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SELECTION FOR CREATION OF TWO HIGH-YIELD MEAT DUCK LINES FOR INTENSIVE FARMING

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LIST OF RELEVANT SCIENTIFIC PUBLICATIONS OF THE THESIS

1. **Le Thanh Hai, Duong Xuan Tuyen and Ho Van The. 2017.** *Genetic parameters and genetic trend of body weight and breast meat thickness at 7 weeks old in the V52 male line ducks at VIGOVA duck breed farm.* Journal of Breeding Science and Technology, No. 76, June/2017, page 34-42.
2. **Le Thanh Hai, Duong Xuan Tuyen and Ho Van The. 2018.** *Selection for creation of two high-yield meat duck lines (V52 and V57) for intensive farming.* Journal of Breeding Science and Technology, No. 88, June/2018, page 12-26.
3. **Ho Van The, Le Thanh Hai and Duong Xuan Tuyen. 2018.** *Productivity of commercial ducks from V52 and V57 high-yield meat duck lines.* Journal of Breeding Science and Technology, No. 87, May/2018, page 2-8.

INTRODUCTION

1. THE NECESSITY OF THESIS

Meat duck lines created in Vietnam in last few years have many advantages such as high body weight, good egg yield, high carcass and thigh meat percentage. These duck lines with long and strong thighs were suitable for rearing in paddy field, semi-intensive farming and other ecological farming systems. However, the duck selection was only focused on the high body weight, egg yield. There was a little study about carcass quality traits. Therefore, current duct lines have some limitations. Firstly, although slaughter weight of commercial duck was high (3.3 - 3.4 kg/head), but rearing period was 8 - 10 weeks depending on rearing methods and FCR remains high (2.75 - 2.8). It was necessary to select for creation of new meat-type duck lines having shorter rearing time (7 weeks old or less), better FCR (less than 2.5), faster production turnover and suitable for intensive farming. Secondly, the percentage of breast muscle which was the most nutritional and economically valuable part of the carcass, remains at a low level. Breast muscle rate at 7 weeks old in the recent duck lines was 12 - 15% only, meanwhile this figure in the world has reached to 22%.

The demand of high-yield meat duck breeders for domestic production was very high in recent years. Moreover, competitiveness in breeder market is getting fiercer day by day. Domestic breeder producers should make regular improvement of their breeds by selection to create high-yield duck lines to meet the market demand. In addition, duck lines selected in the country had a good adaptation with rearing conditions in Vietnam. Therefore, in 2014, VIGOVA duck breed farm imported SM3 Heavy grandparent breeders from Cherry Valley company (UK) as the materials of selection for high-yield meat duck lines. SM3 Heavy meat ducks have white feather and fast growth rate. This was one of the highest carcass quality duck breeds in the world. Compared to previous SM, SM2 meat duck breeds, SM3 Heavy had shorter body, smaller and shorter thighs, faster growth, shorter rearing time, more well-developed breast and higher breast muscle rate. Using SM3 Heavy ducks as the materials for selection to create two high-yield duck lines is necessary to meet the increasing breeder demand for the intensive farming. To meet this necessity, the study *"Selection for creation of two high-yield meat duck lines for intensive farming"* was conducted.

2. RESEARCH OBJECTIVE

This study aims to select for creation of two high-yield meat duck lines for intensive farming using the imported SM3 Heavy ducks as the materials with following expected yield criteria:

The male line has egg production of 190 eggs/female for 42 laying weeks, 3.35 kg/head body weight at 7 weeks old in males and 3.20 kg/head in females and breast muscle rate at 7 weeks old of more than 20%.

The female line has egg production of 212 eggs/female for 42 laying weeks, 3.00 kg/head body weight at 7 weeks old in males and 2.85 kg/head in females and breast muscle rate at 7 weeks old of more than 20%.

3. SIGNIFICANCE IN SCIENCE AND PRACTICE

The REML (VCE software) and BLUP methods (PEST software) were used to estimate genetic parameters and breed value, respectively. With these methods, the high accuracy data will be released and can be used as reference for scientific studies on genetic and selection, education and training in poultry production, especially in water fowl.

The success in creation of the V52 and V57 duck lines with high meat yield and quality will contribute to development of duck production in industrial farms.

From the V52 and V57 duck lines, parents and commercial ducks will be produced with high yield and quality and much lower price than importing. It will contribute in increasing the duck production efficiency, saving foreign currency and creating jobs for farmers.

4. NEW CONTRIBUTIONS OF THE SUBJECT

This is a new and systematic study to select for the trait of breast meat thickness that is closely related to carcass quality of meat-type ducks in Vietnam.

The V52 and V57 duck lines created in this study have some outstanding productive characteristics compared with existing duck lines, including fast growth, short rearing time and high breast muscle rate. They will suitable for industrial farming and diversify of duck genetics in Vietnam.

The new results in chemical composition and physical features in thigh and breast muscle of commercial ducks will be acted as science references for future studies.

CHAPTER 1. LITERATURE REVIEW

Genetic basis of some yield traits in duck

For meat ducks, the most importance trait is body weight. Genetic levels of this trait varied a lot in previous studies. Some author's results showed that, heritability of body weight in meat female was in the average level of 0.20 - 0.41 (Duong Xuan Tuyen, 1998; Duong Xuan Tuyen et al., 2001; Li et al., 2005; Duong Xuan Tuyen et al., 2006a; Akbar and Turk, 2008; Nguyen Duc Trong et al., 2009a; Pingel, 2011; Georgina et al., 2013; Nguyen Van Duy, 2012; Zhang et al., 2017). While other authors showed the heritability of body weight in meat female at the high level of 0.42 - 0.88 (Pingel, 1999; Szwaczkowski et al., 2010; Mucha et al., 2014; Duong Xuan Tuyen et al., 2015; Thiele et al., 2017; Rouvier et al., 2017; Xu et al., 2018; Pham Van Chung, 2018; Damayanti et al., 2019). Consequently, body weight is a trait with average-to-high heritability subject to duck breed, line, age, etc. Therefore, the selection for genetic improvement of this trait will become easier. This has proved by results of many selection studies in super meat ducks in the past time. Selection results in super meat ducks have indicated that, selection efficiency for body weight was 16.8 - 74.95 g/generation (Duong Xuan Tuyen et al., 2001, 2006a, 2011 and 2015; Phung Duc Tien et al., 2010b; Nguyen Van Duy, 2012 and Pham Van Chung, 2018).

Most of studies showed that, breast muscle weight of female has a huge range in genetic level. Li et al. (2005) noticed heritability of breast muscle weight was in the high level of 0.53 in Pekin ducks at 6 weeks old, while this level in the study of Xu et al., (2018) was 0.23. Marie-Etancelin et al. (2011) reported a result of 0.32 in Pekin ducks at 13 weeks old, but Mucha et al. (2014) recorded a very high result of 0.69 in Pekin ducks at 11 weeks old. Some authors have studied the correlation between breast muscle rate or weight and other traits as the scientific basis for indirect selection of this trait (Michalik et al., 1984; Dean, 2005; Bielinska et al. 2005). It was judged by several authors that, breast muscle thickness in female has average and low genetic level with heritability of 0.12 – 0.34 (Bielinska et al., 2005; Hall, 2005; Pingel, 2011; Georgina et al., 2013; Thiele et al., 2017; Xu et al., 2018). Heritability of breast meat thickness in Pekins at 6 weeks old is high (0.51), proved by Li et al. (2005).

For the traits of fertility, egg yield was considered as the most important trait and most studies on genetic ability have focused on it. Study results in egg female have proved that, heritability ranges 0.10 - 0.22 (Cheng et al., 1995 and 1996; Poivey et al., 2001; Liu et al., 2013; Lin et al., 2017; Rouvier et al., 2017; Vu Hoang Trung, 2019). Studies in meat female line by some authors indicated that, genetic ability to this trait seems higher than that of egg female, which fluctuates from 0.20 - 0.34 (Nguyen Duc Trong et al., 2009c; Duong Xuan Tuyen et al., 2006a and 2015; Pham Van Chung, 2018). Some authors showed that the selection efficiency to egg yield

could be varied from 0.52 to 1.59/egg/generation (Duong Xuan Tuyen et al., 2006a; 2016; Nguyen Van Duy, 2012; Pham Van Chung, 2018).

Foreign study on selection of ducks

By selection, Powel (1985) created popular SM duck lines with high body weight. Klemm (1995) compared responses in yield after 11 generations between selection line and controlled line. The parameters of body weight at 7 weeks old, FCR at 4-7 weeks old and percentage of breast and thigh skin were measured and the results respectively were2.649 g, 2.847 and 11.7% in low FCR line; 2.306 g, 3.710 and 16.1% in high FCR line; 2.145 g, 3,.305 and 14.4% in controlled line. On Pekin ducks, Hall and Martin (2005) improved duck productivity and quality by applying the BLUP selective method. Efficiency selection for increased body weight in Pekin ducks were relatively high, body weight was 327 g in males and 277 g in females after 6 generations (Dean, 2005). According to Pingel (2011), selection of FCR at 4 - 7 weeks old in Pekin ducks after 11 generations resulted in an increase of feed efficiency by 25%. After 7 generations of selection, there was an increase by 18.2% in body weight, 17.2% in breast meat thickness and 9.4% in breast muscle rate. It was suggested by Thiele et al. (2017) that genetic and phenotype correlation between body weight and breast meat thickness at 6 weeks old in Pekin ducks were 0.57 and 0.66, respectively. Xu et al. (2018) conducted ultrasound selection of breast muscle thickness combined with breast width and breastbone length values after 10 generations in Pekin ducks. Heritability of breast meat weight and rate were low (0.23 and 0.16) while genetic ability of body weight was high (h^2 = 0.48). The selective result of breast meat weight increased from 1.18 g in the 1st generation to 30.22 g in the 11th generation. Body weight and breast meat rate increased by 349.45 and 1.41%, respectively. Breast width, breastbone length and breast muscle thickness increased by 0.70 cm, 0.90 cm and 0.50 cm, respectively. Selection efficiency of traits was considered well.

Many authors have selected to improve reproductive performance and egg-related traits. Cheng et al. (1995) selected brown Tsaiya ducks through 5 generations in Taiwan. The results showed that genetic ability was low in traits such as eggshell strength at 40 and 30 weeks old, laying performance at 52 and 40 weeks old, feather length at 20 weeks old, yolk weight at 40 weeks old and the first laying age (h^2 = 0.094 - 0.201). It revealed the average genetic ability level in the ratio of egg and body weight at 40 weeks old, egg weight at 40 and 30 weeks old, body weight at 20 and 40 weeks old (h^2 = 0.327 - 0.499). Cheng et al. (1996) applied selection index in breed value by the BLUP method in Taiwanese Tsaiya ducks. The results showed that, after 4 generations, genetic progress at 40 weeks old in female gained 0.91 g in body weight, 0.05 g in egg weight, 0.035 kg/cm^2 in eggshell strength and 213 eggs in laying performance at 52 weeks old. Cheng et al. (2009) conducted the selection in order to increase embryo egg rate in Brown Tsaiya ducks. After 12 generations of selection, embryo egg rate after artificial insemination for 2 - 8 days gained 89.14% in selected duck line (S) and 61.46% only in controlled duck line (T). Liu et al. (2015) selected a Taiwanese duck line to raise embryo period for duck eggs after each insemination. It was shown by genetic trend that the selection efficiency of embryo eggs from the 4th generation to the 10th generation was 2.74 eggs.

