MINISTRY OF EDUCATION AND TRAINING

MINISTRY OF AGRICULTURE AND ENVIRONMENT

INSTITUTE OF ANIMAL SCIENCE

NGUYEN TRONG THIEN

RESEARCH ON SELECTING AND CREATING TWO COLOURFUL CHICKEN LINES: HTP AND RTN

Industry: Animal Husbandry
Code: 9620105

DOCTORAL THESIS SUMMARY

HANOI – 2025

The thesis is completed at NIAS

Supervisors:

1. Dr. Phung Duc Tien
2. Associate Professor. Pham Doan Lan

Reviewer 1: PGS.TS. Tran Hue Vien

Reviewer 2: PGS.TS. Nguyen Hoang Thinh

Reviewer 3: TS. Pham Cong Thieu

The thesis will be defended at the Institute-level doctoral thesis evaluation council, organised at NIAS on day month 2025 year

The thesis can be found at:

- The national library
- The NIAS library

INTRODUCTION

1. Urgency of the topic

To meet the needs of breeders and consumers for colored chicken breeds, it is necessary to select and create new lines that possess delicious meat quality, good disease resistance, and better productivity compared to native chicken breeds and free-range colored chicken breeds. This will thereby improve economic efficiency for breeders and proactively breed high-quality colored chicken breeds in the country. From that issue, the topic "Research on selection and breeding of two colored chicken lines HTP and RTN" was implemented.

The average body weight at 20 weeks old of Ho shows that males are 2165g and females are 1748g;

Egg yield/birn/68 weeks old was 67.64 eggs (Ho Xuan Tung et al., 2011). Ri chicken, body weight at 20 weeks old of a male was 1757-1858.83g while a female was 1241.83- 1353g; egg yield/68 weeks old was 148.72-158.02 eggs (Nguyen Quy Khiem et al., 2021). These two native chickens have delicious meat quality, good adaptability to climatic conditions in different ecological regions, however, productivity is still limited, and long-term rearing time leads to high product cost.

TP chickens have an egg yield/female/68 weeks old of 179.78-182.68 eggs; the weight of broiler at 9 weeks old was 2.39-2.41 kg (Phung Duc Tien et al., 2017). TN chickens have an egg yield/female/ 68 weeks old of 180.46-185.12 eggs, the weight of broiler at 8 weeks old was 2.27-2.34 kg (Pham Thuy Linh et al., 2020). These chicken lines are gene sources to produce heterosis and create different crossbreeding formulas to improve the productivity of native chickens.

The combination of these genetic resources is expected to create two new colored chicken lines to add to the high-quality chicken breeds in production.

1. Objectives of the topic

Successfully select and create two colored chicken lines (father and mother lines) from native chickens and high-yield colored chickens

HTP father line (¾Hồ, ¼TP) is selected aiming to improve body weight.

RTN mother line (¾Ri, ¼TN) is selected, aiming to improve egg production.

Evaluation of the broilers crossing between HTP and RTN chickens.

2. New contributions of the thesis

The thesis used the combined selection method, including phenotype value and breeding value, to create two new colored feather chicken lines with high productivity and meat quality. The father line owns 75% Ho chicken genes and 25% TP chicken genes; the mother line possesses 75% Ri chicken genes and 25% TN chicken genes towards egg productivity. From the two selected chicken lines, broilers were produced owning genes of 4 chicken breeds (Ho, Ri, TN, TP).

Scientific and practical significance

Scientific significance

The thesis is a systematic scientific research work, providing a scientific basis for selecting and creating high-quality and productive colored chicken lines from native chicken genes combined with high-productivity colored chickens, contributing to enriching the poultry gene pool in Vietnam.

The thesis uses the BLUP method in genetic evaluation to improve the accuracy of selection.

The research results are an important foundation for further research to improve productivity and meat quality of colored chicken breeds/lines.

The results of the thesis are also valuable reference materials in research, teaching and learning at training facilities and poultry breeding facilities.

Practical significance

Providing livestock production with two parent lines of colored-feather chickens with high productivity, while meat quality is equivalent to native chickens. These new lines are suitable for different farming methods and ecological regions, adding to the group of Vietnamese chicken breeds, meeting the market demand for colored-feather chickens for production, bringing economic and social efficiency.

Broilers have outstanding heterosis in terms of growth ability, feed consumption, creating products with competitive prices in the market and meeting the increasing demand for high-quality food of consumers at reasonable prices.

CHAPTER I
DOCUMENT OVERVIEW

1.1. Scientific basis of the research problem

The thesis applied the scientific basis of genetic characteristics of quantitative traits, crossbreeding and heterosis, as well as suitable and common methods to discuss the research problems of the topic.

1.2. National and international research situation

The thesis evaluated the domestic and foreign research situation on the selection and crossbreeding of colored chicken breeds and native chickens.

Studies around the world show that the selection and crossbreeding of poultry breeds started early. In recent years, many studies in developing countries have been relatively comprehensive on indigenous chicken breeds, applying existing selection methods to increase egg productivity of indigenous chickens, creating hybrids and selecting hybrids. Some countries, such as China, Japan, South Korea and Thailand, have rapidly adopted new genetic technologies in poultry breeding research.

In Vietnam, research results in recent years show that breeding selection and applying selection technologies have received attention, resulting in the creation of many new lines with high quality and productivity, meeting the domestic demand. In recent years, poultry breeding in Vietnam has effectively applied selection methods. Based on exploiting the genetic potential of superior traits from existing chicken lines, raw materials are selected for cross-breeding to create new lines that combine good characteristics of productivity, quality and environmental adaptability. Many studies applied similar genetic principles, oriented selection of desired traits through information sources of individuals and ancestors. Through generations, genetic parameters are determined: Heritability (h^2) of body weight and egg productivity, determining selection deviation (S), selection efficiency (R) and genetic progress (Δg).

1.3. Introducing the chicken genes for selecting and creating two chicken lines HTP and RTN

Ho chicken originated from the project "Research on selection and pure breeding of some domestic chicken breeds. 2008-2010 period", the Ministry level. The results of the project summary report in 2011 showed that Ho chicken, through 3 generations of selection, has plum color in the feather, a strawberry comb; females are light brown and strawberry comb. The body weight of the 20-week-old male is 2,168.70g; the female is 1,786.20g. Egg number is 67.64 eggs/68 weeks old (Ho Xuan Tung et al., 2011).

Ri chicken is the product of the key ministerial-level project "Research on selecting and creating some colored- feather chicken lines for eggs and meat for high productivity and quality to serve the restructuring of the industry, period 2017-2021". The results of the project summary report in 2021 show that Ri chicken mother line, through 5 generations of selection, has the feather colour of bright yellow for males and straw yellow for females, neck feather has black spots or no back spots, single comb, yellow beak and shanks.

