowest level in the third generation. The differences in these indicators among generations were statistically significant ($P<0.001$). Therefore, the semen volume and sperm quality of two pig lines DVN1 and DVN2 were improved through selection with a higher result in the selected generation compared with the previous generations. It indicates that the selection of DVN1 and DVN2 pigs for breeding purposes was effective in improving the semen volume and sperm quality of the selected pig generation compared to previous ones. The semen volume and sperm quality of DVN1 and DVN2 pig lines through different generations meet the standard level according to the national standard number TCVN 9111:2011 exotic breeding pigs– technical requirements by Ministry of Science and Technology (2011) about the standard for exotic boars using in artificial insemination to meet the demand of breeding program in animal production in North Vietnam.

4.2. THE GROWTH PERFORMANCE, CARCASS YIELD, AND QUALITY OF CROSSBRED MARKET PIGS PRODUCED FROM DVN1 AND DVN2 SIRE CROSSED WITH PARENT SOWS PS1 AND PS2

4.2.1. The growth performance, carcass yield of crossbred market pigs produced from DVN1 and DVN2 sire crossed with parent sows PS1 and PS2

4.2.1.1. Effects of some factors on the growth performance and carcass yield of crossbred market pigs

The effects of some factors on the growth performance and carcass yield of crossbred market pigs were indicated in table 4.14.

Table 4.14. Effects of some factors on the growth performance and carcass yield of crossbred market pigs

Parameters	Crossbreeds	Sex	Farm locations
Initial body weight (kg)	0.372	0.292	0.360
Final body weight (kg)	0.219	0.515	0.728
Average daily weight gain (g/day)	0.038	0.941	0.831
Age at 100kg of body weight (days)	0.218	0.515	0.729
Backfat thickness (mm)	0.0016	0.023	0.666
Depth of the *longissimus dorsal* (mm)	0.096	0.124	0.022
Lean meat percentage (%)	<0.0001	0.311	0.128

The commercial crossbreeds had a significant effect on the lean meat percentage (P<0.001), average daily weight gain (P<0.05), and backfat thickness (P<0.01), but did not significantly affect the initial body weight, final body weight, and age at 100kg of body weight (P>0.05). The sex of pigs did not affect most examined parameters of growth performance of crossbred market pigs (P>0.05), but had a significant effect on backfat thickness (P<0.05). The farm locations did not affect most of the examined parameters of growth performance of crossbred market pigs (P>0.05), but had a significant effect on the depth of the *longissimus dorsal* (P<0.05).

4.2.1.2. The growth performance and carcass yield of crossbred market pigs

The growth performance and carcass yield of crossbred market pigs from DVN1 and DVN2 sire lines crossed with parent sows PS1 and PS2 were presented in table 4.15.

Table 4.15. The growth performance and carcass yield of crossbred market pigs

(n = 90)

Parameters	TP1	TP2	TP3	TP4	SEM
Initial body weight (kg)	30.55	30.29	30.45	30.30	0.12
Final body weight (kg)	102.93	102.50	102.73	102.39	0.20
Average daily weight gain (g/day)	937.96[a]	930.99[ab]	929.54[ab]	926.34[b]	2.88
Age at 100kg of body weight (days)	146.33	146.70	146.50	147.80	0.17
Backfat thickness (mm)	11.41[b]	11.39[b]	11.49[ab]	11.57[a]	0.03
Depth of the *longissimus dorsal* (mm)	60.21	59.92	60.00	59.68	0.15
Lean meat percentage (%)	61.60[a]	61.57ab	61.47[b]	61.32[c]	0.03
Feed conversion ratio (kg)	2.34[a]	2.29[b]	2.34[a]	2.33[a]	0.03

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.15, the body weight gain, lean meat percentage of market pigs TP1 were at the highest level (937.96 g/day and 61.60 %) and those of TP4 pigs were at the lowest level (926.34 g/day and 61.32 %). For the backfat thickness and the age at 100kg of body weight, the results for TP1 pigs were at the lowest level (11.41 mm and 146.33 days), whereas those of TP4 pigs were at the highest level (11.57 mm and 147.80 days). The differences in these parameters were statistically significant between two crossbreeds TP1 and TP4 (P<0.05), but were not significantly different between crossbreeds TP1and TP2 and TP3 (P>0.05). It can be concluded that the crossbreed between the DVN1 sire line and parent sow PS1 had an improvement of daily body weight gain, backfat thickness, lean meat percentage, and age at 100kg of body weight compared with the crossbreed between DVN2 boar and PS2 parent sow.

