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SELECTION FOR EGG PRODUCTION INCREASING OF TRIET GIANG AND TC DUCK

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INTRODUCTION

1.REANABLE

Vietnam is a country with a large market for consumption of fresh duck eggs and, half-hatched eggs, and especially, is an export market for the salted eggs. Therefore, from imported raw materials (Triet Giang - China ducks) combined with the famous Vietnamese duck breed for eggs (Co duck), 4 new egg specialized duck lines have been selected and created including TG1, TG2, TC1 and TC2. In which, TG1 and TG2 lines were selected from Triet Giang ducks, while TC1 and TC2 lines were selected from TC ducks. It is very necessary and has scientific and practical significance, the creation of commercial duck eggs of TG12 and TC12 with high egg productivity and quality, meeting the current demand on high performance ducks specialized for egg that is very necessary and has scientific and practical significance.

However, these duck lines still have unstable egg productivity,while the potential of egg production is high, therefore, it is necessary to continue selecting and improving egg productivity in next generations. At the same time, the evaluation of the production ability of TG12 and TC12 hybrid ducks needs to be conducted.

For above reasons, we conduct a research on: "The selection for egg productivity improvement of Triet Giang and TC ducks".

2. OBJECTIVES

2.1. Objectives

Selection of 2 egg-specialized duck breeds contains of 4 high performance lines to meet the needs of the farmers and the development of raising egg-specialized ducks in Vietnam.

3. SCIENCETIFIC AND PRACTICAL VALUES

3.1. Sciencetific values

- Sciencetific values: Systematically researching appearance characterizations and productive criteria in order to achieve a scientific data set on 4 duck lines of 2 breeds, which is valuable for future research and training.

3.2. Practical values

Achieved 4 lines of 2 duck breeds specializing in egg production to produce high performance hybrids to serve the production needs for developing egg specialized ducks in Vietnam.

4. RESEARCH SCOPE

TG1, TG2, TC1 and TC2 duck lines and TG12 and TC12 hybrids.

5. NEW CONTRIBUTIONS

- Selecting to improve the egg productivity of 4 duck lines of TG1, TG2 (Triet Giang duck), TC1 and TC2 (TC duck) with uniform appearance characterization, and stable body weight.
- Creating TG12 and TC12 hybrids with high commercial egg productivity.
- Providing a complete set of scientific data on 2 duck breeds including 4 lines and hybrids producing commercial eggs for production and consumption.

Chapter 1. Literature review

Domestic research

Since the 1970s, the selection of waterfowl breeds in Vietnam has been focused, and by 2000-2005 many studies on selective pure breeding of waterfowl breeds have created high performance and quality lines, bringing economic efficiency for farmers.

Co Duck is a domestic duck breed of Vietnam with many different colors and Co Duck "màu cánh sẻ" (Co duck with sparrow-wing colored feather) has been selected by the Dai Xuyen Duck Research Center for egg productivity, with an increase from 258 to 261.4 eggs /hen/ 52 laying weeks, age of first laying at 20-21 weeks, egg weight of 63.7 - 65.8g /egg, and feed consumption for 10 eggs of 2.29 - 2.30kg (according to Nguyen Thi Minh et al., 2008).

The Khaki Campbell Duck is an egg specialized breed originating in the UK, the duck was imported to Vietnam from Thailand in 1990 and was selected at the Dai Xuyen Duck Research Center, the duck had the first laying at the age of 141 - 144 days and at body weight of 1399.0 - 1420.0g /duck, the egg productivity reached 277.4 - 284.2 eggs/ hen /52 laying weeks (Nguyen Hong Vy et al., 2008).

Nguyen Duc Trong et al. (2009) conducted a selection of Triet Giang ducks through 3 generations including the founder generation, the first generation

and the second generation. The study shows that the average reproduction rate of 52 laying weeks was high, from 68.85-71.35%; egg productivity of 251.30 eggs / hen /52 laying weeks in the founder generation has increased to 259.71 in the second generation.

The results from a study of Doan Van Xuan et al. (2005) when selecting through 3 generations on CV 2000 Layer ducks showed that egg productivity was significantly improved. Productivity of CVL1 Duck increased from 247.74 eggs/hen/year in the 1st generation to 258.95 eggs/hen/year in the 3rd generation. And productivity of CVL4 duck increased from 248.38 eggs/hen/year in the 1st generation to 264.84 eggs/female/year in the 3rd generation.

Nguyen Duc Trong et al. (2010) selected PL2 Dom Duck through 3 generations and found that the egg productivity of PL2 Duck eggs increased from 164.63 eggs/hen/52 laying weeks in the first generation to 176.20 eggs/hen/52 laying weeks in the 3rd generation.

Chapter 2. MATERIALS AND METHODS

2.1. MATERIALS

- Triet Giang ducks including TG1 and TG2 lines
- TC duck including 2 TC1, TC2 lines
- TG12 and TC12 hybrids.

2.2. STUDY AREA AND DURATION

- Study area: Dai Xuyen Duck research center.
- Duration: 3/2012 - 12/2017.

2.3. STUDY CONTENTS

2.3.1. Selection of TG1 and TG2 for egg productivity improvement

2.3.2. Selection of TC for egg productivity improvement (TC1 and TC2 lines)

2.3.3. Evaluation of productive capacity of TG12 and TC12 commercial ducks

2.4. STUDY METHOD

Breeding management methods:

- Stage of duckling and young ducks were individually monitored.
- Laying duck was monitored in family, each line includes 24 families and each line was divided into 4 family groups, drakes were rotated in each generation according to family groups to avoid inbreeding.