Domestic study on selection of ducks

In the North, Hoang Thi Lan et al. (2001) selected to create pure lines from SM grandparent ducks at Dai Xuyen Duck Research Center. Pure line selection from SM grandparents at DaiXuyen Duck Breeding and Research Center had regularly and constantly been conducted and improved the duck performance of 2879 g in males and 2669 g in female for male line at 7 weeks old. The egg yield for female line at 66 weeks old was 234.2 eggs (Hoang Thi Lan et al., 2006). Hoang Thi Lan et al. (2004) conducted the selection based on phenotype, appearance, breed in closed line to create 2 duck lines as T5 male line and T6 female lines. After 4 generations of

selection, T5 line had 60-115 g heavier in body weight at 7 weeks old than T1 controlled line. Laying performance at 68 weeks old in T6 female line was 7-8 eggs more than T4 line.

Phung Duc Tien et al. (2010a) selected to create two meat-type duck lines from the imported SM3 grandparent duck genomes. SD1 line has been selected by the high body weight of 320.1 g in males and 251.3 g in female; SD2 line has been selected for the increased egg yield of 6.8 eggs/female/48 laying weeks. Breeding selection of two lines, SH1 and SH2, from imported SM3 Heavy grandparents showed that, after 2 generations of selection, SH1 line had an increase of body weight by 49.17 g in males and 72.69 g in female; SH2 line had the increased egg yield of 234.27 eggs at 48 laying weeks, which was 3.15 eggs more than the starting generation (Phung Duc Tien et al., 2010b).

In some other studies, the selection of meat lines was based on imported gene sources. Nguyen Duc Trong et al. (2010) conducted the selection for body weight improvement in M14 duck line imported from France to create a new male line after 3 generations, which result had the selection efficiency reached 37.3 - 77.84 g for each generation. Nguyen Van Duy (2012) selected MT1 and MT2 lines, whose selection efficiency gained 52.51 g/head in weight in MT1 line and 1.06 eggs/female in egg yield in MT2 line. Nguyen Ngoc Dung et al. (2015a) used the material of SM3 Heavy and SM3 grandparents to create four meat lines. After five generations, the weight in TC1 line was 163.63 g in males and 118.11 g in female, and for TC2 line the result was 135.45 g in males and 111.88 g in female. After five generations, egg yield in TC3 and TC4 lines at 48 laying weeks increased by 6.04 and 7.70 eggs/female, respectively.

In the South, Duong Xuan Tuyen (1998) studied the traits of production, thereby determined some statistic, genetic parameters of CV Super-M grandparent lines imported from the UK. Heritability of body weight at 8 weeks old was 0.13 (males) and 0.19 (females) in male line; 0.22 (males) and 0.21 (female) in female line. Nguyen Van Dien (2002) reported that the response of selection for SM duck body weight at 49 weeks old gained 5.59 – 8.88 g/generation. Duong Xuan Tuyen et al. (2001) continued the successful selection of 2 high-yield meat duck lines at VIGOVA duck breed farm. V5 male line was selected to increase body weight at 7 weeks old, after four generations, attaining 2673.5 g (males) and 2483.8 g (female), heritability of body weight at 7 weeks old was 0.21-0.39, selection efficiency gained 32.5-44.5 g/generation (males) and 16.8-22.1 g (female). V6 female line was selected to increase egg yield, after four generations, attaining 192.6 eggs/female/42 laying weeks. After five generations of selection, created V12 line was found that typical appearance traits in male line, body weight increased by 7.49% compared to the starting generation. Duong Xuan Tuyen et al. (2015) continued the creation of V22 high-yield meat duck line at VIGOVA duck breed farm. Heritability of body weight at 7 weeks old was 0.53. Genetic progress of this trait gained 36.69 g in males and 56.03 g in female. Besides, V27 high-yield meat female line with high egg yield was also selected at VIGOVA duck breed farm (Duong Xuan Tuyen et al., 2016). Heritability of V27 line egg yield at 42 weeks old was 0.28; genetic progress gained 1.21 eggs/generation.

CHAPTER 2. MATERIAL, CONTENT AND METHODOLOGY

2.1 MATERIAL

2.1.1. Material of study

- The material for selection was two imported SM3 Heavy grandparent lines at 1 day old.
- The V52 male line: Selected core flock, flock under fertility survey, flock under growth survey.
- The V57 female line: Selected core flock, flock under fertility survey, flock under growth survey.
- The VSM6 commercial duck: Crossbreeding of V52 and V57 lines.

2.1.2. Location and time of study

- The VIGOVA duck breed farm, An Tay commune, Ben Cat district, Binh Duong province.
- From January 2014 to December 2019.

2.2. CONTENT

2.2.1 Selection of two meat duck lines

- Selection of V52 male line.
- Selection of V57 female line.

2.2.2 Productivity assessment of commercial crossbred ducks from two new duck lines

Productivity assessment of commercial cross-bred combination between the V52 male line and the V57 female line.

2.3. METHODOLOGY

2.3.1 Method of selection of two V52 and V57 duck lines

a. Crossbreeding chart of material flock

Male A X Female B ↓ V52 line starting generation

Male C X Female D ↓ V57 line starting generation

A pure breeding in closed line is made from the 1st generation to the 5th generation. The 1st generation is selected by the individual phenotype value. The 2nd – 5th generations are selected by the individual index value.

b. Monitoring, collection method of individual data

Individual numbering: Each duck after hatching was attached a number to its wing. Numbering convention was as the followings: generation with 1 digit-number (1, 2, 3…), line with 2 numbers (52, 57), sex with 1 digit-number (1 for female, 2 for male), family with 2 digit-numbers (01, 02…30…) and the number of duck individuals in the family with 2 numbers (01, 02…).

Collection of individual data: The individual data contains all sufficient information of family tree, generation, line, hatching date, sex, individual code and individual productivity criteria. This data was continuously collected in the form.

The body weight, breast meat thickness for each individual are tested at 7 weeks old were made by weighing female at 7:00 a.m with dry feather and no feed. The body weight of each duck is weighed by 5-kg scales. The breast meat thickness was measured by American RENCO ultrasonic machine.

In each generation, there are approximately 800 – 1000 breed individuals per line at one day old. In the end of growth stage, the selection was made for reserve stage, females and males were paired in families in the system of individual coop cells at the time of 22 weeks old. Each individual coop cell keeps a family including 1 male and 5 females. Each line was established at least 30 families with minimum female number of 150 individuals. A monitoring recording system comprises records of flock managing, weighing, daily egg picking, hatching, data were stored in the computer. Egg yield of female individuals was daily monitored collected until 42 weeks old.

c. Expriment method of growth and fertility for two lines ducks

The fertility servey and growth servey flocks were picked hatching eggs after collecting breeds from selected flock in each generation. The assessment was implemented for the growth productivity of each generation with 120 males and 120 females in each line. The assessment was also implemented for fertility productivity of each generation with 25 males and 150 laying females in each line.

Productivity criteria for growth experiment flock:

- For body weight, FCR for increased body weight, and so on, refer to Vietnam standards.
- Slaughter criteria: According to the method by Auaas and Wilke (1978).

Productivity criteria for fertility experiment flock:

- For body weight, laying age, laying performance, and so on, refer to Vietnam standards.
- For egg survey criteria, use Japanese digital machine DET-6000.

d. Nursing care

All flocks were kept in captive breeding method in accordance with the process of VIGOVA duck breed farm. Selected flocks were kept in the system of open floor coops, in fertility stage. They were reared in the system of individual coops to facilitate in monitoring and assessing individual laying performance. The flocks of two lines under fertility survey were located in closed coops and in the growth survey, flocks were kept in open coops. Breeding flocks for reproduction were fed in accordance with the defined process of 0-24 weeks old. The selected core flock of male line had freely feeding in daytime in the stage of 0-7 weeks old and restricted feeding in the stage of 8-24 weeks old. The flocks for growth expriment are freely fed.

e. Selection assessment method of two pure lines

Index selection was based on Estimated Breeding Value (EBV) using the BLUP method and economic coefficient of selected traits applied to each separate line as below:

Selected index of V52 male line: SLI = 0.07*EBV1 + 6.71*EBV2

Selected index of V57 female line: MLI = 0.07*EBV1 + 6.71*EBV2 + 8.01*EBV3

In which: EBV1 is the breed value of body weight at 7 weeks old; EBV2 is the breed value of breast meat thickness at 7 weeks old; EBV_3 is the breed value of egg yield until 42 weeks old; Pre-EBV coefficients are the respectively economic coefficients of the trait (vi).

The economic value of the trait is balanced between total revenue and total cost due to further increase of a selected trait unit in the following equation: Vi = Ri - Ci

In which: Vi is the economic value of trait i; Ri is the total revenue due to further increase of a trait unit i; Ci is the total cost due to further increase of a trait unit i.

Based on values of indexes in each selected individual in the end of 7 weeks old in V52 male line and in the end of 42 weeks old in V57 female line, the selection rate of V52 line is 8.73 – 14.45% in males, 25.68 – 34.46% in female, and the selection rate of V57 line is 8.82 – 10.39% in males, 18.32 – 20.89% in female.

2.3.2 Productivity assessment method of commercial crossbred combination

Crossbreeding chart of V52 and V57 lines:

Line	V52 male	X	V52 female	V57 male	X	V57 female
	↓				↓	
Parents	V52 male		X	V57 female		
			↓			
Commercial			**VSM6**			

Arrangement of test for meat yield survey: The number of breeders at 1 day old is 180 males + 180 female, which are uniform and healthy.

Nursing care:

Ducks for the test were kept in dry in the system of open floor coops and freely fed until 7 weeks old in accordance with the process by the VIGOVA duck breed farm.

Criteria for monitoring and assessing flocks:

- Body weight at 1-day old, 3, 5 and 7 weeks old, survival rate, FCR for increased live weight at 3, 5 and 7 weeks old were referred to Vietnam standards.
- Slaughter criteria under expriment at 7 weeks old were applied according to the method by Auaas and Wilke (1978). The number slaughter experiment duck were 10 ducks/sex for each type of ducks.

Criteria and method of meat analysis:

- Dry matter, raw protein, raw fats, minerals, pH, amino acid concentration and composition were analyzed at the Center for Testing Analysis Services of Ho Chi Minh City.

- Moisture, water activity, cooking loss, hardness, springiness, gumminess, chewiness, and cohesiveness of meat were analyzed at the Nong Lam University - Ho Chi Minh City.

2.3.3 Method of statistic analysis

Analysis of factors affecting traits:

Factors affecting selected traits were analyzed in GLM linear model by statistic software Minitab 16.0.2. The statistic model was as follows:

$$Y_{ijkl} = \mu + TH_i + GT_j + Day_k + e_{ijkl}$$

In which: Y_{ijkl} is the value received of monitored trait; μ is the mean value of complex; TH_i is the effect of generation i (i=1, 5); GT_j is the effect of gender j (j=1, 2); Day_k is the effect of birthday k (k = 1, ...); and e_{ijkl} is the random error.

Estimated genetic parameter and breed value of selected traits:

Variance and genetic parameter of selected traits, including body weight at 7 weeks old, breast muscle thickness at 7 weeks old and laying performance at 42 weeks old were estimated by the REML method by software VCE 6.0.2. Breed values of traits were estimated by the BLUP method by software PEST 4.2.3. Determination of consanguineous coefficient was performed by SAS 9.1. The statistic model uses genetic statistical analysis as a multi- trait animal model below:

$$Y_{ijklu} = \mu + TH_i + GT_j + Day_k + Dam_l + a_m + e_{ijklmu}$$

In which: Y_{ijklmu} is the value received of monitored trait; μ is the mean value of complex; TH_i is the effect of generation i (i=1, 5); GT_j is the effect of sex j (j=1, 2); Day_k is the effect of birthday k (k = 1, ...); Dam_l is the effect of mother l (l = 1, ...); a_m is the additive genetic effect of individual m; and e_{ijklmu} is the random error. Sex is excluded from the model in analyzing the trait of laying performance at 42 weeks old.