The weight of 20-week-old males was 1,757.00g; females was 1,241.82g. Egg productivity was 158.20 eggs/ 68 weeks old (Nguyen Quy Khiem et al., 2021)

TN chicken is the product of the Ministry-level project "Research on selecting and breeding some colored- feather chicken lines for industrial farming, period 2012-2016", and select and stabilise the productivity of 3 TN chicken lines in the next generations under the Ministry-level SXTN project, period 2018-2020. The results of the summary report of the 2020 show that the TN3 line through 3 generations have the male's feather color of dark brown while the female's feather color is brown. The body weight of 20-week-old males was 2,891.11g; females was 2,294.3g. Egg yield/female/64 weeks old was 185.12 eggs (Pham Thuy Linh et al., 2020)

TP chicken is the product of the Ministry-level project "Research on selection and development of some colored feather chicken lines for egg and meat production, period 2006-2010", and continued to select to improve productivity under the Ministry-level project "Research on selection to improve productivity of 5 colored feather chicken lines for meat production, period 2012-2016". The results showed that the TP1 line through 5 generations has light brown feather for males and yellow brown with black spots for females. The weight of the male at 20 weeks old is 2,858.3 kg; the female is 2,260.9 kg. The egg yield/female/68 weeks old is 182.68 eggs (Phung Duc Tien et al., 2017).

Thus, the combination of these genetic resources is expected to create two new high-quality, productive colored chicken lines, adding to the Vietnamese chicken breed group, contributing to the highest efficiency in production, ensuring the stability and sustainability of the livestock industry.

CHAPTER II
MATERIALS, CONTENTS AND METHODS

2.1. Materials, location, and research time

2.1.1. Research materials

Chicken: Ri (R2), TN3, Ho, TP1; F1 (HTP), F1 (RTN)

HTP and RTN chickens initial generation, 1st generation, 2nd generation, and 3rd generation HTPRTN broiler

2.1.2. Research location

Pho Yen Chicken Breeding Research Station - Thuy Phuong Poultry Research Centre, Dac Son Ward, Pho Yen City, Thai Nguyen Province.

Feed and livestock products analysis department – National Institute of Animal Science, Thuy Phuong ward, Bac Tu Liem district, Hanoi city.

03 areas: Phu Xuyen district, Hanoi city; Pho Yen city, province Thai Nguyen; Pac Nam district, Bac Kan province.

2.1.3. Research time

From January 2021 to December 2024

2.2. Research content

***2.2.1.* Content 1: Selecting and creating two chicken lines HTP and RTN**

Select and create HTP father lines aiming high BW

Select and create RTN mother lines aiming high egg production

2.2.2. Content 2: Evaluation of broiler quality

Evaluation of meat production and quality of HTPRTN broiler

Testing the breeding of HTPRTN broilers in external farms

2.3. Research method

2.3.1. Selecting and creating two chicken lines HTP and RTN

*2.3.1.1. Steps to create a line **

*Step 1: Selection of breeding materials

Use Ho males to cross with TP1 hens to create F1 chickens (HTP)

Use Ri males to cross with TN3 hens to create F1 chickens (RTN)

* Step 2: Create the initial generation (THXP)

Backcrossing:

Use F1 (HTP) hens to cross with Ho males to create hybrids (¾Hồ, ¼TP) as THXP to select and create HTP father line.

Use F1 hens (RTN) to cross with Ri fathers to cross hybrids (¾Ri, ¼TN) as THXP to select and create RTN mother line

* Step 3: Analyze the inheritance of traits through generations: THXP and generation 1 (TH1) selected according to phenotypic values; Generation 2 (TH2) and Generation 3 (TH3) selected according to breeding value (GTG)

Selection for body weight to create HTP father line

Selection for egg productivity to create RTN mother line

2.3.1.2. Building a data collection system

* Numbering individuals:

Generation uses 1 digit (0,1,2,3), sex uses 1 digit (1 is male, 2 is female), individual chicken uses 4 digits (0001,0002.....).

* Collecting individual data:

Body weight at 8 and 20 weeks of age; egg productivity up to 38 weeks of age

* Collecting population data:

Time: 01 day old; 1-7 weeks old and 9-19 weeks old; laying and 38 weeks of age.

2.3.1.3. Selection method

a) For HTP father line

* Selection at 1 day old (NT):

THXP to TH3 select 1,280 birds (640 males + 640 females)/TH.

* Selection at the end of 8 weeks of age:

+ THXP and TH1: selection by phenotype value, males and hens select individuals with high to low weight: THXP retains (94 males + 400 females); TH1 retains (96 males + 400 females).

+ TH2 and TH3: selection by breeding value (GTG), males and hens select individuals with high to low GTG: select to retain (100 males + 400 females)/TH.

* Selection at the end of 20 weeks of age:

THXP to TH3 select technical type: select to retain males (60 males + 300 females)/TH.

* Selection at the end of 38 weeks of age:

THXP to TH3 monitor individual egg productivity until the end of 38 weeks of age: select to keep (20 males + 200 females)/TH for the next generation.

b) For the RTN mother line

* Selection at 1 day old (NT):

THXP to TH3 select 2,400 (1,200 males + 1,200 females)/TH.

* Selection at the end of 8 weeks of age:

THXP to TH3: select based on phenotypic value keep (173 males + 788 females)/TH.

* Selection at the end of 20 weeks of age:

THXP to TH3 using the technical method to select to keep (115 males + 600 females)/TH.

* Selection at the end of 38 weeks of age:

+ THXP and TH1: selection based on phenotypic value, select individuals with high to low egg productivity to keep (40 males + 360 females)/TH, to multiply the flock for the next generation.

+ TH2 and TH3: selection based on breeding value (GTG), select individuals with high to low GTG: select to keep (40 males + 360 females)/TH, to multiply the flock for the next generation.

2.3.1.2. Breeding method

Using the pedigree method, the HTP line includes 20 families, each of which consists of 1 male and 10 females.

RTN include 40 families, each family consists of 1 male and 9 females. Males were rearranged to avoid inbreeding.

2.3.1.3. Management

The management guideline followed the principles from Thuy Phuong Poultry Research Centre.

2.3.1.4. Parameters

The parameters: physical characteristics, survival rate, body weight, feed consumption, laying rate, egg productivity, egg weight, hatching parameters, are determined according to TCVN 13474-1:2022-Procedure for testing and inspecting livestock breeds-part 1: poultry breeds.

2.3.2 Experimental to evaluate the broiler

2.3.2.1 Experiment design

a) Diagram of creating HTPRTN broiler

Parents ♂HTP x ♀RTN

↓

Broilers HTPRTN

b) Evaluation of meat production and meat quality of HTPRTN hybrids

Using the single-factor randomization method to evaluate meat production and heterosis of HTPRTN hybrids. The experiment was arranged with 150 HTP chickens, 150 RTN chickens and 150 HTPRTN chickens. Experimental chickens were raised under the same conditions, kept in naturally ventilated cages, repeated 3 times, each time 50 chickens (25♂+25♀).

To evaluate meat quality, at the end of the 16-week-old experimental period, 6 chickens (3 males, 3 females) were selected from each batch with a weight equivalent to the average weight, and slaughtered to evaluate meat yield and some meat quality indicators. The experimental implementation period is from April to August 2024.

c) Testing the raising of HTPRTN hybrids in external farms

Select three experimental raising sites for HTPRTN hybrids in 3 different farms in different areas

HTPRTN hybrids are raised and cared for in naturally ventilated barns with the yard.