Selection methods

- Oriented selection of TG1, TG2, TC1 and TC2 ducks were applied using the method of selecting individual duck by body weight, and selecting egg productivity according to the family.
- The selection of TG1 and TG 2 ducks was conducted at the ages of 1 day, 8 weeks and 14 weeks by egg productivity up to 30 laying weeks.
- The selection of TC1 and TC 2 ducks was conducted at the ages of 1 day, 8 weeks and 14 weeks by egg productivity up to 30 laying weeks.
- TC1 and TC2 ducks were selected at the time of first day of age, 8 weeks of age and 16 weeks of age and selected by egg productivity until the end of 30 weeks of laying.
- At the first day of age: selected by coat color for the ducks with yellowish feather and black trace on head and tail. Selection of ducklings based on the pedigree of the previous generation (selecting those from families with average egg productivity or above of the population), application of individual ID tag for selected by body weight.
- At 8 weeks of age: selected by feather color for the individuals with light sparrow- wing colored feathers. Weighed the whole herd to calculate the average value of body weight, then weighed individually for the selection. Selected female duck $Xtb - \delta \leq Xi \leq Xtb + \delta$, selected male $Xtb - \delta \leq Xi \leq Xtb + \delta$, stable body weight of about 750 - 950g/duck for TG1 and TG2 ducks and about 800 - 1000g for TC1 and TC2 ducks; Selected for body weight stability.
- At 14 weeks of age with TG1 and TG2 ducks; At 16 weeks of age with TC1 and TC2 ducks: selected by feather color for the individuals with light sparrow-wing colored feathers. Weighed the whole flock to calculate the average body weight, then weighed individually for the selection. Selected the body weight of male and female duck using the method of stabilizing $Xtb - \delta \leq Xi \leq Xtb + \delta$. Selected body weight of about 1000 - 1150g/ head for TG1, TG2 ducks and 1200 - 1400g/head for TC1, TC2 ducks. Selected ducks from families with an egg productivity was not less than 260 eggs/hen/52 laying weeks.
- Follow up 24 families in the reproductive period. Each family includes 1 drake/7 hens and 1 waiting drake. The number of male ducks were selected 50 - 55% and selective female ducks of 55 - 60% compared with one day old ducks.

The average egg productivity of each family was monitored for at least 30 weeks of laying. Selection for replacement for the next generation from families with average egg productivity higher than the average of the whole flock, some families were born and some families were lost from culled in the family and the rotation of males was implemented according to the family group.

2.5. DATA ANALYSIS

The obtained data were compared between experience groups by variance analysis, the average values were compared using the comparison of Turkey, the ratios were compared using the comparison of $\chi 2$, genetic heritability was calculated according to the variance analysis using Minitab software 18.

Chapter 3. Results and Discussions

3.1. Selection for productivity improvement of TG1 Duck

3.1.1. Appearance features of TG1 Duck

Ducklings:

Feather color: yellowish with black spots at the head and tail.

Beak and feet: yellowish, might be grey or grey-black.

Mature ducks (33 weeks old):

A hen has light sparrow- wing colored feather, a drake has grey or blue-black colour on head, white section on neck, and brown red combined with white feather on body, and blue-black tail with 2 - 3 curved feathers.

Head, neck: Small head, slim and very long neck

Body: Very thin and small, standing posture perpendicular to the ground.

Beak and feet: yellow or yellowish or might be greyish.

3.1.2. Body-size measurements of TG1 Duck:

The ratio of breast/ body length of TG1 duck after each generation reaches about 1.05- 1.10 in drake and 1.21 – 1.22 in hen. This ratio of breast and body length shows clearly that this is a duck line specialized for egg.

3.1.3. Survival rate of TG1 duck at duckling and young hen period.

The survival rate of TG1 Duck after 4 generations is high. In the first 8 weeks, the rate is 97- 98.25%; and in the first 16 weeks, the rate is 96.72 –

98%. This rate is higher than that of Triet Giang Duck of 94.74% and lower than Grass duck of 98.95%.

3.1.4. Body weights at different weeks of age

Table 3.1: Body weight of TG1 Duck at different weeks of age (g/ duck)

Age in week	Generation 1		Generation 2		Generation 3		Generation 4	
	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
1nt	30.35^{a} ±0.85	29.85^{x} ±0.77	31.00^{a} ±0.77	30.23^{x} ±0.82	29.98^{a} ±1.05	28.53^{x} ±0.94	28.22^{a} ±0.77	28.28^{x} ±0.89
4	431.30^{a} ±3.14	438.72^{x} ±3.36	432.58^{a} ±4.16	429.93^{x} ±3.62	430.07^{a} ±2.93	428.80^{x} ±2.88	429.43^{a} ±2.88	428.78^{x} ±3.04
8	825.97^{a} ±8.24	807.30^{x} ±8.47	826.23^{a} ±8.40	808.23^{x} ±9.49	821.25^{a} ±7.04	806.28^{x} ±9.33	824.72^{a} ±7.09	810.78^{x} ±6.47
12	949.52^{a} ±18.16	934.82^{x} ±17.16	945.97 ±14.97	942.42^{x} ±14.59	945.22^{a} ±12.45	942.20^{x} ±10.70	956.15^{a} ±12.93	944.93^{x} ±9.58
14	984.35^{a} ±21.11	988.98^{x} ±19.58	996.22^{a} ±24.16	982.53^{x} ±22.65	993.15^{a} ±24.72	985.28^{x} ±20.40	987.13^{a} ±18.57	974.85^{x} ±19.36
16	1034.85^{a} ±20.79	996.90^{x} ±25.26	1033.95^{a} ±38.84	993.47^{x} ±34.49	1039.10^{a} ±24.56	998.80^{x} ±29.98	1037.98^{a} ±20.38	997.65^{x} ±26.08

Notes: Values in a row and by sex, with different letters are significantly different at P< 0.05.