Assessment of genetic and phenotype trends, genetic progress:

The genetic and phenotype trends, genetic progress were assessed by linear regression analysis using SCATTER menu on MS Excel 2016 in the following model: **y = a + bx**

Methods of processing data for survey of the growth and reproduction of pure and crossbred ducks:

Analysing ANOVA variance and Chi-Test on Minitab 16.2.0 were applied for comparable statistic analysis on traits between factors (line, generation, and so on).

CHAPTER 3. RESULTS AND DISCUSSION

3.1 RESULTS OF SELECTION OF V52 AND V57 DUCK LINES

3.1.1 Effect of some fixed factors on selected traits

Table 3.1: Effect of generation, sex and birthday on selected traits

Lines	Traits	n (ducks)	Factors		
			Generation	Sex	Birthday
V52	BW7	3718	***	***	**
	BMT7	3718	***	***	**
V57	BW7	5219	***	***	***
	BMT7	5219	***	***	***
	LP42	955	***	-	*

*Statistic illustration: *: P<0.05; **: P<0.01; ***: P<0.001; BW7: body weight at 7 weeks old; BMT7 breast meat thickness at 7 weeks old; LP42: laying performance for 42 weeks old.*

Generation, sex and birthday affected the traits of body weight and breast meat thickness at 7 weeks old in both V52 and V57 duck lines. The effect of sex on body weight in two duck lines in this study was in agreement with studies of Hoang Thi Lan et al., (2001), Duong Xuan Tuyen et al., (2006a; 2015), Le Thanh Hai et al. (2019b). With the breast meat trait in female, many authors have shown the effect of generation (Duong Xuan Tuyen, 1998; Phung Duc Tien et al., 2008; Le Thanh Hai, 2012). Whereas, duck sex affected of carcass traits including breast muscle rate in female and some poultry (Mignon-Grasteau et al., 1998; Le Bihan-Duval et al., 1998; Witkiewicz et al., 2004; Zerehdaran et al., 2007). It concluded from the results in table 3 that, the fixed affecting factors which were used for genetic statistic model for body weight and breast meat thickness traits at 7 weeks old of two V52 and V57 duck lines include 3 factors as generation, sex and hatching day. With the egg yield trait of V57 duck line, the fixed affecting factors were generation and hatching day.

3.1.2 Variance components and heritability of traits

Table 3.2: Variance components and heritability of traits

Lines	Parameters	Traits		
		BW7	BMT7	LP42
V52	σ^2_A	29,828.10	2.70	-
	σ^2_D	6,001.81	0.16	-
	σ^2_E	38,178.60	3.30	-
	σ^2_P	74,008.50	6.20	-
	$h^2 \pm SE$	0.40 ± 0.04	0.44 ± 0.04	-
V57	σ^2_A	8,542.31	1.11	246.57
	σ^2_D	1,932.83	0.20	3.70
	σ^2_E	39,773.75	1.76	608.80
	σ^2_P	50,248.90	3.0	859.10
	$h^2 \pm SE$	0.17 ± 0.07	0.37 ± 0.08	0.29 ± 0.11

The result shows that, in the same trait (BW7 and BMT7), the value of variance components in V52 male line tends to be higher than those in V57 female line. This was appropriate as the body weight in V52 male line was higher than that in V57 female line. A remarkable point in table 3.2 is mother's affecting variance. Many previous genetic analyses on yield traits in meat female have been made but this variance component was not mentioned (Nguyen Van Duy, 2012; Duong Xuan Tuyen et al., 2015; Pham Van Chung, 2018…). There were only 2 studies showed the analysis of mother's effect on yield of SM meat female (Duong Xuan Tuyen et al., 2014; Le Thanh Hai et al., 2020).

Variance components due to mother's effect on traits of body weight and breast meat thickness at 7 weeks old in V52 male line were 8.11% and 2.58%, respectively, compared with phenotype variance. Variance components with mother's effect on body weight, breast meat thickness traits at 7 weeks old and egg yield at 42 weeks old in V57 female line were 3.85%, 6.67% and 0.43%, respectively compared with phenotype variance. Therefore, selected traits in both duck lines were affected by mother duck. The effect level by mother in each trait of every duck line was different and small. This result was in agreement with the study of Le Thanh Hai et al. (2020a) in V22 meat duck line in regard to mother's effect level.

For body weight at 7 weeks old, there was a significant difference in heritability between V52 and V57 lines. Heritability of body weight was relatively high in V52 male line (h^2 = 0.40) but low in V57 female line (h^2 = 0.17). Therefore, the selection for genetic improvement of body weight in V52 male line will be more favorable than in V57 female line.

Local and oversea studies on genetic level of body weight in ducks showed a fluctuation due to duck line, breed, age, and so on. Previously, some researchers reported that heritability in

Pekin ducks at 6 - 8 weeks old was in the range of 0.20 – 0.47 (Klemm, 1995; Pingel, 1999; Li et al. 2005; Akbar and Turk, 2008; Pingel, 2011). In this stage, local researchers have also reported genetic ability of body weight trait in several SM meat lines. Duong Xuan Tuyen (1998) noticed that, heritability of body weight at 8 weeks old in SM meat line was 0.13 - 0.19 in male, 0.21 - 0.22 in female. This author (2001 and 2006a) showed that the heritability of body weight at 7 weeks old in V5 and V2 lines at VIGOVA duck breed farm ranged 0.21 - 0.39. Nguyen Duc Trong et al. (2009a) reported that, heritability of body weight at 7 weeks old in T5 duck line was 0.22 – 0.25. In these studies, heritability was usually analyzed in the variance analysis method. Recently, the REML method by advanced softwares was used to analyze the genetic ability of body weight trait in female. Georgina et al. (2013) reported that, MLF duck weight at 5 weeks old had heritability of 0.31 to 0.41. The study of Mucha et al. (2014) gave the heritability of body weight at 11 weeks old in Pekin ducks at high level ($h^2 = 0.75$). Other studies in Pekin duck indicated that, heritability of body weight at 6 weeks old were 0.39 - 0.48 (Thiele and Alletru, 2017; Zhang et al., 2017; Xu et al., 2018). The results of heritability of body weight at 7 weeks old in V52 male line and V57 female line, in sum, were in agreement with published studies.

For breast meat thickness at 7 weeks old, heritability was 0.44 in V52 male line and 0.37 in V57 female line. Genetic ability of breast meat thickness trait at 7 weeks old in both duck lines were in the average and high levels, respectively. This was good condition for genetic improvement selection of this trait. The difference in genetic ability of breast meat thickness has been reported by some authors. Li et al. (2005) noticed that, heritability of breast meat thickness in Pekin ducks at 6 weeks old was high, at 0.51, whereas the level of this trait at 8 weeks old was 0.32 (Pingel, 2011). The results given by study of Georgina et al. (2013) showed that, heritability of breast meat thickness in MLF female at 5 weeks old varied at the low, at 0.17 – 0.20. In the similar trend, the study of Xu et al. (2018) appeared a low heritability of breast meat thickness (0.12) in Pekin ducks at 6 weeks old. However, heritability of breast meat thickness of Pekin ducks at 6 weeks old in the study by Thiele et al. (2017) was almost equivalent to current study in V57 line ($h^2 = 0.34$). Recently, the study of Pham Van Chung (2018) revealed that there was a great difference in genetic level of breast meat thickness between males and females in meat-type ducks (0.81 and 0.24, respectively). Consequently, heritability of breast muscle thickness trait in two V52 and V57 duck lines were in the average level compared with previous studies.

Heritability of egg yield trait at 42 weeks old in V57 line was 0.29 in current study. This result was in agreement with some authors such as Duong Xuan Tuyen et al. (2006a, 2015); Nguyen Duc Trong et al. (2009a) and Pham Van Chung (2018).

In general, heritability of selected traits in V52 and V57 lines were in average and high level, except the body weight trait of V57 line. Therefore, genetic improvement selection for these traits in two duck lines was favorable and highly efficient.

3.1.3 Correlation between traits

Table 3.3: Correlation between selected traits

Lines	Parameters	Pair of traits		
		BW7 - BMT7	BW7 - LP42	BMT7 - LP42
V52	$r_G \pm SE$	-0.09 ± 0.07	-	-
	$r_E \pm SE$	0.42 ± 0.02	-	-
	r_P	0.26	-	-
V57	$r_G \pm SE$	-0.07 ± 0.04	-0.16 ± 0.09	-0.13 ± 0.07
	$r_E \pm SE$	0.57 ± 0.02	0.11 ± 0.05	0.15 ± 0.06
	r_P	0.43	-0.03	-0.01

The genetic correlation between body weight and breast meat thickness was reverse. However, the absolute value of genetic correlation coefficient between two traits in both duck lines was too small (approx 0). Two traits were almost independent in respect of genetics. Accordingly, to make genetic improvement of body weight and breast meat thickness traits in these two duck lines, selection of both two traits in the same time was required. However, environmental correlation of two traits in both duck lines were favorable and in relatively high level, 0.42 in V52 male line and 0.57 in V57 female line, respectively. This result indicates that, the change in environmental conditions will affect these two traits in the same direction. Because genetic correlation was weak, phenotype correlation was dependent on external correlation. Hence, phenotype correlation among two duck lines was also favorable in average level (0.26 and 0.43).

There was a negative genetic correlation between body weight at 7 weeks old and egg yield at 42 weeks old in V57 duck line. It was shown that, the individual duck in V57 line with high genetic value of body weight trait will show the lower egg yield trait. In other words, the selection for improvement of body weight trait will decrease egg yield and vice versa. Phenotype correlation between these two traits was also negative at low level (-0.03). Previous studies indicated that the correlation among body weight and egg yield traits was reverse correlation and fluctuated with line, breed (Hudsky et al., 1986; Nguyen Duc Trong et al., 2008; Minh et al., 2013; Pham Van Chung, 2018).

Negative genetic and phenotype correlations were observed in breast meat thickness at 7 weeks old and egg yield at 42 weeks old and appeared at the low level of -0.13 and -0.01, respectively. The result in this study shows that, the selection for improvement of egg yield trait may decrease breast meat thickness in meat female and vice versa, which need to be concerned in the selection method. The application of selection index for body weight at 7 weeks old, breast meat thickness at 7 weeks old and egg yield at 42 weeks old traits of V57 duck line in this study was completely suitable for the improvement of these above traits.

3.1.4 Estimated Breeding Value and genetic progress

The data from V52 male line showed that, breed value of body weight and breast meat thickness traits in males and female ducks increased through selected generations. Genetic progress of body weight at 7 weeks old had an average increase of 44.47 g/generation in males and 42.68 g/generation in female. Genetic progress of breast meat thickness at 7 weeks old showed an average increase of 0.304 mm/generation in males and 0.292 mm/generation in female. Therefore, genetic improvement speed was higher in males than that in females in repect of both selected traits. However, the difference in improvement speed was small. Index value in males and female increased gradually through each generation with average speed per generation at 5.15 in males and 4.95 in female.