Number of HTPRTN hybrids raised for testing: 150/1 raising site
Experimental raising period from May to September 2024

2.3.2.2 Management

The experimental commercial chicken flock is raised according to the management guidelines of Thuy Phuong Poultry Research Centre.

2.3.2.3 Parameters

Parameters: physical characteristics, survival rate, body weight, feed consumption, heterosis, meat yield analysis, meat value and nutritional composition, determined according to TCVN 13474-1:2022.

2.4. Data processing method

Data were collected and analysed using biological statistics and ANOVA on Excel software; mean values were compared using the Tukey method (P<0.05) of Minitab 16.0 software. Genetic parameters were determined using PEST 4.2.3, VCE 6.0.2 software. Regression analysis and genetic trends were performed using the SCATTER menu on Excel 2016 software.

CHAPTER III
RESULTS AND DISCUSSION

3.1. Results of selection of two chicken lines HTP and RTN

3.1.1. Selection to create the HTP line

3.1.1.1. Variance components of body weight traits at 8 weeks of age

Table 3.1. Variance components of body weight and heritability of BW at 8 weeks old

Parameters	Value		
	TH1	TH2	TH3
Cumulative genetic effect variance (V_A)	19,175.2	18,450.3	17,455.9
Environmental effect variance (V_E)	16,895.5	18,362.3	19,446.5
Phenotypic effect variance (V_P)	36,070.7	36,812.6	36,902.4
Heritability (h^2±SE)	0.53±0.05	0.50±0.03	0.47±0.03

The influence of the cumulative genetic effect variance (VA) component on the phenotypic variance (VP) of the 8-week-old body weight trait through the selection generations was relatively high and tended to decrease, TH1 was 53.16% (VA/VP x100), and TH3 was 47.30%. The influence of the environmental effect variance (VE) component on the phenotypic effect variance (VP) of the body weight trait at the end of 8 weeks of age was also quite strong and increased gradually through each generation. The influence level of TH1 was 46.84% (VE/VP x100) and gradually increased to 52.7% in TH3.

The results of analysis through selected generations showed that the heritability of body weight trait at the end of 8 weeks of age of HTP father line in TH1 was 0.53±0.05 and tended to decrease gradually, to TH3, it was 0,47±0,03, with the low standard error showing the stability of quantitative trait to each generation.

Thus, the genetic nature of the body trait of the HTP father line is relatively stable in each selection generation and still has great genetic potential, confirming

that the selection method is appropriate. However, to continue to improve and increase the body of the HTP father line, it is necessary to pay attention to external conditions such as nutrients and environment to ensure the best performance.

3.1.1.2. Breeding value and genetic progress of BW at 8 weeks old

Table 3.2. Breeding values and genetic progress body weight at 8 weeks of age

Parameters	n (birds)	Average breeding value		
		Males	Females	Mean
Initial generation	1280	-101.12	-99.03	-100.08
TH1	1280	-16.29	-10.40	-13.35
TH2 2	1280	56.14	54.92	55.53
TH3 3	1280	112.20	105.43	108.81
Genetic progress (g)		71.24	67.87	69.55
P		0.004	0.008	0.006
Determination index (%)		99.19	98.43	98.86

The results show the estimated average breeding value of the 8-week-old final body trait with males in the initial generation is -101.12, increasing through each generation of selection, and is highest in TH3 was 112.20; the female in THXP was -99.03, also increasing through each generation, to TH3, it was 105.43. This shows that the use of the BLUP method has estimated the breeding value of individuals in the initial generation and TH1, even though those individuals have no or little pedigree data, thereby assessing the level of genetic improvement of the 8-week-old final body weight trait through each generation is good. The genetic progress of the 8-week-old final body weight trait for males was 71.24 g/generation; for females was 67.87 g/generation. P-value of the regression analysis of the value of the variance of all traits was less than 0.01, indicating high confidence in genetic progress.

3.1.1.3 Selection of body weight trait at 8 weeks of age

Table 3.3 Selection results of males at 8 weeks old

Parameters	Initial generation	TH1	TH2	TH3
Number of 1-day-old individuals	640	640	640	640
Number of individuals before selection	615	617	608	612
Number of individuals after selection	94	96	100	100
Number of individuals used for breeding	20	20	20	20
Selection rate at 8 weeks old (%)	15.28	15.56	16.45	16.34
Breeding rate (%)	3.25	3.24	3.29	3.27
Body weight before selection (g)*	1,016.57^{d}	1,105.48^{c}	1,185.41^{b}	1,244.89^{a}
Coefficient of variation (%)	14.68	12.78	12.19	11.49
Body weight selected for breeding (g)**	1,273.00	1,351.00	1,409.00	1,438.50
Selection deviation of BW (g)	256.43	245.52	223.59	193.61
Expected selection efficiency of BW (g)		130.13	111.79	91.00

*Note: Mean values in the same row with different letters are statistically different (P<0.05); *: sample size in the initial generation, TH1, TH2 and TH3 are 615, 617, 608 and 612, respectively; **: sample size in THXP, TH1, TH2 and TH3 is 20.*

Table 3.3. Selection results of female at 8 weeks old

Parameters	Initial generation	TH1	TH2	TH3
Number of 1-day-old individuals	640	640	640	640
Number of individuals before selection	616	610	621	615
Number of individuals after selection	400	400	400	400
Number of individuals used for breeding	200	200	200	200
Selection rate at 8 weeks old (%)	64.94	65.57	64.41	65.04
Breeding rate (%)	32.47	32.79	32.21	32.52
Body weight before selection (g)*	854.77^{d}	956.46^{c}	1,012.45^{b}	1,053.01^{a}
Coefficient of variation (%)	15.34	13.02	12.21	11.22
Body weight selected for breeding (g)**	986.10	1,070.85	1,100.45	1,151.30
Selection deviation of BW (g)	131.33	114.39	88.00	98.29
Expected selection efficiency of BW (g)		60.63	44.00	46.20

*Note: Mean values in the same row with different letters are statistically different (P<0.05); *: sample size in the initial generation, TH1, TH2 and TH3 are 616, 610, 621 and 615, respectively; **: sample size in THXP, TH1, TH2 and TH3 is 200.*

Through 4 generations, the HTP father line show that the final body weight at 8 weeks of age has been increased. The results show that: in THXP, the male reaches 1,016.57g, increasing gradually through each generation of selection, reaching 1,244.89g in TH3 (increased by 228.32g compared to intinal generation), correspondingly, the female initial generation was 854.77g, also increasing gradually through each generation, was 1,053.01g in TH3 (increased by 198.24g compared to the intial generation). The difference in the final weight at 8 weeks of males and females in the initial generation and the following generations is statistically significant(P<0.05).

The values of the coefficient of variation, selection deviation tend to decrease through the generations of selection. The coefficient of variation (CV) in males of the initial generation was 14.68% with a decreasing trend, TH3, it was 11.49%; correspondingly, female THXP was 15.34% with a decreasing trend, and TH3 was 11.22%. The trend followed the rules of selection and reflects that the care and nurturing process is appropriate and ensures selection to improve the genetic trait of the HTP father line weight.