Table 3.1 shows that: The body weight of TG1 Duck at the age of 8 weeks is 821.25 – 826.23 g/head for drake and 806.28 – 810.78 g/head for hen.

3.1.5. Reproductive productivity of TG1 Duck after 4 generations:

Table 3.2: Some reproductive performances of TG1 Duck over 4 generations

Performance	Unit	G1	G2	G3	G4
Age at first laying	Week	17	16	16	16
Weight at first laying	g	1112.34^{a}	1107.17^{b}	1115.42^{b}	1103.67^{b}
Average reproduction rate	%	71.35	71.69	72.17	72.48

Egg productivity/hen/52 laying weeks	eggs	259.71	260.94	262.69	263.81
Feed consumption/10 eggs	kg	2.19	2.19	2.18	2.18

3.1.6. Selection efficiency, Selection rates, Selection differential for egg productivity of TG1 Duck over generations

Generation	Indicator	TG1
1	Number of hens in the beginning of the term (hen)	168
		67
	Selection rates (%)	39.88
	Number of selected hens for producing next generations (hen)	151.33
	Egg productivity /selected hens/30 laying weeks (egg/hen)	163.18
	Selection differential (S, egg)	11.85
2	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	65
	Selection rates (%)	38.69
	Selection efficiency (R, egg)	2.18
	Egg productivity /all hens in flock/30 laying weeks (egg/hen)	153.47
	Egg productivity /selected hens/30 laying weeks (egg/hen)	164.38
	Selection differential (S, egg)	10.91
	Heritability h2	0.2
3	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	63
	Selection rates (%)	37.50
	Selection efficiency (R, egg)	2.24
	Egg productivity /all hens in flock/30 laying weeks (egg/hen)	155.68
	Egg productivity /selected hens/30 laying weeks (egg/hen)	165.87
	Selection differential (S, egg)	10.19
	Heritability h2	0.22
4	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	61
	Selection rates (%)	36.31
	Selection efficiency (R, egg)	2.16
	Egg productivity /all hens in flock/30 laying weeks (egg/hen)	156.72
	Egg productivity /selected hens/30 laying weeks (egg/hen)	166.53
	Selection differential (S, egg)	9.81
	Heritability h2	0.22

Average egg productivity of selected hens in 30 weeks of laying increases. Heritability is low from 0.20 – 0.22. Selection efficiency is 2.16 – 2.24. Egg productivity increases over generations, reaches 163.18 – 166.53 eggs/30 laying weeks.

3.1.7. Some data on eggs quality

Egg weight of TG1 duck over generations reaches 59.93 – 61.46g, morphological index is 1.40 -1.41, the rate of yolk is 32.57% - 34.89%; Haugh unit reaches 90.90 – 91.83. Eggshell is 0.32 – 0.34 cm thick. TG1 duck egg meets requirements for breeding egg.

3.1.8. Some data on hatching

TG1 duck has high rate of eggs with embryo, more than 96.74 – 98.78%, hatching rate/ total incubated eggs is 85.52 – 86.19%, hatching rate/ total eggs with embryo is 87.25 – 88.40%.

3.2. Selection for productivity improvement of TG2 Duck

3.2.1. Appearance characteristics of TG2 Duck

Ducklings:

Feather color: light yellow with black spots at the head and tail.

Beak and feet: Light yellow, or might be slightly grey, grey-black.

Mature ducks (33 weeks old):

Hens have lighter sparrow wing colored feather compared to TG1, 2 – 4% of them are pure white, drakes have grey or blue – black feathers on head, partially white neck, body with brown-red and white feathers combined, tail with blue-black feathers and 2 -3 highly curved feathers.

Head, neck: Small head, slim and long neck

Body: Very thin, standing posture perpendicular to the ground.

Beak and feet: light yellow, some have light grey, grey-black

TG2 Duck has stable feather color after 4 generations, and lighter sparrow wing colored feather compared to TG1 Duck

3.2.2. Size and body measurements of TG2 Duck:

TG2 Duck has 7.97 – 8.53 cm breast length in drake and 7.54 – 8.69 cm in hen. Length of wing feather is 8.65 – 11.36cm in drake and 9.12 – 12.05 cm in hen. The ratio of breast and body length of TG2 duck over generations is

1.05 – 1.08 in drake and 1.21 – 1.24 in hen. In the case of Triet Giang duck, it is 1.1 in drake and 1.21 – 1.24 in hen. (Nguyen Duc Trong, 2009).

3.2.3. Survival rate of TG2 duck in duckling period and young hen.

The survival rate of TG2 Duck after 4 generations is high. In the first 8 weeks, the rate is 97- 98%; and in the first 16 weeks, the rate is 96.5 – 97.42%. This rate is higher than that of Triet Giang Duck with 94.74% and lower than Grass duck with 98.95%.