Table 3.4: Average EBV of traits and selection index (SLI) through generations in V52 line

Generations (G)	Male			Female		
	EBV_{BW7}	EBV_{BMT7}	SLI	EBV_{BW7}	EBV_{BMT7}	SLI
G1	-141	-0.095	-10.50	-146	-0.020	-10.37
G2	-157	0.275	-9.15	-130	0.261	-7.33
G3	-103	0.758	-2.13	-92	0.726	-1.53
G4	-38	0.891	3.32	-37	0.838	3.03
G5	22	1.117	9.03	21	1.151	9.18
Regression coefficients (b)	*44.47*	*0.304*	*5.15*	*42.68*	*0.292*	*4.95*
P	*0.016*	*0.004*	*0.002*	*0.003*	*0.002*	*0.000*
R^2	*0.88*	*0.95*	*0.97*	*0.96*	*0.97*	*0.99*

Table 3.5: Average EBV of traits and selection index (MLI) through generations in V57 line

G	Male				Female			
	EBV_{BW7}	EBV_{BMT7}	EBV_{LP42}	MLI	EBV_{BW7}	EBV_{BMT7}	EBV_{LP42}	MLI
G1	-27	-0.515	-1.348	-16.13	-38	-0.383	-2.391	-24.39
G2	-29	-0.365	-0.986	-12.36	-36	-0.446	-0.502	-9.55
G3	-19	0.128	0.349	2.35	-17	0.121	0.230	1.48
G4	4	0.536	1.322	14.47	6	0.624	0.887	11.72
G5	13	0.630	1.475	16.97	8	0.696	1.692	18.79
b	*11.30*	*0.319*	*0.80*	*9.16*	*13.46*	*0.323*	*0.96*	*10.73*
P	*0.017*	*0.004*	*0.006*	*0.005*	*0.009*	*0.014*	*0.006*	*0.001*
R^2	*0.89*	*0.96*	*0.94*	*0.95*	*0.92*	*0.90*	*0.94*	*0.98*

The breed value of three target traits including body weight, breast meat thickness at 7 weeks old, egg yield at 42 weeks old in V57 female line have been improved through generations. Genetic progress of body weight at 7 weeks old increased by 11.30 g/generation in males and 13.46 g/generation in female. Similar trend was also observed in the breast meat thickness at 7 weeks old and egg yield traits. It increased by 0.319 mm/generation in males and 0.323 mm/generation in female in the breast meat thickness at 7 weeks old trait. While, genetic progress of egg yield at 42 weeks old was increased by 0.80 egg/generation in males and 0.96 egg/generation in female. Index value in males and female of V57 line also increased equally through each generation with an increase speed per generation at 9.16 in males and 10.73 in female. Genetic progress of body weight trait at 7 weeks old in V57 line was much lower than that in V52 line. This was suitable. The possible explanation may come from the higher number of selected traits in V57 line. It reduces the selection pressure in consideration of 1 trait with a small influence of negative correlation response among selected traits and the controlled raring of female.

In general, all selected traits in both lines have genetic progress. The application of selection index for duck line was efficient, enabling genetic improvement while the traits have important economic value in orientation of each line. Value P in regression analysis of breed value for selected traits was smaller than 0.05. It indicated the high reliability of study's data in genetic progress. Determination coefficient R^2 in high level (88% or more) indicated that, average breed value through generations of selected traits in each line were suitable with linear regression and it reflects to some extent equally genetic improvement of selected traits through generations.

The genetic progress of body weight at 7 weeks old in V52 line in agreement with many previous studies in super meat duck lines. The fluctuation of genetic progress of body weight trait at 7 weeks old was 16.8 – 77.8 g/generation (Duong Xuan Tuyen et al., 2001, 2006a, 2011, 2015; Phung Duc Tien et al., 2010b, Nguyen Van Duy, 2012). Consequently, genetic progress of body weight trait at 7 weeks old in V57 female line of this study was lower than that in previous studies. Nonetheless, all results were selected in male line in orientation of genetic improvement for one body weight trait only.

The selection of breast meat thickness trait is to orient to improve breast muscle rate thanks to response of correlation among these two traits. However, a little information about genetic improvement selection of breast meat thickness and breast muscle rate in female was published. Pingel (2011) noticed that, the application of selection of breast meat thickness in Pekin ducks has improved by 17.2% breast meat thickness. The breast muscle rate was also increased by 9.4%. Pham Van Chung (2018) revealed that, genetic progress of breast meat thickness trait in selecting TS132 and TS142 lines at DaiXuyen Duck Breeding and Research Center was 0.47 and 0.69 mm/generation, respectively.

Studies of genetic improvement selection of egg yield trait were rarely published. The reason is that the selection of this trait is performed with monitoring individual egg yield and high expenses. Genetic progress of egg yield trait in V57 line was in average level compared with some published studies. Some Vietnamese researchers have reported that genetic progress of egg yield in meat female line varies 0.52 - 1.59/egg/generation (Nguyen Van Duy, 2012; Duong Xuan Tuyen et al., 2006a; 2016; Pham Van Chung, 2018).

In summary, the application of selection index in estimated breed value by the BLUP method improved genetics of all target traits in both V52 and V57 lines.

3.1.5 Genetic and phenotype trend of traits

Genetic trend showed that, breed value of selected traits in both duck lines had an incremental trend through generations. All traits hah genetic progress (positive coefficient of regression equation) as analyzed in section 3.1.4. Nevertheless, in consideration of breed value of every trait in each duck line in each generation, there was always a difference. The results from below charts reflected that there was no common trend between phenotype and breed values. Breed value of traits increased equally through generations while phenotype value did not absolutely conform to this rule. Moreover, the phenotype of each trait in different sex of each duck line through selection generations showed an opposite trend. This proves that, sometimes phenotype value does not correctly reflect breed's genetic ability, the breed-based selection will be more correct and efficient than the phenotype-based selection (Le Thanh Hai et al., 2020c).

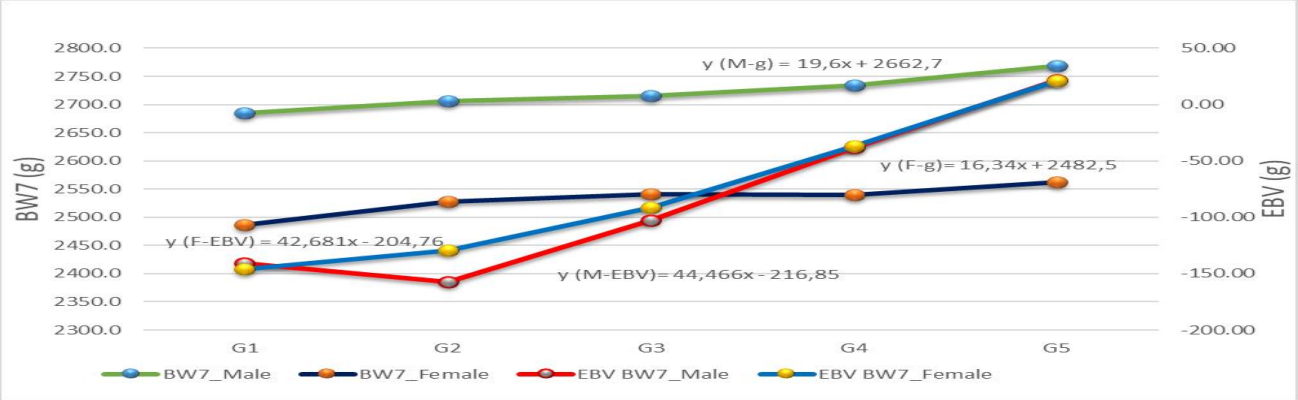


Chart 3.1: Genetic and phenotype trends of BW7 in V52 line

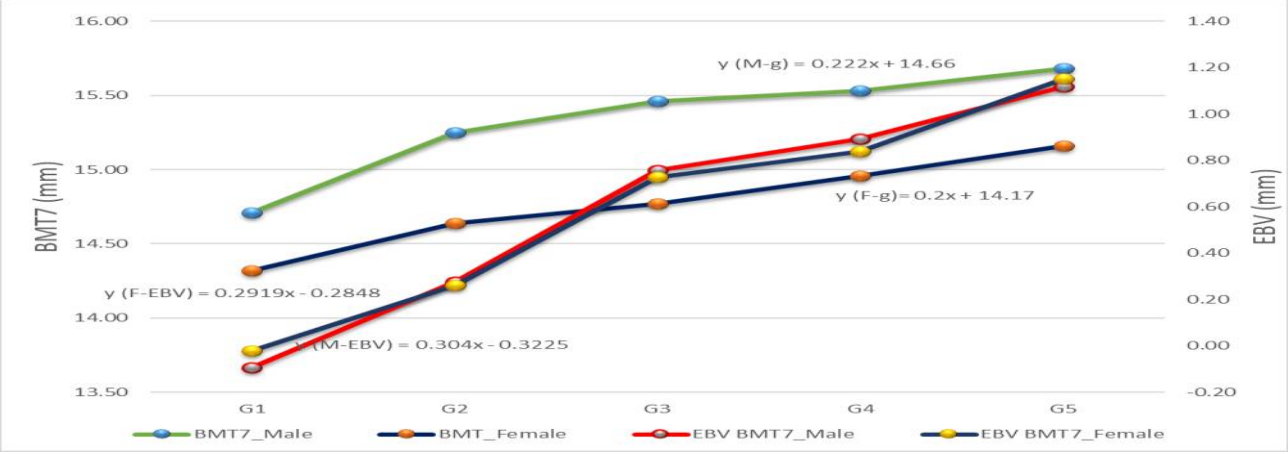


Chart 3.2: Genetic and phenotype trends of BMT7 in V52 line

For V52 line, breed value of body weight trait at 7 weeks old had a significant difference between males and female in the 2nd and 3rd generations. It was equivalent in the 1st, 4th and 5th generations. The figure 3.2 showed that, the breed value of body weight trait at 7 weeks old in V52 line in the 2nd generation was not significantly enhanced. For breast meat thickness at 7 weeks old in V52 line, breed value between males and female had not significant difference through

generations. The genetic improvement speed of this trait was quite equal, except that in the 3rd generation tend to be slightly higher. Phenotype value of body weight and breast meat thickness at 7 weeks old in V52 line had an incremental trend. However, the improvement speed was slower than that of genetic improvement. A factor affecting phenotype of growth traits directly and externally was the breeding system with limited feeding to ensure fertility of selected breed flock. It was the reason why many authors did both assessment of genetic trend and surveying the growth rate of duck with free feeding system to assess selection result of growth trait more correctly (Nguyen Van Duy, 2012; Duong Xuan Tuyen et al., 2015; Pham Van Chung, 2018).