Selection deviation of body weight at the end of 8 weeks of age: male THXP is 256.43g with a decreasing trend, reaching TH1 is 245.52; TH2 is 223.59g and the lowest in TH3 is 193.61g; The corresponding THXP female is 131.33g, decreasing gradually, to TH3 is 98.29g, the large difference in the difference between males and females is due to the very low selection rate of males (3.24-3.29%), while females (32.21-32.79%), with high selection pressure, the coefficient of variation gradually decreases, so the average weight of the offspring population born from parents who have been selected in the previous generation has gradually increased, causing the difference to gradually decrease through the generations. This result is completely consistent with the selection law and the gradual increase in estimated breeding value through the selection generations.

The expected selection effect of the body weight trait at the end of 8 weeks of age of the HTP father line tends to decrease through the generations. For TH1, the male reaches 130.13g, decreasing gradually to TH3, reaching 91.00g; The corresponding weight in TH1 females is 60.63g, down to 46.20g in TH3. This shows that in order to

achieve high efficiency in selection, the selection ratio is very important. From the results of genetic analysis and the results of the phenotype of the selected trait, it can be seen that there is not much difference between the expected selection efficiency and the direct selection efficiency. This can be explained by the fact that the 8-week-old body weight trait of the HTP father line has a high heritability coefficient and a large selection deviation, so selection is easy and effective, and selection is achieved as expected.

3.1.1.4 Selection at the end of 20 weeks old

Table 3.4. Selection results at 20 weeks old

Parameters	THXP	TH1	TH2	TH3
Males				
Number of individuals before selection	89	92	95	96
Number of individuals after selection	60	60	60	60
Selection rate (%)	67.42	65.22	63.16	62.50
BW before selection (g)*	2,837.75^{b}	2,923.05^{ab}	2,979.79^{a}	3,025.10^{a}
Coefficient of variation (CV)(%)	12.44	12.07	11.83	11.38
Females				
Number of individuals before selection	390	392	389	393
Number of individuals after selection	300	300	300	300
Selection rate (%)	76.92	76.53	77.12	76.34
BW of before selection (g)**	1,851.15^{c}	1,922.41^{b}	1,962.87^{ab}	2,001.31^{a}
Coefficient of variation (CV) (%)	12.64	12.22	11.22	11.57

*Note: Mean values in the same row with different letters are statistically different (P<0.05); *: sample sizes in THXP, TH1, TH2 and TH3 are 89, 92, 95 and 96, respectively; **: sample sizes in THXP, TH1, TH2 and TH3 are 390, 392, 389 and 393, respectively.*

At the end of 20 weeks of age, the selection rate of males was 62.50-67.42%; female was 76.34-77.12%. The number of chickens retained for breeding was 60 males/ generation and 300 females/generation. The flocks were under good development, showing through the low coefficient of variation (CV): male 11.38-12.44%; female 11.22-12.64%. The body weight of THXP was 2,837.75g for male and indicated the gradual increase to reach 3,025.10g in TH3 (increased by 187.35g compared to THXP); Correspondingly, the female was 1,851.15g, increasing gradually to TH3 reaching 2,001.31g (increased by 150.16g compared to THXP), the difference in body weight at the end of 20 weeks of age between THXP and TH3 for males and females was statistically significant (P<0.05). Thus, it is confirmed that the response of selection for body weight traits showed imprevement in 4 generations.

3.1.1.5 Selection of mother line at the end of 38 weeks old

Table 3.5. Selection results at 38 weeks old

Parameters	THXP	TH1	TH2	TH3
Number of individuals before selection	281	279	283	281
Number of individuals after selection	200	200	200	200
Egg yield (quả)	41.16	40.38	40.63	41.24
Coefficient of variation (%)	22.16	21.72	20.40	20.21
Selection rate (%)	71.17	71.68	70.67	71.17

300 hens of the HTP line were selected during the breeding period to monitor egg production. At the end of 38 weeks of age, the selection rate through 4 generations was 70.67-71.68%, with the number of hens retained to multiply the flock for the next generation in each generation being 200 hens.

Results over 4 generations, the egg productivity at the end of 38 weeks of age of the HTP father line showed small change, hens in THXP layed 41.16 eggs and was stable in the following generations, reaching 41.24 eggs in TH3, egg productivity in TH1 and TH2 decreased slightly compared to THXP but within the stable range, this is consistent with the orientation of selection to increase body mass, egg productivity will fluctuate and decrease. The coefficient of variation (CV) over 4 generations shows that the CV of egg productivity up to 38 weeks of age in THXP is 22.16% and tends to decrease gradually to TH3 at 20.21%. This coefficient of variation is a bit high, but within the allowable range for body mass-oriented selection, egg productivity will have certain fluctuations.

3.1.1.6. Physical characteristics

To the 3rd generation, the feather colour of the HTP male chicken line shows that at 1 day old, light yellow feathers accounted for 88.44%, light yellow feathers with 2 stripes on the back accounted for 11.56%, with yellow shank and beak.

At mature age, the male has a ripe plum color, with strawberry comb 89.01% and single comb 10.99%; the female has a light dry banana leaf color 89.92%, dark dry banana leaf color (owl feathers) 10.08%. The skin of the shank and beak is pale yellow.

3.1.1.7 Survival rate and feed consumption in starter (0-8) and pullet stages (9-20)

The results showed that the survival rate through all stages was high in 4 generations. From 01weeks old to 8 weeks old, the survival rate of male was 95.00-96.41% and females was 95.31-97.03%; from 9 to 20 weeks old, it was 94.68-96.00% and 95.81-98.25% for males and females, respectively. The result indicates that the HTP father line has affirmed the superiority of the chicken breed with native genes, which is the ability to adapt well to all climatic conditions and farming environments in all seasons of the year.

Feed consumption for the starter, males was 2.50-2.58kg, females was 2.30-2.33kg; for the pullet period: males are 7.05-7.14kg, females are 6.11-6.15kg. Calculating the total for the starter and pullet, males was 9.58-9.72kg, females was 8.43-8.46kg.

3.1.1.8 Reproductive productivity

Table 3.7. Laying performance

Parameters	THXP	TH1	TH2	TH3
Age at laying, days	160	164	165	161
Body weight at laying, g	2,159.67	2,199.00	2,223.33	2,252.00
Body weight at 38 weeks, g	2,552.33	2,592.00	2,627.33	2,651.33
CV, %	10.01	10.16	10.15	10.16
Egg weight at 38 weeks, g	48.87	49.09	49.43	49.71
CV, %	7.42	6.54	6.58	6.61
Egg yield/hen/68TT, eggs	107.38	106.94	106.98	107.64
TTTA/10 eggs, kg	3.96	4.00	4.05	3.98

Through 4 generations of monitoring, the laying age of the HTP father line is 160-165 days. The weight of laying hens through the generations reaches 2,159.67-2,252.00g; at 38 weeks of age, the weight of laying hens reaches 2,552.33-2,651.33g.

Egg productivity/68 weeks of age: THXP was 107.38 eggs/hen and there was no significant change from TH1 to TH3, reaching 106.94-107.64 eggs/hen. The difference in egg productivity from 23 to 68 weeks of age between THXP and the following generations was not statistically significant (P>0.05). This result is consistent with the selection of HTP father lines as an improvement in body mass, so egg productivity

fluctuated slightly but within a stable range.