3.2.4. Body weights at different weeks of age

Table 3.4: Body weight of TG2 Duck at different weeks of age (gram/ duck)

Week age	G1 (Mean ±SE)		G2 (Mean ±SE)		G3 (Mean ±SE)		G4 (Mean ±SE)	
	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)
1nt	30.32^{a} ±0.85	30.18^{x} ±0.73	31.23^{a} ±1.13	30.42^{x} ±0.73	30.22^{a} ±0.77	29.68^{x} ±0.96	31.15^{a} ±0.75	30.09^{x} ±1.10
4	432.06^{a} ±8.70	431.12^{x} ±6.16	433.89^{a} ±11.13	431.23^{x} ±4.85	440.12^{a} ±6.16	439.19^{x} ±8.17	445.63^{a} ±11.17	435.81^{x} ±7.79
8	825.17^{a} ±18.52	819.03^{x} ±14.36	827.65^{a} ±16.00	826.15^{x} ±16.00	834.33^{a} ±16.95	831.26^{x} ±15.79	846.23^{a} ±15.90	836.72^{x} ±21.49
12	951.22^{a} ±22.23	943.16^{x} ±13.88	951.18^{a} ±23.32	949.74^{x} ±20.37	961.78^{a} ±15.67	959.72^{x} ±16.83	967.29^{a} ±18.03	952.22^{x} ±19.33
14	998.87^{a} ±18.89	975.09^{x} ±21.24	990.53^{a} ±22.42	980.80^{x} ±15.52	986.02^{a} ±15.57	990.08^{x} ±14.10	985.23^{a} ±14.97	976.12^{x} ±18.40
16	1041.29^{a} ±16.07	1021.11^{x} ±21.33	1033.52^{a} ±23.56	993.36^{y} ±14.11	1056.27^{a} ±24.29	1038.89^{x} ±18.40	1067.43^{a} ±17.68	1041.16^{x} ±16.39

Notes: Values in a row and by sex, with different letters are significantly different at P< 0.05.

3.2.5. Reproductive performance of TG2 Duck after 4 generations:

Table 3.5: Some productive performance of TG2 Duck after 4 generations

Performance	Unit	**G1**	**G2**	**G3**	**G4**
Age at first laying	Week	17	17	17	17
Weight at first laying	g	1128.04	1115.67	1152.52	1123.7
Average reproduction rate	%	66.88	67.32	69.76	69.91
Egg productivity/hen/52 laying weeks	eggs	252.54^{b}	253.16^{b}	255.89^{ab}	256.59^{a}

Feed consumption/10 eggs	kg	2.01	2.00	2.19	2.19

Table 3.5 shows that TG2 Duck has the first laying age of 17 weeks, weight at first laying weight varies from 1115.7 – 1152.52 kg/hen. Average reproduction rate is 66.88 – 69.91%. Egg productivity rises over selected generations, reaches its peak in generation 4: 256.59 egg/hen/52 laying weeks. Feed consumption/ 10 eggs varies from 2.0 – 2.19kg. The first laying age of TG2 duck is 17 weeks. Egg productivity of TG2 far exceeds the hybrid of Khakhi Capell and White Grass Ducks.

3.2.6. Selection efficiency, Selection rates, Selection differential for egg productivity of TG2 Duck over generations

Table 3.6: Selection efficiency for egg productivity of TG1 Duck

Generation	Performance	TG2
1	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	79
	Selection rates (%)	47.02
	Egg productivity /all hens/30 laying weeks (egg/hen)	146.50
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	157.86
	Selection differential (S, egg)	11.36
2	Number of hens in the beginning of the term	168
	Number of hens selected to reproduce the next generation	75
	Selection rates (%)	44.64
	Selection efficiency (R, egg)	147.38
	Egg productivity /all hens/30 laying weeks (egg/hen)	158.20
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	10.82
	Selection differential (S, egg)	0.19
	Heritability h2	2.06
3	Number of hens in the beginning of the term	168
	Number of hens selected to reproduce the next generation	73

	Selection rates (%)	43.45
	Egg productivity /all hens/30 laying weeks (egg/hen)	148.19
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	157.72
	Selection differential (S, egg) egg)	9.53
	Heritability h2	0.22
	Selection efficiency (R,	2.10
4	Number of hens in the beginning of the term	168
	Number of hens selected to reproduce the next generation	71
	Selection rates (%)	42.26
	Egg productivity /all hens/30 laying weeks (egg/hen)	149.58
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	158.80
	Selection differential (S, egg) egg)	9.22
	Heritability h2	0.21

Average egg productivity/ selected hen/30 laying weeks rises (generation1is 157.86 eggs; generation 2 is 158.20 eggs and generation 4 is 158.80 eggs) Selection differential is 0.19 – 0.21. Selection efficiency varies from 1.94 to 2.11 eggs. Egg productivity over generations reaches 146.50 in generation 1, and 149.58 eggs/ 30 laying weeks in generation 4.

3.2.7. Some data on eggs quality

Egg weight of TG2 duck over generation reaches 60.35 – 61.52g, morphological index is 1.40 -1.41, the rate of yolk is 32.70% - 34.6%; Haugh unit reaches 90.89 – 92.05. Eggshell is 0.33 – 0.34 cm thick. TG2 duck egg meets requirements for breeding egg.

3.2.8. Some data on hatching

TG2 duck has eggs with high embryo rates, from 95.48 – 96.38%, hatching rate/ total incubated eggs is 84.90 – 86.05%, hatching rate/ total eggs with embryo is 88.93 – 89.29%.