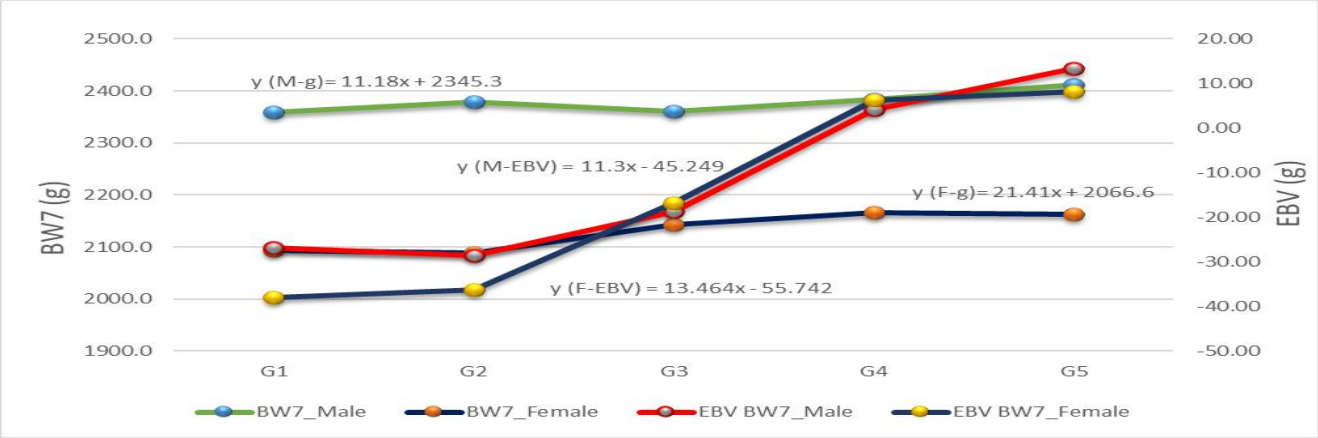


Chart 3.3: Genetic and phenotype trends of BW7 in V57 line

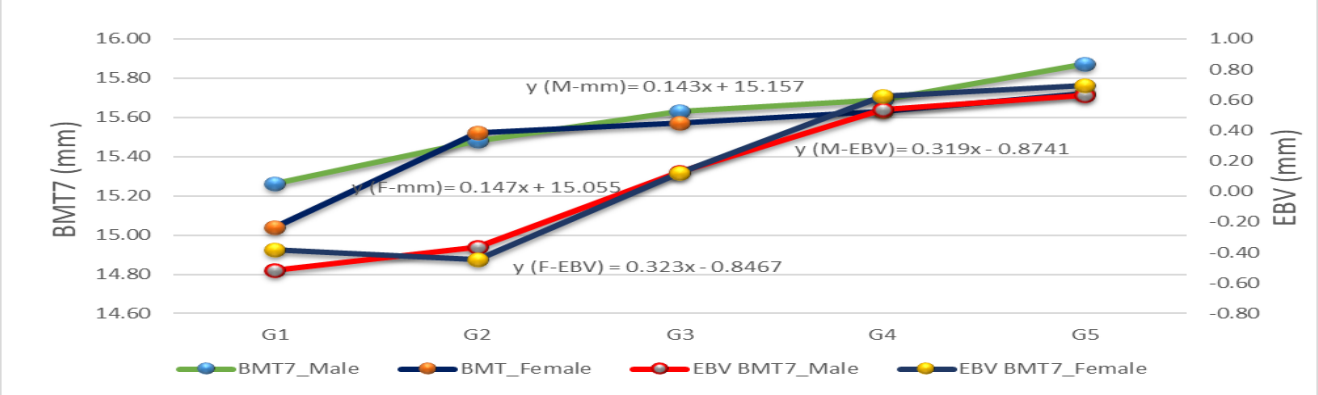


Chart 3.4: Genetic and phenotype trends of BMT7 in V57 line

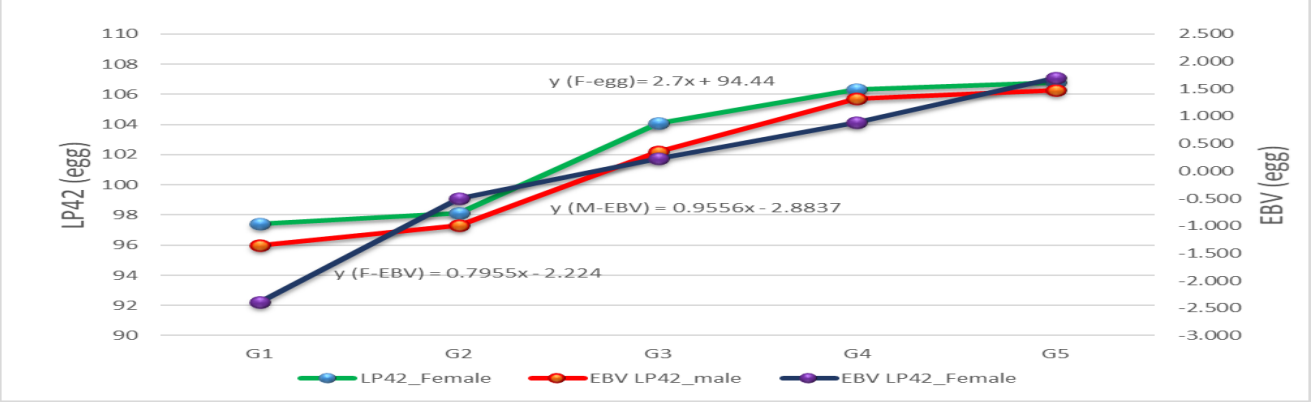


Chart 3.5: Genetic and phenotype trends of LP42 in V57 line

For V57 female line, the breed value of body weight and breast meat thickness at 7 weeks old had a similar trend. There was no genetic improvement in the 2nd generation compared to the 1st generation. The genetic improvement speed of above two traits enhanced clearly in the 3rd, 4th generations. However, it decreased in the 5th generation. Egg yield trait at 42 weeks old in V57 line had an equal genetic improvement through generations. Breed value of egg yield trait in males and female were different and various through generations. In the 1st generation, breed value in

males was higher than that in female, but vice versa in the 2nd generation, and this phenomenon continues occurred in next generations. The difference of breed value between two sexes for this trait may involve in the natures of information resources to estimate breed value of this trait in comparison with other traits. The estimation of breed value using the information from grandparents, parents, brothers and sisters and themselves. Phenotype value of body weight and breast meat thickness at 7 weeks old in V57 line did not follow heredity trend. Moreover, the weight of female in the 2nd generation and males in the 3rd generation were decreased compared to the previous generations. In case of phenotype value of egg yield at 42 weeks old, there was a significant increase of 2.7 eggs/generation while the result of genetic improvement just showed 0.88 egg/generation. This indicated that external factors had a huge effect on this trait. The possible explanation for that may come from the better external factors in the 4th and 5th generations. This factors in combination with selection response have created a great difference on phenotype value of egg yield trait.

In general, genetic and phenotype trend of all selected traits in both lines indicated genetic improvements through selection generations, although the improvement level of each trait in every duck line was different.

3.1.6 Inbreeding of generations

Table 3.6: Inbreeding coefficient of V52 and V57 lines

G	V52 line				V57 line			
	n (ducks)	Individual ducks (%)	Inbreeding coefficient ($\bar{X}$ ±SD)	Maximum value	n (ducks)	Individual ducks (%)	Inbreeding coefficient ($\bar{X}$ ±SD)	Maximum value
G1	833	0.00	0.00	0.00	1040	0.00	0.00	0.00
G2	636	5.51	0.01 ±0.00	0.50	1041	3.94	0.02 ±0.00	0.25
G3	580	21.70	0.09 ±0.01	0.25	1061	29.41	0.07 ±0.01	0.25
G4	805	36.30	0.05 ±0.00	0.13	1051	40.43	0.03 ±0.00	0.13
G5	864	43.28	0.04 ±0.00	0.07	1026	46.98	0.04 ±0.00	0.13

Inbreeding degree was always drawn attention in multiplication selection programs. Inbreeding due to cross-fertilization may result in the depression in some yield traits, but this was also a method to change genetic structure of a population, sometimes it was useful with selection for line creation (Falconer and Mackay, 1996). To make a selection for closed line multiplication, cross-fertilization is unavoidable (Jeyaruban et al., 1995). A reason in multiplication selection, which often raises inbreeding degree, was due to crossing good individuals in order to multiply excellent individuals or families. The result in this study showed that, inbreeding coefficient of two lines in the 1st generation was absent because the individual's parents was unidentified. From the 2nd generation and later, inbreeding individuals increased gradually through generations but inbreeding coefficient in average was high in the 3rd generation and then decreased. This results were in the agreement with the study of Duong Xuan Tuyen et al., (2016) in V27 meat line. The data showed that, the maximum inbreeding coefficient of 0.5 was observed in the 2nd generation of V52 line. This was the result of cross-fertilization among birth brothers and sisters. The individuals duck having inbreeding coefficient of 0.25 in the 2nd and 3rd generations in two duck lines, were the result of cross among brothers and sisters with same fathers but different mothers. However, the number of individuals with high inbreeding coefficient was low. They were children of some pairs of intentional cross in a group of individuals with maximum productivity in the 2nd and 3rd generations. In the 5th generation, percentage of inbreeding individuals were 43.28% in V52 line and 46.98% in V57 line, inbreeding coefficient was 4% only, which will not affect line multiplication.

3.1.7 Growth ability in V52 and V57 lines through selectied generations

a. Body weight

Table 3.7: Body weight at 7 weeks old in V52 lines

Sex	Statistic parameters	Generations				
		G1	G2	G3	G4	G5
Male	n	115	116	112	117	114
	$\bar{X}$ (g)	3340.3^{d}	3364.9^{d}	3425.2^{c}	3484.2^{b}	3539.3^{a}
	SD (g)	305.3	294.4	261.6	261.7	254.3
Female	n	115	114	116	116	115
	$\bar{X}$ (g)	3170.4^{d}	3204.3^{cd}	3237.2^{bc}	3292.2^{ab}	3331.6^{a}
	SD (g)	302.1	280.4	231.4	258.8	243.9

Average values in the same line with the same letters have no statistic difference (P > 0.05)

The body weight of both male and female of V52 line improved gradually through generations. Body weight at 7 weeks old in the 1st generation was 3340.3 g in males, 3170.4 g in female. Body weight in the 5th generation were higher than that in the 1st generation males and females 199 g and 161.2 g, respectively. This result was similar to published results of genetic improvement selection of this trait. Duong Xuan Tuyen et al. (2015) noticed that, body weight of selecting V22 male line in the 4th generation was higher than that in the 1st generation in males and female at 124.2 g (3.76%), 108.7 g (3.44%), respectively. Dean (2005) selected Pekins ducks through 6 generations, its body weight increased 327 g in males and 277 g in female. The body weight at 7 weeks old of V52 male line was belongs to a group with large body weight, equivalent to V22 male line at the VIGOVA duck breed farm and higher than that in SM male line at DaiXuyen Duck Breeding and Research Center by Hoang Thi Lan et al. (2001), higher than that in V5, V2 male lines (Duong Xuan Tuyen et al., 2001, 2006a) and higher than that in MT1 line (Nguyen Van Duy, 2012).

Table 3.8: Body weight at 7 weeks old in V57 line

Sex	Statistic parameters	Generations				
		G1	G2	G3	G4	G5
Male	n	116	116	116	117	115
	$\bar{X}$ (g)	3017.2^{b}	3022.6^{b}	3063.7^{ab}	3094.4^{ab}	3103.8^{a}
	SD (g)	281.2	261.5	243.3	247.9	238.4
Female	n	115	114	115	116	114
	$\bar{X}$ (g)	2820^{b}	2848^{b}	2883^{ab}	2908^{ab}	2922.2^{a}
	SD (g)	263.5	242.6	236.1	209.6	212.4

Average values in the same line with the same letters have no statistic difference (P > 0.05)

In V57 female line, average body weight of duck had an increase trend through selection generations. Average body weight of male ducks in the 5th generation was higher 86.6 g than that in the 1st generation and it was also higher 102.2g than that in female ducks. The average improvement level of body weight was 21.7 g/generation in males and 25.55 g/generation in female. Accordingly, in both V52 male and V57 female lines, the speed of body weight improvement through generations is higher to some extent when compared to the assessment by genetic trend analysis for this trait. The explanation may come from the good collaboration of genetic progress and external conditions in subsequent generation compared with previous generations. This is just the reason why the study on completion of nursing care process (external factors) is always drawn attention when applied on new lines to make the most of genetic potential. After 5 selection generations, the average body weight at 7 weeks old was 3103.8 g in

males and 2922.2 g in females. Standard deviation of body weight through selection generations in V52 and V57 lines had downward trend. It indicated that the uniformity of lines through the selection was improved. The result of growth assessment in both lines of free feeding system through generations has further confirmed the selection efficiency for body weight at 7 weeks old in 02 V52 and V57 lines.

b. Feed Conversion Rate for increased body weight

FCR of ducks in V52 line of generations 1, 2, 3, 4 and 5 at 7 weeks old were 2.65, 2.63, 2.58, 2.56 and 2.54, respectively, while, FCR of ducks in V57 line of generations 1, 2, 3, 4 and 5 were 2.65, 2.64, 2.62, 2.62 and 2.61.

The FCR of both duck lines were decreased through generations. With the selection focused on growth ability, weight gain in V52 and V57 lines decreased 0.11 kg and 0.04 kg/1 kg, respectively. This was explained by Klemm and Pingel (1992). The selection for body weight could resulted in the FCR improvement. It was in response to correlation between growth and FCR. FCR in both lines after 5 generations were generally low compared with previous super meat duck lines and conformed to the rule that the larger body weight was, the lower FCR duck had.