4.2.1.3. The growth performance and carcass yield of crossbred market pigs by their sex

The results of growth performance and carcass yield of crossbred market pigs, which produced from DVN1 and DVN2 sire lines crossed with parent sows PS1 and PS2, by their sex were presented in table 4.16, 4.17, 4.18 and 4.19.

Table 4.16. The growth performance and carcass yield of crossbred market pigs TP1 (LSM, n = 45)

Parameters	Female pigs	Male pigs	SEM
Initial body weight (kg)	30.51	30.67	0.170
Final body weight (kg)	102.63	103.04	0.28
Average daily weight gain (g/day)	936.89	939.72	4.00
Age at 100kg of body weight (days)	146.26	145.91	0.25
Backfat thickness (mm)	11.45	11.38	0.05
Depth of the *longissimus dorsal* (mm)	60.25	60.16	0.23
Lean meat percentage (%)	61.57	61.63	0.05

From table 4.16, the female TP1 pigs had a lower final body weight (102.63kg), lower body weight gain (936.89 g/day) and lower lean meat percentage (61.57 %) than those of castrated males (103.04 kg; 939.72 g/day and 61.63 %). However, there was no significant difference in these parameters between TP1 female pigs and castrated male pigs (P>0.05). Therefore, the utilization of both female pigs and male pigs of TP1 crossbreed did not affect the growth performance parameters.

Table 4.17. The growth performance and carcass yield of crossbred market pigs TP2 (LSM, n = 45)

Parameters	Female pigs	Male pigs	SEM
Initial body weight (kg)	30.47	30.09	0.17
Final body weight (kg)	102.73	102.16	0.32
Average daily weight gain (g/day)	937.73	924.68	4.39
Age at 100kg of body weight (days)	146.30	146.80	0.28
Backfat thickness (mm)	11.40	11.36	0.05
Depth of the *longissimus dorsal* (mm)	59.83	59.99	0.27
Lean meat percentage (%)	61.53	61.61	0.06

From table 4.17, the female TP2 pigs had a higher final body weight

(102.73kg), higher body weight gain (937.73 g/day) than those of castrated males (102.16 kg; 924.68 g/day), and the female TP2 pigs had a younger age at 100kg of body weight (146.30 days) than the castrated male pigs (146.80 days). However, there was not a significant difference in these parameters between TP2 female pigs and castrated male pigs (P>0.05). Therefore, the utilization of both female pigs and male pigs of TP2 crossbreed did not affect the growth performance parameters.

Table 4.18. The growth performance and carcass yield of crossbred market pigs TP3 (LSM, n = 45)

Parameters	Female pigs	Male pigs	SEM
Initial body weight (kg)	30.55	30.32	0.20
Final body weight (kg)	103.73^{a}	101.80^{b}	0.32
Average daily weight gain (g/day)	943.35^{a}	915.49^{b}	4.80
Age at 100kg of body weight (days)	145.73^{b}	147.42^{a}	0.28
Backfat thickness (mm)	11.48	11.51	0.06
Depth of the *longissimus dorsal* (mm)	60.06	59.95	0.22
Lean meat percentage (%)	61.50	61.44	0.04

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.18, the female TP3 pigs had a higher final body weight (103.73kg), higher body weight gain (943.35 g/day) than those of castrated males (101.80 kg; 915.49 g/day), and the female TP3 pigs had a younger age at 100kg of body weight (145.73 days) than the castrated male pigs (147.42 days). The differences in these parameters between TP3 female pigs and castrated male pigs were statistically different (P<0.0001). Therefore, the utilization of female TP3 pigs helps improve the final body weight, daily weight gain, and age at 100kg of body weight compared with the castrated male TP3 pigs.