3.3. Selection for improving productivity of TC1 Duck

3.3.1. Appearance features of TC1 Duck

Ducklings:

Feather color: light yellow with black spots at the head and tail.

Beak and foot: Light yellow, some are greyish.

Mature ducks (33 weeks old):

Hens have light sparrow wing colored feather, drake has grey head (accounting for 8,23%) or blue-black head (occupying 91,77%), partially white neck, body with brown-red and some white feathers, tail with blue-black feathers and 2 -3 highly curved feathers.

Head, neck: Small head, slim and long neck

Body: Very thin, standing posture is at the angle of more than 45 degree to the ground

Beak and foot: light yellow, some have light grey

3.3.2. Some measurements of body size of TC1 Duck:

TC1 Duck has breast length of 8.40 – 8.75 cm in drake and 9.00 – 9.12 cm in hen. Length of wing feather is 7.14 – 7.50cm in drake and 10.05 – 10.94 cm in hen. The ratio of breast and body length of TC1 duck after generations is 1.11 – 1.13 in drake and 1.21 – 1.24 in hen. In the case of Triet Giang duck, it is 1.1 in drake and 1.21 – 1.24 in hen.

3.3.3. Survival rate of TC1 duck in period of duckling and young hen.

The survival rate of TC1 Duck after 4 generations is high. In the first 8 weeks, the rate is 98.13- 98.93%; and in the first 16 weeks, the rate is 95.73 – 96.53%. This rate is higher than that of Triet Giang Duck with 94.74% and lower than Grass duck with 98.95% (Nguyen Duc Trong 2011).

3.3.4. Body weight at different weeks of age

Table 3.7: Body weight of TC1 Duck at different weeks of age (gram/ duck)

Age week	Generation 1		Generation 2		Generation 3		Generation 4	
	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)	Drake (n = 30)	Hen (n = 30)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
1nt	40.28^{a} ± 0.67	40.82^{x} ± 0.81	40.31^{a} ± 0.55	40.75^{x} ± 0.49	40.67^{a} ± 0.60	40.91^{x} ± 0.71	40.85^{a} ± 0.83	40.63^{x} ± 0.65
4	490.07^{a}	475.75^{x}	489.52^{a}	467.91^{x}	492.65^{a}	472.52^{x}	494.26^{a}	475.26^{x}

	±8.57	±9.25	±8.67	±8.75	±7.57	±8.26	±8.43	±8.39
8	925.78^{a} ±9.62	905.25^{x} ±9.69	915.14^{a} ±9.97	907.26^{x} ±9.67	925.34^{a} ±9.85	915.19^{x} ±10.57	935.25^{a} ±9.59	920.15^{x} ±9.55
12	1113.93^{a} ±10.50	1029.25^{x} ±11.20	1162.63^{a} ±11.58	1090.12^{x} ±11.52	1165.14^{a} ±10.86	1087.20^{x} ±10.88	1175.99^{a} ±11.24	1103.69^{x} ±11.40
16	1285.00^{a} ±10.94	1235.00^{x} ±12.21	1212.90^{a} ±12.36	1200.00^{x} ±10.96	1252.40^{a} ±12.37	1210.10^{x} ±11.61	1268.57^{a} ±10.85	1225.50^{x} ±11.49

Notes: Values in a row and by sex, with different letters are significantly different at P< 0.05.

Table 3.7 shows that body weight of TC1 Duck at the age of 8 weeks ranges from 915.14 – 935.25 g/head in drake and 905.25 – 920.15 g/head in hen. Body weight of TC1 Duck at the age of 16 weeks is 1212.9 – 1285 g/head in drake and 1200 – 1235 g/one in hen. The results show that the body weight of TC1 Duck at the age of 8 weeks is higher than that of Triet Giang (827.10 g/head in drake and 809.30g/head in hen) (Nguyen Duc Trong 2009).

3.3.5. Reproductive performance of TC1 Duck over 4 generations:

Table 3.8: Some data on productivity of TG2 Duck over 4 generations

Parameters	Unit	**Gen 1**	**Gen 2**	**Gen 3**	**Gen 4**
First laying age	Week	17	17	17	17
Weight at first laying	g	1244.92	1229.80	1290.15	1275.67
Average reproduction rate	%	78.06	78.37	78.73	78.94
Egg productivity /hen/52 laying weeks	eggs	284.13	285.28	286.56	287.52
Feed consumption/10 eggs	kg	2.15	2.12	2.13	2.11

Data on table 3.8 show that TC1 Duck has the first laying age of 17, weight at first laying varies from 1229.8 – 1290.15 kg/one. Average reproduction rate is 78.06 – 78,94%. Egg productivity rises over selected generations, reaches its peak in generation 4: 287.52 egg/hen/52 laying weeks. Feed consumption/ 10 eggs varies from 2.0 – 2.19kg.