The FCR at 8 weeks old in T13 duck line was 2.72 (Nguyen Duc Trong et al., 2007). After that, Duong Xuan Tuyen et al. (2011b) reported that, FCRs for body weight in V12, V2 and V7 lines at VIGOVA duck breed farm were 2.58, 2.60 and 2.76, respectively. While, Pham Van Chung (2015) showed the FCR of MT1 and MT3 lines at DaiXuyen Duck Breeding and Research Center were 2.73 and 2.64, respectively.

c. Carcass composition

Table 3.9: Carcass, breast muscle and thigh muscle percentage at 7 weeks old in V52 line

G	n	Carcass (%) ($\overline{X}$ ± SD)		Breast muscle (%) ($\overline{X}$ ± SD)		Thigh muscle (%) ($\overline{X}$ ± SD)	
		Male	Female	Male	Female	Male	Female
G1	10	69.91±1.23	70.52±2.07	18.40^{c}±0.63	18.63^{c}±0.69	12.11±0.23	11.89±0.50
G2	10	70.23±1.21	69.88±2.08	18.81^{bc}±0.43	19.23^{bc}±0.62	12.41±0.64	12.17±0.45
G3	10	71.06±1.18	71.17±1.24	19.31^{abc}±0.60	19.70^{abc}±0.61	12.23±0.36	12.21±0.67
G4	10	70.67±0.74	70.54±1.12	19.59^{ab}±0.63	20.02^{ab}±0.48	12.21±0.27	12.14±0.66
G5	10	70.94±1.15	70.82±0.89	20.43^{a}±0.42	20.59^{a}±0.51	12.56±0.63	12.45±0.47

Average values in the same column with the same letters have no statistic difference (P > 0.05)

Table 3.10: Carcass, breast muscle and thigh muscle percentage at 7 weeks old in V57 line

G	n	Carcass (%) ($\overline{X}$ ± SD)		Breast muscle (%) ($\overline{X}$ ± SD)		Thigh muscle (%) ($\overline{X}$ ± SD)	
		Male	Female	Male	Female	Male	Female
G1	10	69.19±1.68	70.79±1.16	19.14^{c}±0.31	19.21^{c}±0.49	12.56±0.45	12.33±0.70
G2	10	70.24±1.55	71.15±1.17	19.60^{bc}±0.73	19.81^{bc}±0.76	12.72±0.31	12.57±0.97
G3	10	70.06±1.67	70.39±0.73	20.10^{b}±0.19	20.32^{b}±0.47	12.40±0.59	12.45±0.96
G4	10	70.53±0.82	70.31±0.92	20.34^{ab}±0.53	20.62^{ab}±0.50	12.61±0.44	12.51±0.75
G5	10	70.73±0.97	70.96±1.46	20.65^{a}±0.34	20.93^{a}±0.52	12.59±0.43	12.37±0.56

Average values in the same column with the same letters have no statistic difference (P > 0.05)

The carcass percentage of males and females duck in the 5^{th} generation were 70.94% and 70.82% for V52 male line; 70.73% and 70.96% for V57 line, respectively. There was no statistical difference among generations (P > 0.05). Carcass percentage at 70% level in both lines were quite high and meaningful as it was an important criterion to decide the selling price. Many domestic

studies on carcass percentage in super meat duck lines have already reported. Duong Xuan Tuyen (1998) indicated that carcass percentage of CV Super–M female were 68.33% in male line, 68.99% in female line. While, Hoang Thi Lan et al. (2001) reported that carcass percentage in CV Super–M meat female was 68.66 – 69.6%. In the study of Nguyen Duc Trong et al. (2008), carcass percentage of T5 and T6 duck lines were 70.25% and 68.14%. The newest study of Le Thanh Hai (2012) revealed that, carcass percentage of V12 and V2 male lines at VIGOVA farm were 70.18% and 70.11%.

After selection for 5 generations, breast muscle percentage in males and female were 20.43% and 20.59% in V52 line, 20.65% and 20.93% in V57 line, respectively. In comparison with the 1st generation, breast muscle percentage in males and female were increased by 2.03% and 1.96% in V52 line, 1.51% and 1.72% in V57 line, respectively ($P < 0.05$). Breast muscle percentage in these two lines were 4 - 7% higher than those in other meat lines, bringing economic value to the production of meat female. Reports on breast muscle percentage in female have a great fluctuation subject to line, breed, age, etc. Breast meat and breast muscle percentages were reported by many authors for meat female in Vietnam. As reported by Duong Xuan Tuyen (2013), breast meat percentage at 7 weeks old in V12517, V2517, V127 lines were in range of 18.8 - 18.9%. Another researcher noticed that breast meat and breast muscle percentages were 18.74% and 11.33% in VSM3 commercial female; 19.64% and 11.98% in VSM4 commercial female (Le Thanh Hai et al., 2016). Some foreign authors reported that breast muscle percentage at 7 weeks old in Pekins duck was 12.0% (Crawford, 1990), 18.1% (Pingel et al., 2013) and 11.9 – 15.0 (Witkiewicz et al., 2004).

The result of thigh muscle percentage in all studied generations of both lines had no statistical difference ($P > 0.05$). Thigh muscle percentage in males and female were 12.56% and 12.45% in V52 male line; 12.59% and 12.37% in V57 female line. This result was similar to that in the studies of many researchers such as Witkiewicz et al. (2004); Pingel et al. (2013) and Le Thanh Hai et al. (2016).

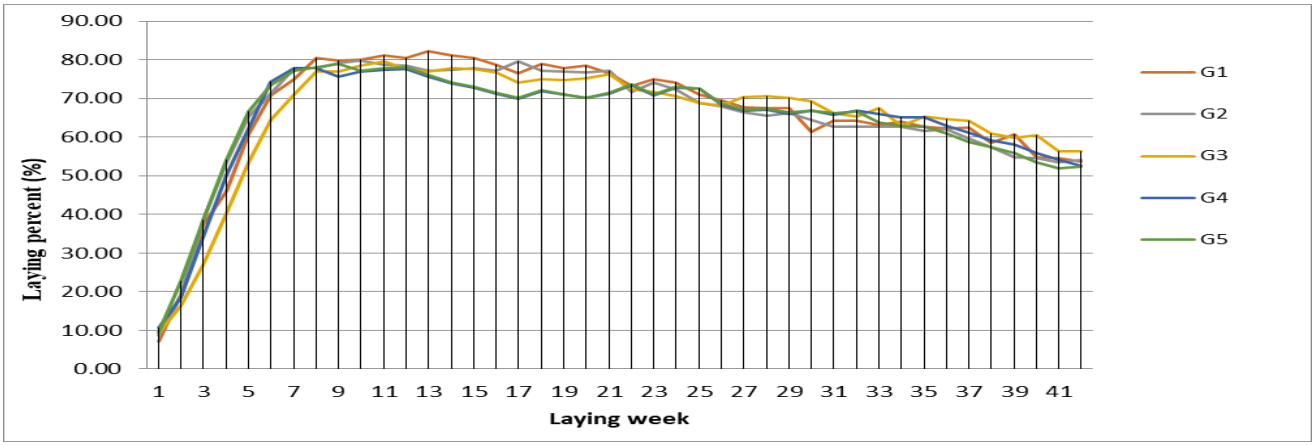
Consequently, high breast muscle percentage was an outstanding trait of carcass composition in two V52 and V57 lines compared to other duck lines.

3.1.8 Production parameters of V52 and V57 lines through selected generations

a. Laying age, laying percentage and laying performance

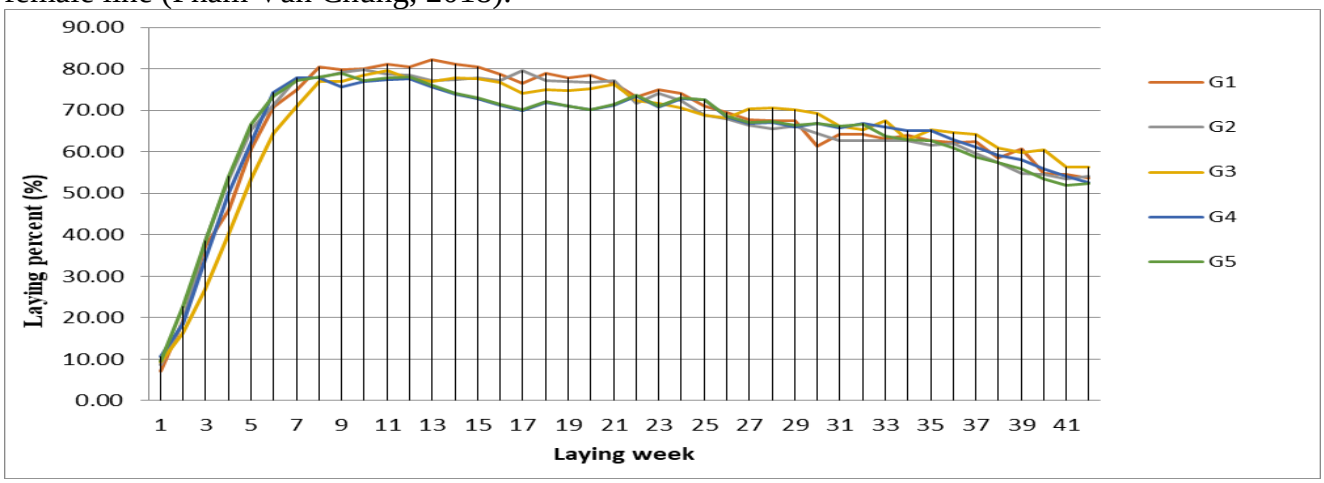
Laying age in generations 1, 2, 3, 4 and 5 were 175, 176, 179, 181 and 182 days old in V52 line, while in V57 line, the laying age were 173, 170, 169, 168 and 167 days old. The selection for the improvement of body weight resulted in increase of laying age in V52 line. However, the selection for improvement of egg yield resulted in decrease in laying age of V57 female line. This explanation of this come from the negative correlation between body weight and egg yield, and between egg yield and laying age (Hudsky et al, 1986; Marai et al, 1989).

Laying percentage and egg yield at 42 laying weeks of V52 in generations 1, 2, 3, 4 and 5 were 66.21% and 194.65 eggs, 65,45% and 192.71 eggs, 65.14% and 191.52 eggs, 64.73% and 190.3 eggs, 64.87% and 190,71 eggs, respectively. Figure 3.6 showed that, laying percentage of generations had a significant difference in the period of 12 - 20 laying weeks. The laying percentage in the 1st generation for 42 laying weeks was 1.34% higher than that in the 5th generation. The egg yield in the 5th generation was 3.94 eggs/female. It was lower than in the 1st generation. The selection for body weight in V52 line leaded to decrease of laying performance. This results are in agreement with study of Nguyen Van Duy (2012) in MT1 male line and Pham Van Chung (2018) in TS132 male line. The explanation may come from the negative correlation between body weight and egg yield (Hudsky et al., 1986; Pham Van Chung, 2018). Egg yield in V52 line was also quite high for the high-yield meat male line with quick growth speed and high lean meat rate. The V2, V12 and V22 meat male lines at VIGOVA duck breed farm had egg yield at 42 weeks old of 156.5 - 185.37 eggs/female (Duong Xuan Tuyen et al., 2006a, 2011 and 2015).