Table 4.19. The growth performance and carcass yield of crossbred market pigs TP4 (LSM, n = 45)

Parameters	Female pigs	Male pigs	SEM
Initial body weight (kg)	30.43	30.17	0.16
Final body weight (kg)	102.12^{b}	102.90^{a}	0.25
Average daily weight gain (g/day)	915.00^{b}	936.80^{a}	3.70
Age at 100kg of body weight (days)	147.44^{a}	146.76^{b}	0.22
Backfat thickness (mm)	11.69^{a}	11.47^{b}	0.06
Depth of the *longissimus dorsal* (mm)	60.01^{a}	59.37^{b}	0.21
Lean meat percentage (%)	61.27	61.35	0.03

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.19, the daily body weight gain of market female pigs TP1 (915.00 g/day) was lower than the castrated male pigs (936.80 g/day). However, a controversial trend was found for the age at 100kg of body weight, backfat thickness, depth of the *longissimus dorsal*, where the female TP4 pigs had a higher result of age at 100kg of body weight (147.44 days), backfat thickness (11.69mm), and depth of the *longissimus dorsal* (60.01mm) than the castrated male pigs (146.76 days; 11.47 mm and 59.37 mm). The differences in these parameters were statistically significant. Therefore, the utilization of crossbred TP4 male pigs resulted in a better improvement of daily body weight gain, age at 100kg of body weight compared with the female pigs, whereas the female TP4 pigs can help improve the backfat thickness better than that of castrated male pigs.

4.2.2. The carcass characteristics of crossbred market pigs produced from DVN1 and DVN2 sire lines crossed with PS1 and PS2 parent sows

The results of carcass characteristics of crossbred market pigs produced from DVN1 and DVN2 sire lines crossed with PS1 and PS2 parent sows are shown in table 4.20.

Table 4.20. Carcass yield of crossbred market pigs (LSM, n = 10)

Parameters	TP1	TP2	TP3	TP4	SEM
Live body weight at slaughter (kg)	103.69	102.39	102.26	102.08	0.67
Hot carcass weight (kg)	86.80^{a}	85.02^{ab}	84.21^{b}	83.70^{b}	0.60
Dressed carcass weight (kg)	76.22	74.94	74.64	74.44	0.59
Killing-out percentage (%)	83.71^{a}	83.04^{ab}	82.36^{b}	81.98^{b}	0.29
Dress carcass percentage (%)	73.51	73.20	73.00	72.90	0.27
Area of *longissimus dorsi* muscle (cm^2)	60.14	60.33	59.07	60.20	0.42
Carcass length (cm)	101.10	102.80	100.60	100.30	0.97

Note: In the same parameter, the LSM with different superscripts shows statistically significant differences

From table 4.20, the hot carcass weight and the killing-out percentage of crossbred TP1 pigs achieved the highest level (86.80 kg and 83.71%) compared with the lowest level in crossbred TP4 (83.70 kg and 81.98%). Differences in these parameters between the TP1 and TP4 pigs were statistically significant ($P<0.01$), but no difference was found between TP1 and TP2 pigs, and between TP3 and TP4 pigs ($P>0.05$). Therefore, the crossbreeds between the DVN1 and DVN2 boar lines and the PS1 parent sows improved the hot carcass weight and the killing-out percentage compared with the crossbreeds between the two DVN2 boars and the PS2 parent sows.

4.2.3. Carcass quality of crossbred market pigs produced from DVN1 and DVN2 boars and PS1 and PS2 parent sows

The results of meat quality of crossbred market pigs produced from DVN1 and DVN2 boars and PS1 and PS2 parent sows are presented in table 4.21.

Table 4.21. Carcass quality of crossbred market pigs (LSM, n=10)

Parameters	TP1	TP2	TP3	TP4	SEM
pH45	6.63	6.64	6.60	6.58	0.04
pH24	5.70	5.73	5.69	5.67	0.02
L*(lightness)	57.24	57.64	57.17	57.04	0.50
a*(redness)	14.81	14.97	14.52	14.40	0.39
b* (yellowness)	8.65	8.66	8.74	8.39	0.25
Drip loss percentage (%)	2.30	2.28	2.41	2.36	0.19
Cooking loss percentage (%)	27.82	27.60	27.69	28.28	0.81
Shear force of the muscle (N)	48.93	48.74	47.73	47.88	1.17

The results in table 4.21 showed no effect of the crossbreed on the meat quality parameters (P>0.05). The pH value at 45 minutes (pH45) and the shear force of the muscle had a trend of the highest level in TP1 crossbred pigs (6.63 and 48.93 N), and the lowest level in TP4 crossbred pigs (6.58 and 47.88 N). The drip loss percentage and cooking loss percentage had a controversial trend, where the lowest level was seen in TP1 crossbred pigs (2.30 and 27.82 %), and the highest level was found in TP4 crossbred pigs (2.36 and 28.28 %). However, there was no statistical difference in these parameters between the two crossbreeds (P>0.05). Therefore utilization of four crossbred TP1, TP2, TP3, TP4 pigs produced from DVN1 and DVN2 boars and PS1 and PS2 parent sows did not affect the meat quality parameters.