3.3.6. Selection efficiency, Selection rates, Selection differential for egg productivity of TC1 Duck over generations

Table 3.9: Selection efficiency for egg productivity of TC1 Duck

Generation	Target	TC1
1	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	70
	Selection rates (%)	41.60
	Egg productivity /all hens/30 laying weeks (egg/hen)	159.22
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	170.35
	Selection differential (S, egg)	11.13
	Heritability h2	0.21
	Selection efficiency (R, egg)	2.34
2	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	63
	Selection rates (%)	37.50
	Egg productivity /all hens/30 laying weeks (egg/hen)	161.21
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	171.47
	Selection differential (S, egg)	10.26
	Heritability h2	0.19
	Selection efficiency (R, egg)	1.95
3	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	63
	Selection rates (%)	37.50
	Egg productivity /all hens/30 laying weeks (egg/hen)	163.25
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	172.50
	Selection differential (S, egg)	9.25
	Heritability h2	0.19
	Selection efficiency (R, egg)	1.76
4	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	60
	Selection rates (%)	35.71
	Egg productivity /all hens/30 laying weeks (egg/hen)	164.08
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	173.20

	Selection differential (S, egg)	9.12
	Heritability h2	0.19
	Selection efficiency (R, egg)	1.73

Average egg productivity of selected hen/30 laying weeks rises (generation 1 is 170.35 eggs; generation 2 is 172.5 eggs and with generation 4 is 173.2 eggs).

Selection differential is 0.19 – 0.21. Selection efficiency varies from 1.73 to 2.34 eggs. Egg spawning productivity after generations reaches 170.35 – 173.20 eggs/30 laying weeks

3.3.7. Some data on eggs quality

Egg weight of TC1 duck over generations reaches 65.29 – 65.89g, morphological index is from 1.40 to 1.41; The percentage of yolks reached 44.50 – 33.78%.; Haugh unit reaches 91.17 – 91.56. Eggshell is 0.33 – 0.34 cm thick. TC1 duck egg meets requirements for breeding egg.

3.3.8. Some data on hatching

TC1 duck has eggs with high embryo rates, more than 96.5 – 96.8%, hatching rate/ total incubated eggs is 86.6 – 88.63%, hatching rate/ total eggs with embryo is 89.74 – 91.72%.

3.4. Selection for improving productivity of TC2 Duck

3.4.1. Appearance features of TC2 Duck

Ducklings:

Feather color: light yellow with black spots at the head and tail.

Beak and foot: Light yellow, some are slightly grey and grey-black.

Mature ducks (33 weeks old):

Hens have light sparrow-wing colored feather, drakes have grey head (accounting for 10.25%) or blue-black head (occupying 89.75%), partially white neck, body with brown-red and some white feathers, tail with blue-black feathers and 2 -3 highly curved feathers.

Head, neck: Small head, slim and long neck

Body: Very thin, standing posture is at the angle of more than 45 degree to the ground

Beak and foot: yellow and yellowish, some have light grey

3.4.2. Some measurements of body size of TC2 Duck:

The ratio of breast and body length of TC2 duck after generations is 1.13 – 1.15 in drake and 1.22 – 1.25 in hen. In the case of Triet Giang duck, it is 1.1 in drake and 1.21 in hen. (Nguyen Duc Trong et al, 2009).

3.4.3. Survival rate of TC2 duck in the period of duckling and young hen.

The survival rate of TC2 Duck after 4 generations is high. In the first 8 weeks, the rate is 98.13- 98.93%; and in the first 16 weeks, the rate is 96.27 – 97.07%. This rate is higher than that of Triet Giang Duck with 94.74% and lower than Grass duck with 98.95% (Nguyen Duc Trong 2011) and lower than that of Khakhi Cambell Duck 97.54% (Nguyen Hong Vi 2007)

3.4.4. Body weight at different weeks of age

Table 3.10: Body weight of TC1 Duck at different weeks of age (gram/ duck)

Age (week)	**Gen1 (Mean ±SE)**		**Gen2 (Mean ±SE)**		**Gen3 (Mean ±SE)**		**Gen4 (Mean ±SE)**	
	Drake (n=30)	Hen (n=30)	Drake (n=30)	Hen (n=30)	Drake (n=30)	Hen (n=30)	Drake (n=30)	Hen (n=30)
1nt	40.67	40.90	40.32	40.59	40.71	40.19	40.53	40.38
4	492.70 ±9.15	471.57 ±9.12	490.45 ±8.86	465.51 ±8.97	491.61 ±7.85	482.25 ±8.96	496.42 ±8.54	476.52 ±8.63
8	955.17 ±9.22	916.35 ±9.56	934.51 ±9.49	912.72 ±9.36	935.4 ±9.48	927.68 ±10.75	955.32 ±9.15	925.01 ±9.65
12	1122.29 ±10.25	1054.34 ±11.02	1126.30 ±11.35	1087.90 ±11.26	1175.21 ±10.48	1072.82 ±10.78	1199.75 ±11.22	1163.09 ±11.14
16	1279.00 ±10.52	1241.5 ±12.71	1240.11 ±12.53	1201.24 ±10.46	1244.34 ±12.33	1211.01 ±11.16	1267.85 ±10.37	1235.25 ±11.64

Table 3.10 shows that body weight of TC2 Duck at the age of 8 weeks old ranges from 934.51 – 955.32 g/head in drake and 912.72 – 925.01 g/head in hen. Body weight of TC2 Duck at the age of 16 weeks old is 1240.11 – 1279 g/head in drake and 1201.24 – 1241.5 g/head in hen.