Feed cost/10 eggs of HTP father line in THXP was 3.96 kg, and there was a slight fluctuation in the following generations: TH1 was 4.0 kg; TH2 was 4.05 kg and TH3 was 3.98 kg.

3.1.1.7. Some hatching indicators

Monitoring 7 hatching batches in the 2nd and 3rd month of laying with total eggs incubated in each generation. THXP was 4515 egg; TH1 was 4560 eggs; TH2 was 4560 eggs; TH3 was 4580 eggs.

The rate of selecting eggs for incubation was 92.17-93.92%; the rate of eggs with embryos was 94.28-95.20%; the rate hatching rate/total hatched eggs was 81.14-82.25%; the rate of grade 1 chickens/total hatched eggs was 96.71-97.84%. This result shows that the incubation indicators of all 4 generations are similar and quite high.

In summary, For the results of selecting and creating the HTP father line through 4 generations, the use of the BV estimation method by BLUP to select and improve the body weight trait is suitable and effective, improving the body weight trait at the end of 8 weeks of age, genetic progress for males is 71.24 g/generation; for females it is 67.87 g/generation. Body weight at the end of 8 weeks of age, the male of 3rd generation was 1244.89g (increased by 228.32g compared to the starting generation); the female was 1053.01 (increased by 198.24g compared to the starting generation). At the end of 20 weeks of age, the male was 3025.10g; the female wass 2001.31g. Egg production was 106-107.64 eggs/68TT. Other parameters such as survival rate, feed consumption and hatching rate were stable through the selected generations.

3.1.2 Select to create RTN mother line

3.1.2.1 Select 8-week-old finish

Table 3.8. Selection results at the end of 8 weeks old

Parameters	THXP	TH1	TH2	TH3
Males				
Number of individuals before selection	1,186	1,180	1,190	1,183
Number of individuals after selection	173	173	173	173
Selection rate (%)	14.59	14.66	14.54	14.62
Body weight (g)*	796.59	838.13	835.55	817.30
Coefficient of variation (%)	15.11	13.77	12.09	11.82
Females				
Number of individuals before selection	1,184	1,185	1,182	1,181
Number of individuals after selection	788	788	788	788
Selection rate (%)	66.55	66.50	66.67	66.72
Body weight (g)**	683.59	705.48	724.59	706.55
Coefficient of variation (%)	13.73	13.71	12.05	11.86

*Note: *: sample capacity in THXP, TH1, TH2 and TH3 are 1186, 1180, 1190 and 1183 respectively; **: sample capacity in THXP, TH1, TH2 and TH3 are 1184, 1185, 1182 and 1181 respectively*

The selection rate of THXP was males were 14.59%; females were 66.55%. From TH1 to TH3, males were 14.54-14.66%; females were 66.50-66.72%.

Body weight at the end of 8 weeks of age did not differ much between generations. At THXP, males were 796.59g; females were 683.59g, and there was a light fluctuation from TH1 to TH3, showing that male chickens were 817.30-838.13g; female chickens were 705.48-724.59g. The difference in body weight at the end of 8 weeks of

age between THXP and the following generations was not statistically significant (P>0.05), which showed that the body weight at the end of 8 weeks of age of the RTN mother line was stable through the selection generations. The coefficient of variation: male chickens at THXP were 15.11%, with a tendency to decrease in the following generations, to TH3 at 11.82%; female chickens in THXP were 13.73%, decreasing in the following generations, to TH3 at 11.86%, with the coefficient of variation decreasing, confirming that the flock was more uniform through each selection generation. Thus, the selection method and care and feeding process at this stage are appropriate, ensuring selection in the following stages.

3.1.2.2 Select end 20 weeks old

Table 3.9. Results of selection at 20 weeks of age

Parameters	THXP	TH1	TH2	TH3
Male				
Number of individuals before selection	169	168	166	167
Number of individuals after selection	115	115	115	115
Selection rate (%)	68.05	68.45	69.28	68.86
Body weight (g)*	2,485.08	2,504.10	2,520.50	2,508.02
Coefficient of variation (%)	11.39	11.22	11.09	11.02
Female				
Number of individuals before selection	770	765	777	766
Number of individuals after selection	600	600	600	600
Selection rate (%)	77.92	78.43	77.22	78.33
Body weight (g)**	1,732.52	1,743.01	1,770.58	1,748.36
Coefficient of variation (%)	11.21	11.14	11.10	11.03

*Note: ***** : sample capacity in THXP, TH1, TH2 and TH3 are 169, 168, 166 and 167 respectively; ****** : sample capacity in THXP, TH1, TH2 and TH3 are 770, 765, 777 and 766 respectively.*

The selection ratio through 4 generations for male was 68.05-69.28% and for female was 77.22-78.43%, The number of chickens retained for reproduction: male is 115/generation, female is 600/generation. At the end of 20 weeks of age, the body weight of the male is 2,485.08-2,520.50g; the female was 1,732.52-1,770.58g, the difference in body weight at the end of 20 weeks of age between generations is not statistically significant (P>0.05). The chicken shows good growth, with the coefficient of variation (CV): male 11.02 -1 1.39 %; female 11.03-11.21%

These results show that the final body weight at 20 weeks of age of RTN mother line is stable through generations of selection, with appropriate selection rates ensuring the number of offspring to transition to the reproductive stage to monitor egg production.

3.1.2. 3. Variance components, heritability of egg production at 38 weeks old

Table 3.10 . Variance components and heritability coefficient of chromosome 38TT

Parameters	Value		
	TH1	TH2	TH3
Hepitability variance ($_{VA}$)	76.53	72.47	60.28
Environment effect variance (V_E)	208.67	202.83	179.82
Phenotypic effect variance ($_{VP}$)	285.20	275.30	240.10
Heritability (h^2 ±SE)	0.27±0.01	0.26±0.01	0.25±0.01

The results of the analysis of the variance component of the egg production trait at the end of 38 weeks of age of the RTN mother line showed that the influence of the cumulative genetic variance (VA) on the phenotypic effecy variance (VP) tended to decrease gradually through the generations from 26.83% (VA/VPx100) in TH1 to 25.1% in TH3; on the contrary, the influence of the environemental effect variance on the phenotypic effect variance increased gradually from 73.17% (VE /VPx100) in TH1 to 74.89% in TH3. Thus, the egg production trait of the RTN mother line, in addition to the influence of the cumulative genetic component, is also greatly influenced by external conditions, specifically in this study, the influence of the cages.

The change in variance components causes a change in heritability and decrease through the selection generations. TH1 was 0.27±0.01, gradually decreasing to 0.25±0.01 in TH3. Therefore, it can be seen that the heritability of the egg productivity trait at the end of 38 weeks of age in this study can be used in selection to improve the egg productivity trait of the RTN mother line.

Thus, the genetic nature of the RTN mother trait is relatively stable through 3 generations of selection from TH1 to TH3, confirming that the selection method is appropriate. To promote or maintain the genetic potential of this trait, it is necessary to pay attention to external conditions such as nutrient and managment to ensure the best performance.