The crossbred TP1, TP2, TP3, TP4 pigs had a good meat quality with the acceptable range of drip loss percentage (2-5%) and pH45>5.8 according to the carcass classification by Warner et al. (1997) and Joo et al. (1999), except the lightness (L*) was higher than 50.

CONCLUSIONS AND RECOMMENDATIONS

1. CONCLUSIONS

1.1 The productivity of DVN1 and DVN2 pig lines

**** Growth performance and carcass yield***

- The body weight at the beginning of the performance test period in each generation, pig lines, and sex of the pig were all not statistically different. The generation of pigs significantly affected all examined parameters of growth performance and carcass yield of DVN1 and DVN2 pigs. The pig lines significantly affected the examined parameters of growth performance and carcass yield of DVN1 and DVN2 pigs, except the final body weight and daily body weight gain (P>0.05). The sex of pigs had a significant effect on the backfat thickness, depth of the *longissimus dorsal*, lean meat percentage, intramuscular fat content, and the daily body weight gain, except the final body weight (P>0.05).

- The DVN1 and DVN2 pigs had a moderate growth performance with a daily bodyweight of 893.48 and 890.3 g/day (P>0.05). The DVN1 pig had a higher lean meat percentage, but lower intramuscular fat content than the DVN2 pig. The daily body weight gain, lean meat percentage, and intramuscular fat content of both DVN1 and DVN2 pigs were significantly improved through the selected generations. The male pigs had a higher daily body weight gain than the female pigs, but the intramuscular fat content of male pigs was lower than the female pigs.

**** Reproductive performance of sows***

- The pig line and generation had a significant effect on the age at first artificial insemination and age at first farrowing of gilts. The pig line had an effect on the number of piglets born alive per litter, but no effect on number of weaned per sow per year. The pig line had a significant effect on the born weight per litter and weaned weight per litter. The selected generations did not affect the number of piglets born alive per litter, but significantly affected number of weaned piglets per sow per year, born weight per litter, and weaned weight per litter. The parity affected number of piglets born alive per litter, and significantly influenced number of weaned pigs per sow per year, born weight per litter, and weaned weight per litter.

- The DVN1 pigs had a higher number of piglets born alive per litter, number of weaned pigs per litter, born weight per litter, wean weight per litter than those of DVN2 pigs, but no difference in the number of weaned pigs per sow per year between two pig lines. The reproductive performance of DVN1 and DVN2 sows had an improved trend through generation from the first generation to the third generation.

**** Semen volume and sperm quality of boars***

- The pig lines and generation had a significant effect on the total number of progressively motile spermatozoa per ejaculate (VAC), in which the VAC indicator of DVN1 boar was higher than that of DVN2 and improved through the generation. The semen volume and sperm quality parameters of both DVN1 and DVN2 boars are equivalent to the standard level according to the national standard number TCVN 9111:2011 exotic breeding pigs.

1.2 The growth performance, carcass yield and quality of crossbred market pigs produced from DVN1 and DVN2 sire lines and the PS1 and PS2 parent sows

- The pig crossbreeds affected the daily body weight gain, lean meat percentage. The daily bodyweight of TP1 crossbred pigs was the highest, while that of TP4 crossbred pigs was the lowest, and no difference was found between TP2 and TP3 crossbreeds. The killing-out percentage of four crossbred market pigs TP1, TP2, TP3, and TP4 was at a high level, ranging from 81.89 to 83.71%. The dress carcass percentage ranged from 72.90 to 73.51%. The meat quality of four crossbreeds TP1, TP2, TP3, TP4 is equivalent to the normal meat standard: pH45 ranged from 6.58 to 6.64, pH24 ranged from 5.67 to 5.70.

2. RECOMMENDATIONS

- Continue to select the DVN1 and DVN2 pig lines to improve the productivity of Vietnamese pig lines
- Transfer the DVN1 and DVN2 pig lines to the production as the terminal sire line to produce the market pigs
- Study more about the intramuscular fat content of four crossbred market pigs TP1, TP2, TP3, and TP4.