3.4.5. Reproduction productivity of TC2 Duck over 4 generations:

Table 3.11: Some productivity performances of TG2 Duck over 4 generations

Parameter	Unit	**Gen1**	**Gen2**	**Gen3**	**Gen4**
First laying age	Week	18	18	18	18
Weight at first laying age	g	1275.25	1283.60	1269.27	1265.88
Average reproduction rate	%	76.26	76.43	76.68	77.22
Egg productivity/hen/52 laying weeks	eggs	277.60	278.20	279.70	281.10
Feeding consumption/10 eggs	kg	2.20	2.19	2.17	2.16

Results in table 3.11 show that TC2 Duck has the first laying age of 18 weeks, weight at first laying varies from 1265.88 – 1283.60 kg/one. Average laying rate is 76.26 – 77.22%. Egg productivity rise over selected generations, reaches its peak in generation 4: 281.1 egg/hen/52 laying weeks. Food consumption/ 10 eggs varies from 2.16 – 2.2kg.

3.4.6. Selection efficiency, Selection rates, Selection differential for egg productivity of TC2 Duck over generations

Table 3.12: Selection efficiency for eff productivity of TC2 Duck

Generation	**Target**	**TC2**
1	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	70
	Selection rates (%)	41.60
	Egg productivity /all hens/30 laying weeks (egg/hen)	153.93
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	165.38
	Selection differential (S, egg)	11.45
	Heritability h2	0.21
	Selection efficiency (R, egg)	2.40

2	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	63
	Selection rates (%)	37.50
	Egg productivity /all hens/30 laying weeks (egg/hen)	155.30
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	166.30
	Selection differential (S, egg)	11.00
	Heritability h2	0.20
	Selection efficiency (R, egg)	2.20
3	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	63
	Selection rates (%)	37.50
	Egg productivity /all hens/30 laying weeks (egg/hen)	156.65
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	167.27
	Selection differential (S, egg)	10.62
	Heritability h2	0.20
	Selection efficiency (R, egg)	2.12
4	Number of hens in the beginning of the term	168
	Number of selected hens for producing next generations (hen)	62
	Selection rates (%)	36.90
	Egg productivity /all hens/30 laying weeks (egg/hen)	159.03
	Egg productivity /Selected hens/30 laying weeks (egg/hen)	168.10
	Selection differential (S, egg)	9.07
	Heritability h2	0.20
	Selection efficiency (R, egg)	1.84

Average egg productivity of selected hen/30 laying weeks rises (generation 1 is 165.38 eggs; generation 2 is 166.,27 eggs and generation 4, is 168.1 eggs). Selection differential is 0.2 – 0.21. Selection efficiency varies from 1.84 to 2.40 eggs.

3.4.7. Some data on eggs quality

Egg weight of TC2 duck after 4 generations reaches 66.09 – 66.21g, morphological index is 1.40 -1.41, the rate of yolk is 33.87% - 34.76%;

Haugh unit reaches 90.78 – 91.66. Eggshell is 0.33 – 0.,34 cm thick. Egg of TC2 duck meets requirements for breeding egg.

3.4.8. Some data on hatching

TC2 duck has eggs with high embryo rates, more than 96.9 – 97.12%, hatching rate/ total incubated eggs is 87.5 – 88.5%, hatching rate/ total eggs with embryo is 90.02 – 91.12%.

3.5. Production performance of TG12 ducks

3.5.1. Body weight

Table 3.13. Body weight of TG12 Duck at different weeks of age (gram/ duck)

Age (Week)	n	Mean ± SE	SE
1 day old	30	30.26	0.33
4	30	412.61	7.15
8	30	995.15	9.28
12	30	1096.53	10.42
16	30	1185.27	11.05

The results from the above table show that the body weight of TG12 hen at week 8 is 995.15g/head. At the 16th week, TG12 hen has the body weight of 1185.272 g/head. It means that the body weight of TG1 duck rises over periods and in accordance with common growth rate of poultry as well as with the guidance in duck raising procedure at Dai Xuyen Duck Research Center. This weight is also like TC12 Duck in this research. Low SE means the ducks are similar sizes.

3.5.2. Egg productivity, reproduction rate and feed consumption/10 eggs

Table 3.14. Reproduction performance of TG12 duck

Performance	**Unit**	**Result**
Laying age	Week	16
Laying weight	g/each	1238.21
Average laying rate	%	72.37
Egg productivity/hen/52 laying weeks	egg	264.95
Feed consumption/ 10 eggs	kg	2.12

The results from the above table show that TG12 duck has laying weight of 1238.21 and the laying rate is 72.37%; Egg productivity/hen/52 laying weeks is 264.95 eggs/hen. Feed consumption/10 eggs is 2.12kg. The egg productivity is lower than that of TC12, but feed consumption/10 eggs is equivalent, it means that ducks have good feed conversion rates. Comparing to TG1 and TG2 ducks, T12 duck has higher productivity and laying weight, this illustrates the heretosis of 2 lines.

3.5.3. Some data on eggs quality

Table 3.15: ***Some data on eggs quality of TG12 duck***

Parameter	Unit	n	Mean	SE
Egg weight	g	30	60.38	0.77
Morphological index		30	1.41	0.01
Egg yolk rate	%		34.08	
Egg yolk index		30	0.44	0.004
Albumen rate	%		54.36	
Albumen index		30	0.11	0.003
Egg-shell ratio	%		11.56	
Haugh Unit		30	91.12	0.81
Average egg-shell thickness	mm	30	0.34	0.038
Yolk colour		30	12.53	0.12

The result shows that the average egg weight of TG12 duck is 60.38g. The morphological index is 1.41, the yolk rate is 34.08%, Haugh unit is 91.12. Egg-shell thickness is 0.34cm. The egg meets the standard of good eggs.