3.1.2.4 . Breeding value and genetic progress of egg productivity traits at 38 weeks old

Table 3.11. Breeding values and genetic progress of egg productivity

Interpretation	Number birds	Average breed value
THXP	2,364	-1.49
TH 1	2,361	-0.08
TH 2	2,372	2.36
TH 3	2,364	3.42
Genetic progress (egg)		1.72
P		< 0.001
Coefficient of determination (R^2)		97.00

The analysis results showed that the BV of the 38-week-old egg production trait in the RTN mother line in THXP was -1.49, and tended to increase gradually through the next selection generations from -0.08 in TH1 to 3.42 in TH3. This showed that the use of the BLUP method estimated the BV of individuals in THXP and TH1 even though those individuals had little or no pedigree data, thereby assessing the level of genetic improvement of the 38-week-old egg production trait through each generation was quite good, with an average genetic progress of 1.72 eggs/generation. The above analysis results showed that the selection method for the 38-week-old egg production trait in the RTN mother line was appropriate and improved egg production through 4 generations.

3.1.2. 5. Selection of egg productivity trait at 38 weeks of age

Through 4 generations of egg productivity-oriented selection of the RTN mother line, the egg productivity at 38 weeks of age was improved. The result in THXP was 64.54 eggs, and gradually increased through each generation, reaching 67.52 eggs in TH3 (an increase of 2.98 eggs compared to THXP). The difference in egg productivity at 38 weeks of age between THXP and the following generations was statistically significant (P<0.05).

Table 3.12 Selection results at the end of 38 weeks of age

Target	THXP	TH1	TH2	TH3
Number of 1-day-old individuals	1,220	1,220	1,220	1,220
Number of individuals before selection	1,184	1,185	1,182	1,181
Number of hens tested for individual egg productivity	600	600	600	600
Number of individuals for breeding for the next generation	360	360	360	360
Breeding rate (%)	30.41	30.38	30.46	30.48
Egg yield before selection (eggs)	64.54^{c}	65.80^{b}	66.66^{ab}	67.52^{a}
Coefficient of variation (%)	20.71	19.76	19.20	18.97
Egg yield after selection (eggs)	72.19	72.95	71.54	73.20
Selective deviation of egg productivity (eggs)	7.65	7.15	4.88	5.68
Expected selection efficiency of egg production (egg)		1.61	1.27	1.42

Note: Mean values in the same row with different letters are statistically different (P<0.05)

The values of the coefficient of variation, selection deviation decrease gradually over generations. Specifically, the coefficient of variation (CV) in THXP is 20.71%, and it decreased gradually to 18.97% in TH3. The selection deviation in THXP is 7.65 eggs and decreased gradually to 5.68 eggs in TH3. This result is completely consistent with the selection law and the gradual increase in estimated variety value through the selection generations.

The expected selection efficiency and the direct selection efficiency (calculated by the regression of the breeding value) are different; the direct selection efficiency (1.72 eggs) is higher than the expected selection efficiency (1.42 eggs). This is completely appropriate and reasonable because the egg yield trait has a low heritability coefficient, so the influence of genetic impact is lower than the impact of external factors, and the actual selection efficiency achieved is not as expected.

3.1.2. 6. Physical characteristics

To the third generation, the feather colour of RTN chickens at 1 day old is yellow-brown, the beak and shank are yellow. When mature, the male has purple-reddish brown feathers, a large single red comb; the female has yellow-brown feathers, with or without a neck spots, a single comb, and yellow beak and legs.

*3.1.2.7. Survival rate and feed consumption of starter (0-8) and pullets (9-20)_*

The results showed that the survival rate through all stages was high in 4 generations. In the starter, the males were 96.72-97.54%, and the females were 96.80-97.13%; in the pullet stage, the males were 95.95-97.69%, and the females were 97.08-98.60. Thus, through 4 generations of monitoring, it was shown that the RTN mother line has affirmed the superiority of the chicken breed with native genes, which is the ability to adapt well to all climatic conditions and rearing environments in all seasons of the year.

Feed consumption results in the starter stage: male is 2.22-2.28kg, female is 2.01-2.10kg; in the pullet stage: male was 6.29-6.41kg, female was 5.85-5.91kg; in the starter and pullet stage: males was 8.56-8.63kg, female was 7.90-7.96kg.

3.1.2.8. Reproductive productivity

Table 13. Results on reproductive performance

Parameters	THXP	TH1	TH2	TH3
Age of birth, days	142	144	142	143
Body weight at first egg, g	1,776.67	1,785.33	1,796.67	1,780.00
Body weight at 38 weeks old, g	2,172.00	2,175.33	2,182.00	2,178.67
CV, %	9.89	9.87	9.81	9.71
Egg weight at 38 weeks old, g	47.36	47.32	47.25	47.22
CV, %	7.77	7.47	7.17	7.01
Egg yield/hen/68 weeks old, egg	159.68^{d}	162.20^{c}	164.52^{b}	166.43^{a}
TTTA/10 eggs, kg	2.78	2.72	2.68	2.65

Note: Horizontally, values with different letters are statistically different (P<0.05).

Through 4 generations of monitoring the RTN mother line, the laying age is 142-144 days.

The body weight of first egg through generations was 1,776.67-1,796.67g; at 38 weeks of age, it was 2,172.00-2,182.00g.

Results of egg productivity in the period of 21-68 weeks of age show that, hen at THXP layed159.68 eggs/hen, and gradually increased through the selected generations, reaching 166.43 eggs/hen by TH3 (an increase of 6.75 eggs compared to THXP), the difference in egg productivity during 21-68 weeks of age between THXP and the following generations was statistically significant P<0.05. Thus, the egg productivity trait of the RTN mother line responded well to selection, improving egg productivity through each generation. Up to TH3, it increased by 6.75 eggs compared to THXP. This result is consistent with the selection of the RTN mother line as the direction for improving egg productivity.

Feed consumption/10 eggs of the RTN mother line in THXP was 2.78 kg, and tended to decrease, reaching 2.65 kg in TH3. This result is consistent with the increasing egg productivity through each generation of selection, showing that selection for improved egg productivity has reduced feed cost/10 eggs.

3.1.2.9. Hatching indicators

Monitoring 7 incubation batches in the 2nd and 3rd laying months with total eggs incubated in each specific generation: THXP was 12,640 eggs; TH1 was 13,140 eggs; TH2 was 13,330 eggs; TH3 was 13,540 eggs

The rate of selected eggs for incubation was 92.81-93.77%; the fertility rate was 94.62-95.23%; the hatching rate/total hatched eggs was 81.27-82.07%; the rate of grade 1 chickens/total hatched eggs was 97.95-98.50%. This result shows that the incubation indicators of all 4 generations are similar.

In summary: For the results of selecting the RTN mother line through 4 generations, the use of the BV estimation method by BLUP to select and improve the egg productivity trait up to 38 weeks of age is appropriate and effective, improving the egg productivity trait up to 38 weeks of age, the genetic progress achieved is 1.72 eggs/generation. Egg productivity/68 weeks of age up to generation 3 was 166.43 eggs (increased by 6.75 eggs compared to the starting generation), feed consumption/10 eggs is 2.65 kg. Other indicators, such as survival rate, body weight, feed consumption, and hatchability, are all stable through the selection generations.