Graph 3.6: Weekly egg percentage in V52 line

Laying percentage and egg yield at 42 laying weeks of V57 line in generations 1, 2, 3, 4 and 5 were 71.90% and 211.38 eggs, 72.04% and 211.80 eggs, 72.64% and 213.55 eggs, 73.03% and 214.70 eggs, 73.63% and 216,47 eggs, respectively. Figure 3.7 indicated that, laying percentage of V57 line in generations 1 and 5 had a great difference in the period of 3rd to 8th laying weeks, increased rate of laying percentage in the 5th generation is quicker. From the 8th – 36th laying week, laying percentage in 2 generations were equivalent. Then, the laying percentage reduced more sharply than that in the 5th generation. In sum, the selection not only increased egg yield but also helped to extend the egg production period of V57 line. This will give a great economic efficiency. The laying percentage at 42 laying weeks in the 5th generation was 1.73% (5.09 eggs/female) higher than that in the 1st generation. This proved the selection efficiency for this trait, which was analyzed in the section of genetic trend as stated above. Compared to some meat female lines in the country over the time, egg yield in V57 line was quite high. Egg yield at 42 laying weeks was 207.2 eggs/female in V7 meat female line, 210.14 eggs/female in V27 meat female line (Duong Xuan Tuyen et al., 2006a, 2016) and 215.91 eggs/female in TS142 meat female line (Pham Van Chung, 2018).



Graph 3.7: Weekly egg percentage in V57 line

b. Feed Conversion Rate for egg production

FCR for 10 eggs in generations 1, 2, 3, 4 and 5 were 4.25, 4.38, 4.42, 4.46 and 4.44 in V52 line. In the V57 line, FCR value of generations 1, 2, 3, 4 and 5 were 3.70, 3.69, 3.63, 3.61 and 3.57.

The selection for growth performance in V52 line resulted in the increase of feed expense for egg production through selection generations. The increase in feed expense for egg production was obvious and absolutely suitable for the selection of high-yield male lines with quick growth. FCR for 10 eggs of meat female in male lines with high body weight was reported in range of 4.01

– 5.12 by many researcher (Nguyen Duc Trong et al., 2007, 2011, 2013; Le Thanh Hai, 2012; Nguyen Van Duy, 2012; Duong Xuan Tuyen et al., 2015).

In V57 female line, FCR for egg production at 42 laying weeks had downward trend through selection generations. In aspect of genetics, this was the correlated response between egg yield and FCR for egg production. This was also proved in the result of selection in V27 line (Duong Xuan Tuyen et al., 2016), MT2 line (Nguyen Van Duy, 2012) and TS142 line (Pham Van Chung, 2018). Owing to selection for improvement of egg yield in V57, FCR for 10 eggs in the 5th generation was 0.13 lower than that in the 1st generation. FCR at 3.57 level in V57 was quite low compared to meat female lines selected at VIGOVA duck breed farm as well as other breed farms. FCR for 10 eggs were 3.81 in V7 female line and 3.62 in V27 female line at VIGOVA duck breed farm (Duong Xuan Tuyen et al., 2006a, 2016).

c. Egg weight

Table 3.91: Egg weight in V52 and V57 lines

Line	n (egg)	G1	G2	G3	G4	G5
		$\overline{X}$ ± SD (g)	$\overline{X}$ ± SD (g)	$\overline{X}$ ± SD (g)	$\overline{X}$ ± SD (g)	$\overline{X}$ ± SD (g)
V52	1050	89.73^{c} ± 7.47	91.35^{b}±8.15	92.64^{a}±7.65	92.79^{a}±8.08	92.86^{a}±7.89
V57	1050	89.22^{a}±7.41	88.81^{a} ± 7.15	88.04^{b} ± 7.21	87.92^{b} ± 6.95	87.68^{b} ± 7.01

If the average in the final line has different letters, statistic deviation has P < 0.05.

In V52 male line, average egg weight through selection generations had an upward trend. Average egg weights were 89.73 and 92.05 g in the 1st and 5th generation, respectively (P < 0.05). Accordingly, the selection for improvement of body weight had also helped to enhance the egg weight in V52 line. Egg weight in V52 line was equivalent to V22 male line (91.5 g, Duong Xuan Tuyen et al, 2015) and lower than that in V2 male line (95.8 g, Duong Xuan Tuyen et al., 2006a) and in V12 line (94.6 g, Duong Xuan Tuyen et al., 2011).

In V57 female line, average egg weight gave the downward trend from the 1st generation to the 5th generation. Average egg weight in the 5th generation was 87.68 g. It was 1.54 g lower than that in the 1st generation. Egg weight in V57 line was higher than in CV Super – M female line (82.1 g, Duong Xuan Tuyen, 1998), V6 female line (83.5 g, Duong Xuan Tuyen et al., 2001), V7 female line (85.3 g, Duong Xuan Tuyen et al., 2006a), SM female line (84.1 – 86.4 g, Hoang Thi Lan et al., 2001), and equivalent to V27 female line (88.0 g, Duong Xuan Tuyen et al., 2016).

d. Biological characteristics of eggs

The percentage of shell, albumen and yolk per of eggs weight in two lines were significant difference (P < 0.05). Yolk percentage in two lines in the result were high and the yolk percentage, in particular, in V57 female line was higher than that in V52 male line. The yolk percentage was in range of 28.68 - 29.77% in MT1 line, 31.13 - 31.70% in MT2 line (Nguyen Van Duy, 2012). The egg shape indexes were 1.38 in V52 line and 1.37 in V57 line. Egg shape indexes in two V52 and V57 lines were low in comparison with previous researches (Nguyen Ngoc Dung et al., 2008; Nguyen Van Duy, 2012).

Egg's HU values were 85.19 in V52 line and 88.61 in V57 line. The eggs in both lines were in good quality (AA). Yolk color in two lines were in the high level. The yolk color values were 11.96 and 11.14 for V52 and V57 lines, respectively. Egg shell thickness in both lines were 0.38 mm and eggshell strength was 4.42 kg/cm^2. Some results of egg shell thickness in previous SM meat duck ranged 0.390 – 0.414 mm (Nguyen Duc Trong et al., 2007; Nguyen Ngoc Dung et al., 2008; Nguyen Van Duy, 2012). Yolk index in two lines were equivalent to the result by Nguyen Duc Trong et al. (2007) and Nguyen Van Duy (2012) and higher than that in research of Nguyen Ngoc Dung et al. (2008).

Table 3.12: Egg survey criteria of two lines in the 5th generation

Criteria	Unit	V52 line (n = 50 eggs)		V57 line (n = 50 eggs)		P
		$\overline{X}$	SD	$\overline{X}$	SD	
Egg weight	g	92.10	6.24	89.73	4.62	0.033
Shell percentage	%	12.56	0.80	11.97	0.78	0.000
Yolk percentage	%	31.40	2.22	34.39	2.29	0.000
Albumen percentage	%	55.82	3.08	53.60	2.00	0.000
Large diameter	mm	67.82	2.61	67.21	1.65	0.163
Small diameter	mm	49.04	1.66	48.92	1.15	0.674
Shape index (I)	-	1.38	0.06	1.37	0.05	0.395
Albumen height	mm	8.78	1.69	9.19	1.45	0.200
Haugh unit (HU)	-	85.19	11.34	88.61	7.90	0.084
Yolk color	-	11.96	0.75	11.14	0.45	0.000
Shell thickness	mm	0.38	0.03	0.38	0.03	0.618
Eggshell strength	kg/cm^2	4.42	1.11	4.42	0.89	0.998
Yolk height	mm	20.81	1.33	20.90	0.81	0.670
Yolk diameter	mm	49.35	3.02	51.24	3.13	0.003
Yolk index (YI)	-	0.42	0.02	0.41	0.03	0.006

e. Embryo egg percentage and type 1 hatching percentage on hatched eggs

Embryo egg percentage and hatching percentage at 42 laying weeks in V52 line in generations 1, 2, 3, 4 and 5 were 92.10% and 71.62%, 92.20% and 71.59%, 91.70% and 71.39%, 91.50% and 71.30%, 91.63% and 70.38%, respectively. Two hatching criteria had no statistical difference among generations (P > 0.05). The embryo and hatching percentages in V52 line were high compared with some meat male lines. Embryo percentage in some male lines such as V2, V5, V12 and V22 were 87.2 – 93.3% (Duong Xuan Tuyen, 2001, 2006a, 2011, 2015), 90.50% in T5 line (Nguyen Duc Trong et al., 2013) and 92.8% MT12 (Nguyen Van Duy, 2012). Hatching percentage of V52 line was 71.60 - 73.42%. It was equivalent to that of some meat male lines such as V2, V5, V12, and V22 lines (Duong Xuan Tuyen et al., 2001, 2006a, 2011, 2015).

In V57 line, embryonic egg percentage and hatching percentage at 42 laying weeks of generations 1, 2, 3, 4 and 5 were 92.80% and 71.90%, 92.99% and 72.20%, 93.30% and 72.09%, 93.20% and 72.29%, 93.79% and 73.07%, respectively. The results of two hatching criteria in V57 duck line were similar to the results published by many researchers such as Duong Xuan Tuyen et al. (2001, 2006a, 2016) with V6, V7, V27 female lines at VIGOVA duck breed farm (95.8 – 97.8%), Nguyen Van Duy (2012) with MT12 duck line at DaiXuyen Duck Breeding and Research Center (92.8%,) and Nguyen Duc Trong et al. (2013) in T6 line (92.5%). Hatching percentage of V57 line was higher than that of TS142 female line (Pham Van Chung et al., 2018) but lower than that in V27 line (Duong Xuan Tuyen et al., 2016).

In summary, yield criteria in two lines after 5 generations selection were in the high level in the oriented criteria of each line. Selected traits had outstanding results compared with old lines, which exceed the expected target.

3.2 PRODUCTION CHARACTERISTIC OF VSM6 COMMERCIAL DUCK

3.2.1 Survival rate

Survival rate of VSM6 commercial duck in breeding stages was high, more than 96%. According to Phung Duc Tien et al. (2009), commercial crossbred duck of SM and SM3 lines acquired the survival rate of 96 – 98%, while, survival rate of T1546 was 96.67 - 100% (Le Sy

Cuong et al., 2009). It showed that, rearing ducks was an easy job because of their high adaptibility. Recent studies in commercial meat duck indicated that, survival rate ranged 95.0 – 99.3% (Duong Xuan Tuyen et al., 2011; Le Thanh Hai, 2012 and 2016; Nguyen Van Duy, 2012; Pham Van Chung, 2018).

Table 3.13: Survival rate of VSM6 commercial duck

Week old	Number at beginning period	Dead	Number at end period	Survival rate (%)
0 - 4	360	11	349	96.94
5 - 7	349	3	346	99.14
0 - 7	360	14	346	96.11

3.2.2 Body weight

Table 3.14: Body weight of VSM6 commercial duck

Age	n (con)	$\overline{X}$ (g)	SD (g)
1 day old	360	57.16	3.57
3 weeks old	352	1111.00	79.21
5 weeks old	349	2193.33	142.13
7 weeks old	346	3235.11	227.10

Body weight of VSM6 commercial duck at 7 weeks old in this study was high, 3235.11 g. Some other super meat crossbred ducks previously reported had lower body weight at 7 weeks old than in VSM6 duck such as 3150.0 g in V2517 (Duong Xuan Tuyen et al., 2006b), 3103.8 g in SM3SH (Nguyen Duc Trong et al., 2008), 3126.3 g in V12517 (Duong Xuan Tuyen et al., 2011). Duong Xuan Tuyen et al. (2011b) indicated that, body weight at 7 weeks old of crossbred duck between V2 and V7 lines was 3059.8 g, similar to the crossbred duks of V12 and V7 lines (31263 g). While, Le Thanh Hai (2012) noticed body weight at 7 weeks old of crossbred ducks as V2517 and V12517 lines were 3090.2 and 3175.7 g, respectively. As studied by Nguyen Van Duy (2012), commercial MT12 duck at 8 weeks old had body weight of 3202.9 g. Body weight at 7 weeks old in commerical VSM3 and VSM4 female were 3087.83 g and 3233.08 g, respectively (Le Thanh Hai et al., 2016). Consequently, VSM6 commercial duck had the high growth rateand suitable with breeding in industry scale.