3.6. Production performance of TC12 duck

3.6.1. Body weight

Table 3.16: Body weight of TC12 Duck at different weeks of age (gram/ duck)

Age (week)	n	Mean	SE
1 day old	30	40.58	0.45
4	30	465.23	8.23
8	30	958.56	9.76
12	30	1169.52	10.23

16	30	1267.42	11.02

The results from the above table shows that the body weight of TG12 hen at week 8 is 958.56g/head. At the 16th week, TG12 hen has the body weight of 1267.42 g/head.

3.6.2. Egg productivity, laying rate and feed consumption/10 eggs

Table 3.17: Egg productivity, laying rate and feed consumption/10 eggs of TG12 duck

Target	Unit	Mean±SE
Laying age	Week	17
Laying weight	g/hen	1293,48±10,34
Average laying rate	%	79,54
Egg productivity/hen/52 laying weeks	Egg	289,56
Feed consumption/ 10 eggs	kg	2,11

The results from the above table show that TC12 Duck has laying weight of 1293.48g, laying rate is 79.54%; the egg productivity/hen/52 laying weeks is 289.56 eggs/hen. Feed consumption/10 eggs is 2.11kg.

3.6.3. Some data on egg quality

The average egg weight of TC12 duck is 67.65g. The morphological index is 1.41; Egg yolk rate is 34.76%, Haugh unit is 91.66. Eggshell thickness is 0.34 cm. The egg meets the standard of good eggs.

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion

1.1. Selection for improving egg productivity of two duck lines TG1 and TG2 (Triet Giang duck breed) over 4 generations shows that:

TG1 and TG2 duck lines both have identical uniform appearance features of the duck line specialized for eggs after 4 generations, in which:

- TG1 duck line has laying weight at week 17 of 1103.67 – 1115.42 g/hen; egg productivity is 263.81/hen/52 laying weeks; feed consumption/10 eggs is 2.18kg; egg weight is 61.23 g/egg; egg with embryo rate is 98.78% and the hatching rate/ total incubated eggs is 86.19%. After 4 selected generations, the egg productivity rises by 4.1 eggs while the hen still maintains stable weight.

- TG2 duck line has corresponding results: 1115.67 – 1152.52 g/duck, 256.59 eggs/hen/52 laying weeks; 2.19kg; 61.52 g/egg, 96.05% and 85.76%. After 4 selected generation, egg productivity rises by 4.05 eggs while the hen still maintains stable weight.

1.2. Selection for improving egg productivity of TC1 and TC2 duck lines over 4 generations shows that:

TC1 and TC2 duck lines have identical uniform appearance features of the duck line specialized for eggs after 4 generations, in which:

- TC1 duck line has laying weight at week 17 of 1275.67 g/hen; egg productivity is 287.52/hen/52 laying weeks; feed consumption/10 eggs is 2.11kg; egg weight is 65.72 g/egg; egg with embryo rate is 96,63% and the hatching rate/ total incubated eggs is 88.63%. After 4 selected generations, egg productivity rises by 3.39 eggs while the hen still maintains stable weight.

- TC2 duck line has corresponding results: The laying age of 18 weeks 1265.88 g/hen, 256.59 eggs/hen/52 laying weeks; 2.16kg; 66.17 g/egg, 97% and 87.57%.

After 4 selected generation, egg productivity rises by 3.5 eggs while the hen still maintains stable weight.

1.3. Reproduction performance of 2 hybrid pairs between two lines of two breeds

- TG12 duck has the first laying age of 16 weeks, egg productivity/hen/52 laying weeks is 264.95 eggs; feed consumption/10 eggs ; the egg weight is 60.38g and egg-yolk rate is 34.08%.
- TC12 duck has the first laying age of 17 weeks, egg productivity/hen/52 laying weeks is 289.56 eggs; feed consumption/10 eggs ; the egg weight is 67.30g and egg-yolk rate is 34.76%.

The research results of the thesis on the selection for improving egg productivity of 4 duck lines TG1, TG2, TC1 and TC2 have made a new contribution to the field of breeding on improving egg production of 2 egg-specialized duck lines. Simultaneously, the results of research about selection to improve egg productivity of 4 duck lines TG1, TG2, TC1 and TC2 improve the productivity but also keep other criteria highly identical and stable after selected generations. Especially, we have made observation of hybrid ducks TG12 and TC12 and found that they have high productivity and quality, completely able to cater for the current need of raising poultry duck. TC1 and TC2 currently are the most productive duck species in the world. TC1 và TC2 là những dòng vịt có năng suất trứng cao nhất thế giới hiện nay.

From the results of research on selective improvement of egg yield of 4 duck lines TG1, TG2, TC1, TC2 of the thesis has made a new contribution to the field of breeding in improving egg production of 2 egg-specialized duck lines. At the same time, they confirmed that the selection for the egg productivity improvement from the egg specialized duck lines TG1, TG2, TC1 and TC2 still keeps other indicators in highly homogeneous and stable over selected

generations. In particular, the commercial duck TG12 and TC12 were monitored with high egg productivity and quality, completely meeting the current development demand for egg-oriented duck production. TC1 and TC2 are the duck lines with the highest egg productivity in the world today.

2. Recommendation

Recognition of the result of this thesis and continuation of maintaining 4 duck lines TG1, TG2, TC1 and TC2 to provide breeding egg-specialized ducks with high egg productivity for commercial production.