3.2 HTPRTN commercial hybrids evaluation

3.2.1. Physical characteristics

The feathers of HTPRTN hybrids at 1 day old are mainly yellow-brown, light yellow with stripes on the back, and black spots on the head. At 16 weeks old, the hens are light yellow, light grey, with or without neck spots, with some black feathers; the males have purple-yellow or plum-colored feathers, red back and wings, yellow shank, yellow beak, single comb and strawberry comb in equal proportions.

3.2.2. Survival rate by week of age

The results showed that the survival rate of experimental chickens through the weeks of ages was high. It was 94.00%, equivalent to the HTP chickens (94.00%) and the RTN chickens (95.33%).

Thus, through monitoring the survival rate of HTPRTN hybrids up to 16 weeks of age, it was relatively high, equivalent to HTP and RTN chickens in the same experiment. This shows that HTPRTN hybrids have promoted the superiority of chicken breeds with native genes, which are high disease resistance, suitable for all climatic conditions and breeding environments in all seasons of the year.

3.2.3. Body weight and heterosis

Table 14. Body weight and heterosis (g)

Weeks old	HTP Chicken	RTN Chicken	HTPRTN Chicken
	(Mean±SD)	(Mean±SD)	(Mean±SD)
1	110.14±13.48	103.05±8.99	105.45±9.33
4	504.93^{a}±46.11	373.50^{c}±31.76	436.06^{b}±43.28
8	1193.48^{a}±171.53	928.12^{c}±132.60	1085.49^{b}±169.78
12	1833.69^{a}±238.29	1468.46^{c}±179.22	1704.26^{b}±206.61
16	2262.98^{a} ± 286.18	1899.65^{c} ±230.34	2160.85^{b} ±271.32
	Heterosis (%)		3.82

Note: Mean values in the same row with different letters are statistically different (P<0.05)

The results of monitoring the body weight of HTPRTN hybrids over the weeks of age showed that the cumulative body weight increased steadily over the weeks of age, in accordance with the general growth and development of poultry.

The research results showed that the body weight of the experimental chickens increased gradually over the weeks of age. At the end of 16 weeks of age, the body weight of the HTPRTN hybrid was 2,160.85g. Thus, the body weight at the end of the experiment of the HTPRTN hybrid was 261.2g higher than that of the RTN chicken and 102.13g lower than that of the HTP chicken. The difference in body weight was statistically significant (P<0.05).

The Heterosis in body weight compared to the average of the parents is 3.82%. Thus, the ability to coordinate (Nicking ability) between the father line (HTP chicken) and the mother line (RTN chicken) is effective, creating HTPRTN hybrids with good heterosis exceeding the average of the parents in body weight, and also affirming that the rearing process is appropriate.

3.2.4. Food consumption and heterosis

Table 15. Feed consumption (Mean±SD)

Weeks old	HTP Chicken	RTN Chicken	HTPRTN Chicken
1	1.00±0.01	1.09±0.01	1.11±0.01
4	1.61±0.01	1.73±0.02	1.71±0.05
8	1.89c ± 0.00	2.12a ± 0.01	2.00b ± 0.01
12	2.41c ± 0.01	2.79a ± 0.01	2.53b ± 0.01
16	3.20c ± 0.01	3.63a ± 0.02	3.30b ± 0.02
	Heterosis (%)		-3.49

Note: Mean values in the same row with different letters are statistically different (P<0.05)

The results of monitoring feed consumption/kg body weight gain of HTPRTN crossbreds showed that feed consumption/kg body weight gain increased gradually over the weeks of age. At the end of 16 weeks of age, HTPRTN crossbreds were 3.30kg, 0.1kg higher than HTP chickens, 0.33kg lower than RTN chickens; this difference was statistically significant (P<0.05). This result showed that feed consumption/kg body weight gain of HTPRTN crossbreds was lower than RTN chickens, but higher than HTP chickens.

The heterosis in feed consumption/kg body weight gain compared to the average of the parents is -3.49%. Thus, the ability to coordinate (Nicking ability) between the father (HTP chicken) and the mother (RTN chicken) is effective, creating HTPRTN hybrids with heterosis exceeding the average of the parents in feed consumption/kg body weight gain.

3.2.5. Production index and economic index

The calculation results showed that the production index of HTPRTN hybrid increased gradually, reaching a peak at week 8 of 113.43, then gradually decreased, ending at 16 weeks of age at 46.59.

The economic index of HTPRTN hybrids was highest at 1 week of age at 5.96 and gradually decreased to 1.46 at 16 weeks of age.

Therefore, in raising HTPRTN hybrids, slaughtering at 16 weeks of age should be considered to achieve the highest economic efficiency.

3.2.6. Meat productivity and quality

3.2.6.1. Some meat productivity indicators

Table 16. Survey of some meat productivity indicators (n = 6)

Parameters	HTP	RTN	HTPRTN
	Mean±SE	Mean±SE	Mean±SE
Carcass yield (%)	75.69±0.22	73.50±0.36	74.81±0.19
Thigh meat ratio (%)	23.09±0.23	21.44±0.41	22.11±0.45
Breast meat ratio (%)	21.15±0.16	19.47±0.07	20.78±0.18
Fat ratio (%)	1.02±0.01	0.99±0.01	1.03±0.01

* Carcass ratio:

The carcass ratio of HTPRTN crossbred chickens was 74.81%, this ratio was 1.31% higher than RTN chickens and 0.88% lower than HTP chickens.

* Ratio of thigh and breast meat

The thigh meat ratio of HTPRTN crossbred chickens was 22.11%, this ratio was 0.67% higher than RTN chickens and 0.98% lower than HTP chickens.

The breast meat ratio of HTPRTN crossbred chickens was 20.78%, this ratio was 1.31% higher than RTN chickens and 0.37% lower than HTP chickens.

Thus, the meat yield indicators of HTPRTN crossbred chickens compared with HTP and RTN chickens in this study were different, which confirmed that the factors of breed and crossbreeding formula affected the meat yield parameters.

3.2.6.2. Some meat quality indicators

Table 3.17. Meat quality assessment results (n = 6)

Chicken breeds	Sample type	Analysis indicators			
		Dry matter (%)	**Crude protein** (%)	**Crude fat** (%)	**Total minerals** (%)
HTP	Thigh	24.01	21.29	1.64	1.09
	Breast	25.03	24.25	0.64	1.12
RTN	Thigh	23.21	20.96	1.31	1.14
	Breast	24.89	24.06	0.51	1.11
HTPRTN	Thigh	23.47	21.07	1.43	1.09
	Breast	25.01	23.98	0.58	1.07

* Thigh meat:

The dry matter ratio of HTPRTN crossbred chickens is 23.47%, equivalent to 23.21% for RTN chickens and 24.01% for HTP chickens.

The crude protein ratio of HTPRTN crossbred chicken is 21.07%, this ratio is equivalent to HTP chicken is 21.29%, and RTN chicken is 20.96%.

The crude fat ratio of HTPRTN crossbred chickens is 1.43%, lower than HTP chickens at 1.64%, and higher than RTN chickens at 1.31%.