3.2.3 Feed conversion ratio for increased body weight

Table 3.15: FCR of VSM6 commercial duck

Weeks old	Feed (kg)	Weight (kg)	FCR
0 – 3	577,97	370,49	1,56
0 – 5	1571,72	744,89	2,11
0 – 7	2779,89	1098,77	2,53

FCR for growth of VSM6 duck at 7 weeks old was 2.53. It is better than that some previous studies in commercial meat-type ducks (Duong Xuan Tuyen et al., 2001, Hoang Thi Lan et al., 2004, Phung Duc Tien et al., 2008, Le Thanh Hai, 2012, and Le Thanh Hai et al. 2016).

3.2.4 Carcass composition

Average crcass percentage for VSM6 male and female duck was 70.09%. This result was quite good in comparison the study of Golze and Pingel (2003) with carcass percentage at 9 weeks old was 62.8% and 63.6% in Pekin male in female duck, respectively. This result was also better than that in research of Isguzar and Testik (2003) carcass percentage of males and female duck at 68.6% and 68.1%. The average thigh muscle percentage in both males and females was 12.52%. This percentage in males was higher 0.51% than that in female. The average breast muscle percentage of male and female reached to 20.27%. This ratio in female was higher 0.34% than in males. Most of published studies showed that, breast muscle percentage in meat-type ducks were not high with. Nguyen Duc Trong et al., 2008 noticed that, the muscle percentage of T5164,

SM3SH ducks at 8 weeks old with in capitve breeding was 70.4 – 72.2%. The thigh muscle and breast percentages were 12.1% and respectively. The study of Duong Xuan Tuyen et al (2011b) indicated that, carcass, thigh meat and breast meat percentage of commercial V12517 duck were 70.31%, 16.73% and 18.87%, respectively. While, Pingel et al. (2013) revealed that, breats muscle percentage of Pekin ducks at 7 weeks old was 18.1%. As a result, VSM6 commercial duck had outstanding breast muscle percentage compared to previous breed.

Table 3.16: Carcass characteristics of VSM6 commercial ducks at 7 weeks old

Criteria	Unit	Male (n=10) $\overline{X}$ ± SD	Female (n=10) $\overline{X}$ ± SD	General (n=20) $\overline{X}$ ± SD
Body weight	g	3339.7 ± 23.6	3197.0 ± 30.1	3268.3 ± 14.3
Carcass weight	g	2342.1 ± 22.4	2239.2 ± 24.9	2290.6 ± 13.7
Carcass percentage	%	70.13 ± 0.84	70.04 ± 1.77	70.09 ± 1.85
Thigh muscle weight	g	299.09 ± 8.66	274.52 ± 4.97	286.78 ± 5.63
Thigh muscle percentage	%	12.77 ± 0.49	12.26 ± 0.31	12.52 ± 0.38
Breast muscle weight	g	470.76 ± 11.52	457.68 ± 13.18	464.22 ± 8.67
Breast muscle percentage	%	20.10 ± 0.43	20.44±0.46	20.27±0.41

3.2.5 Chemical composition of thigh and breast muscle

Table 3.17: Chemical composition of thigh and breast muscle in VSM6 commercial duck

Criteria	Unit	Thigh muscle			Breast muscle			P
		n	$\overline{X}$	SD	n	$\overline{X}$	SD	
Dry matter	%	6	25.71	0.64	6	23.43	0.39	0.000
Protein	%	6	19.20	0.11	6	19.88	0.61	0.022
Lipid	%	6	4.79	0.79	6	1.71	0.30	0.000
Mineral	%	6	1.11	0.03	6	1.26	0.02	0.000
pH	-	6	6.18	0.12	6	5.93	0.03	0.001

Chemical composition in thigh and breast muscles were significantly different ($P < 0.05$). Dry matter of thigh muscle was higher 2.28% than that in breast muscle (25.71% vs 23.43%). These results were high compared with many previous publications (Nguyen Minh Quang 1994; Baeza et al., 1999; Hsu 1999; Chen and Hsu 1999; Woloszyn et al., 2006; Ali et al., 2007). Protein percentage of thigh and breast muscle were equivalent to several studies in Pekins (Golze and Pingel, 2003; Baeza et al., 1999; Chen and Hsu, 1999; Woloszyn et al., 2006). Protein percentage of thigh and breast muscle in this study were higher than that in study of Nguyen Minh Quang (1994) in Bach Tuyet ducks.

In VMS6, lipid percentage was 4.79% in thigh muscle, 1.71% in breast muscle, which difference is 3.08%. The study by Golze and Pingel (2003) in Pekin ducks has the similar result, which lipid percentage at 9 and 12 weeks old were 1.5% and 2.1% in breast muscle, 3.2% and 3.2% in thigh muscle.

Mineral percentage of thigh and breast muscle were 1.11 and 1.26%, respectively. They were equivalent to those in published studies (Nguyen Minh Quang, 1994; Chen and Hsu, 1999; Ali et al., 2007).

pH in two muscle groups had light acidity with level of 6.18 in thigh muscle and 5.93 in breast muscle. The difference in pH among 2 muscle groups was also noticed in research of Golze and Pingel (2003). This difference may come from the difference in muscle structure and activity of 2 muscle groups before slaughtering.

Accordingly, chemical composition in thigh and breast muscle of VSM6 duck were different. This result was in agreement with previous studies.

3.2.6 Amino acid components in thigh and breast muscle

Table 3.18: Amino acid of thigh and breast muscles in VSM6 commercial duck

Criteria	Thigh muscle			Breast muscle			P
	n	$\overline{X}$	SD	n	$\overline{X}$	SD	
Essential amino acids (% total protein)							
Histidine	6	7.77	0.28	6	7.58	0.21	0.221
Valine	6	3.99	0.71	6	3.59	1.01	0.446
Threonine	6	7.04	0.35	6	6.29	0.26	0.002
Lysine	6	6.86	0.53	6	7.72	0.75	0.044
Isoleucine	6	3.18	0.20	6	3.56	0.94	0.349
Leucine	6	5.63	0.41	6	5.94	1.46	0.635
Phenylalanine	6	2.83	0.37	6	2.89	0.84	0.862
Non-essential amino acids (% total protein)							
Asparatic	6	3.23	0.42	6	2.97	0.36	0.260
Glutamic	6	11.41	0.22	6	10.45	0.26	0.000
Arginine	6	8.25	0.46	6	7.16	0.50	0.003
Alanine	6	6.41	0.40	6	6.47	0.20	0.733
Glycine	6	7.64	0.23	6	6.68	0.14	0.000
Proline	6	3.92	0.19	6	3.41	0.06	0.000
Serine	6	3.42	0.15	6	3.31	0.14	0.197
Tyrosine	6	3.67	0.10	6	3.99	1.49	0.610

As a result, there wre significant differences in ratios of Threonine, Lysine, Glutamic, Arginine, Glycine, Proline of thigh and breast muscle ($P < 0.05$). Other showed no significant difference among two muscle groups ($P > 0.05$). The published studies showed that, amino acid component in protein structure was dependent on breed, muscle group and age in animals. There was a difference in amino acid in the research of Aronal et al. (2012) in Peking duck. The ratios of Histidine, Threonine, Leucine, Tyrosine in this study were higher than those in the study of Aronal et al. (2012), whereas, other amino acids were lower.

Normally, the glutamic acid had a highest percentage in protein structure of duck meat. It contributes on the sweet taste of duck meat. Glutamic percentages in thigh and breast muscle of VSM6 duck in this study were 11.41% and 10.45%, respectively. Most of previous studies indicated that, glutamic acid rate in duck meat reached over 10% (Nguyen Duy Hoan, 2010 and Kwon et al., 2014).

The analysis data of duck meat in this study showed that, duck meat had a high level of essential amino acids. This is a good food for human.

3.2.7 Physical properties of thigh and breast muscle

A significant difference of physical properties of thigh and breast muscle was observed in this study ($P < 0.05$), only water activity of two muscles was in similar thigh and breast muscle (0.99). Cooking loss in breast muscle was higher 7.89% compared to thigh muscle(34.15% vs 26.26%). Meat cooking loss depends on breed, muscle group, age, storage duration. Golze and Pingel (2003) showed that cooking loss of breast muscle in Pekins at 9 and 12 weeks old were 31.1% and 28.0%; While, this rate in wild goose at 10.5 and 15 weeks old were 27.5% and 30.6%, respectively. The study of Larzul et al. (2002) indicated that the cooking loss of wild goose and Pekin ducks at 15 weeks old were 24.57% and 20.63%. Later that, Ali et al. (2007) revealed that, the cooking loss of breast meat in female at 45 days old within 1, 3, 5 and 7 days of storage were 35.48, 35.45, 35.61 and 35.56%, respectively.

Table 3.19: Physical properties of thigh and breast muscle in VSM6 commercial duck

Criteria	Unit	Thigh muscle			Breast muscle			P
		n	$\overline{X}$	SD	n	$\overline{X}$	SD	
Moisture	%	6	74.03	0.85	6	77.72	0.82	0.000
Water activity	-	6	0.99	0.00	6	0.99	0.00	0.448
Cooking loss	%	6	26.26	2.36	6	34.15	3.24	0.001
Harness	N	6	0.91	0.27	6	8.64	2.58	0.000
Springiness	-	6	0.69	0.01	6	0.73	0.02	0.008
Gumminess	N	6	0.47	0.16	6	3.40	0.95	0.000
Chewiness	N	6	0.34	0.12	6	2.48	0.63	0.000
Cohesiveness	-	6	0.52	0.04	6	0.39	0.03	0.000

Harness values of VSM6 duck were 0.91 N in thigh muscle and 8.64 N in breast muscle. Hardness in breast muscle was 9.49 times higher than in thigh muscle. Criterias of springiness, gumminess, chewiness and cohesiveness had been not published yet in female. The result of physical properties showed that, breast muscle had higher chewiness than that of thigh muscle. It need to be paid attention to meet the market demand about meat quality. This result suggested, the selection of physical traits of duck meat in response to consumer's taste of meat chewiness.

In summary, VSM6 duck had quick growth, low FCR and high meat percentage. This meat duck line met the current market demand about intensive duck farming.

CONCLUSION AND RECOMMENDATION

1. CONCLUSION

The study was succes in selection of two high-yield meat duck lines for intensive duck farming. The main productive characteristics being equal to or better than the expected target, as follows:

The V52 male line: the heritability of body weight and breast meat thickness at 7 weeks old was high (0.40 and 0.44 respectively); genetic progress of the two traits were 43.58 g and 0.298 mm, respectively. Body weight at 7 weeks old were 3,539.3 g in male and 3,331.6 g in female, FCR for body weight gain was 2.54, breast muscle percentage at 7 weeks old was 20.43% in male and 20.59% in female, egg production was 190.71 eggs/female/42 laying weeks and FCR for 10 eggs was 4.44.

The V57 female line: the heritability of body weight and breast meat thickness at 7 weeks old and egg production to 42 weeks old were 0.17, 0.37 and 0.29 respectively; genetic progress of above traits were 12.38 g, 0.321 mm and 0,88 egg, respectively. Body weight at 7 weeks old were 3,103.8 g in male and 2,922.2 g in female, FCR for body weight gain was 2.61, breast muscle percentage at 7 weeks old were 20.65% in male and 20.93% in female, egg production was 216.47 eggs/female/42 laying weeks and FCR for 10 eggs was 3.57.

The average body weight of VSM6 commercial ducks at 7 weeks old was 3,235.11 g, FCR for growth was 2.53, carcass percentage was 70.09%, breast and thigh muscle percentages were 20.27% and 12.52%, respectively.

2. RECOMMENDATION

Further studies for completing rearing techniques to explore genetic potential of the new breeders should be conducted when advancing to the mass production; and studies in genetic of duck meat quality and hatching traits should be carried out to facilitate the selection of breeders on scientific basis.