The total mineral content of HTPRTN crossbred chickens is 1.09%, which is equivalent to 1.14% for RTN chickens and 1.09% for HTP chickens.

* Breast Meat:

The dry matter ratio of HTPRTN crossbred chickens is 25.01%, equivalent to 24.89% for RTN chickens and 25.03% for HTP chickens.

The crude protein ratio of HTPRTN crossbred chicken is 23.98%, this ratio is equivalent to HTP chicken is 24.25%, and RTN chicken is 24.06%.

The crude fat ratio of HTPRTN crossbred chickens is 0.58%, which is lower than HTP chickens at 0.64% and equivalent to RTN chickens at 0.51%.

The total mineral ratio of HTPRTN hybrids is 1.07%, equivalent to 1.11% for RTN chickens and 1.12% for HTP chickens.

Thus, the results of chemical composition analysis of thigh and breast meat of HTPRTN crossbred chickens compared with HTP and RTN chickens in this study were equivalent in terms of dry matter, protein, fat, and total minerals.

3.2.7. Livestock economic efficiency estimation

The results of evaluating the efficiency of commercial crossbred breeding based on achieved technical and economic indicators show that HTPRTN crossbreds have an economic efficiency of breeding 3,955,551 VND for 150 animals, with an average income/animal of 26,370 VND.

Summary: The results of evaluating the meat production and meat quality of HTPRTN hybrids raised to 16 weeks of age showed superiority in body weight compared to the current 3 and 4-breed hybrids with native genetic resources. The body weight at 16 weeks of age was 2,160.85g, and the heterosis was 3.82%. Feed consumption/kg weight gain was 3.30kg, and the heterosis was -3.49%. The chemical composition of the meat was within the limits of chicken meat quality.

3.2.8. Testing commercial hybrid breeding in external farms

3.2.8.1. Survival rate by week of age

The results of monitoring the survival rate of HTPRTN hybrids outside production were all high, at the end of 16 weeks of age, the highest was at the breeding site in Thai Nguyen at 92.67%, followed by the breeding site in Hanoi at 92.00% and the lowest was at the breeding site in Bac Kan at 91.33%.

3.2.8.2. Body weight and feed consumption

Table 3.18. Body weight and feed consumption by weeks of age

(Unit: g; kg; n=50)

Weeks old	Phu Xuyen-Hanoi		Pac Nam-Bac Kan		Pho Yen-Thai Nguyen	
	Mean±SD	TTTA	Mean±SD	TTTA	Mean±SD	TTTA
1	97.10±11.16	1.10	94.90±12.14	1.13	97.50±9.75	1.10
4	409.60±42.76	1.41	415.80±46.91	1.40	415.40±45.09	1.41
8	1,051.20±136.84	1.70	1,048.60±142.30	1.75	1,041.00±178.06	1.76
12	1,551.80±204.64	2.44	1,500.60±210.22	2.52	1,652.60±216.97	2.42
16	1,940.00±287.05	3.35	1,901.60±298.10	3.36	2,002.20±268.66	3.33

The results showed that the body weight of the HTPRTN hybrid raised at 3 locations increased steadily over the weeks of age, under the general growth and development laws of poultry. At the end of 16 weeks of age, the body weight of the HTPRTN hybrid was the highest at the breeding location in Thai Nguyen at 2,002.20g, followed by the breeding location in Hanoi at 1,940.00g, and the lowest at the breeding location in Bac Kan at 1,901.60g. The lowest feed consumption/kg of body weight gain in Thai Nguyen was 3.33kg, followed by Hanoi at 3.35kg, and the highest in Bac Kan at 3.36kg.

* *Comments:* The commercial hybrid HTPRTN raised in three different locations all adapted well, as shown by the high survival rate of 91.33-92.67%. The final body weight at 16 weeks of age was 1901.60-2,002.20g, and the feed consumption/kg of weight gain was 3.33-3.36kg. The results confirmed the superiority of the hybrid HTPRTN, which is the ability to adapt well to all conditions in different regions.

CHAPTER IV
CONCLUSION AND RECOMMENDATIONS

4.1. Conclusion

Selected two lines of colored chicken feathers, HTP and RTN with good quality

The HTP father line has plumage colour of ripe plum for males and bright dry banana leaf colour for females. Improved weight trait at 8 weeks old, genetic progress for males is 71.24 g/generation; females is 67.87 g/generation, high heritability (h^2 = 0.47). Finishing weight at 8 weeks old to the 3rd generation: males was 1,244.89 g (increased by 228.32 g compared to the starting generation); females were 1,053.01 g (increased by 198.24 g compared to the starting generation). Finishing weight at 20 weeks old to generation 3: males were 3,025.10 g; females were 2,001.31 g. Stable egg productivity reaches 106.94-107.64 eggs/68 weeks old. Other parameters are stable over generations of selection.

RTN mother line: the feather colour of males is reddish-brow and females is yellowish-brown, with or without neck spots. Egg production trait up to 38 weeks of age was improved; genetic progress achieved is 1.72 eggs/generation, heritability is average (h^2 = 0.25). Egg production/68 weeks of age to generation 3 was 166.43 eggs (increased by 6.75 eggs compared to the starting generation), feed consumption/10 eggs is 2.65 kg. Final weight at 20 weeks of age: male was 2,485.08-2,520.50g; female was 1,732.52-

1,770.58g. Other parameters are stable through generations of selection.

From two selective breeding lines, HTPRTN commercial hybrids of good quality were produced.

Meat production and meat quality of HTPRTN hybrids raised to 16 weeks of age show that body weight was 2,160.85g, and heterosis was 3.82%. Feed cost/kg weight gain was 3.30kg, and heterosis was -3.49%. The composition of the meat was within the standard of chicken meat quality.

HTPRTN hybrids were experimentally raised in external farms, showing a survival rate of 91.33-92.67%. The final body weight at 16 weeks of age was 1,901.60-2,002.20g, and the feed consumption/kg of weight gain was 3.33-3.36kg.

4.2. Recommendation

Conduct similar studies to effectively exploit the genetic potential and improve the productivity and breed quality of existing colored chicken gene sources.

REFERENCES

1. **Nguyen Trong Thien, Phung Duc Tien, Pham Doan Lan, Nguyen Quy Khiem, Tran Ngoc Tien, Vu Quoc Dung, and Le Van Hung** , 2025. *Selection and creation of HTP colored feather chicken line from Ho chicken and TP chicken*. Journal of Science and Technology of Animal Husbandry No. 149 (February 2025), pp. 45-51.
2. **Nguyen Trong Thien, Phung Duc Tien, Pham Doan Lan, Nguyen Quy Khiem, Tran Ngoc Tien and Vu Quoc Dung, 2025.** *Meat production ability and carcass quality of HTPRTN commercial chicken. Journal of* Animal Science and Technology No. 306-January 2025, pp. 2-5.
3. **Nguyen Trong Thien, Phung Duc Tien, Pham Doan Lan, Tran Ngoc Tien, Le Ngoc Tan and Le Van Hung** , 2025. *Selection and creation of RTN colored feather chicken line from Ri and TN chickens*. Journal of Animal Husbandry Science and Technology No. 307-February 2025, pp. 11-15.