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Growth characteristics of pullets from two-way crossbreeding between Choi and Luong Phuong chickens

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Abstract

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The purpose of the project was to evaluate the growth characteristics of pullets from two-way crossbreeding between ♂ Choi x ♀ Luong Phuong and ♂ Luong Phuong x ♀ Choi chickens. The experiment included 4 treatments (T), namely Treatment 1 (T1): pure Luong Phuong pullets, T2: pure Choi pullets, T3: Hybrid pullets of (♂ Choi x ♀ Luong Phuong), and T4: Hybrid pullets of (♂ Luong Phuong x ♀ Choi). Each treatment consisted of 100 one-day-old female chicks, repeated five times; the experiment concluded when the pullets were 140 days old. T1 and T2 were set up to compare the hybrids (T3 and T4) with their parents. Pullets of all treatments were fed the same complete feed and the same amount of feed at each stage. Chicken feed was divided into four phases, with metabolic energy, protein ratio in feed, and the amount of feed at each stage complying with the standard for meat-colored feather pullets. Pullets of the treatments were raised on rice husk floors and open cages with the same care and feeding regime. The results showed that at 140 days of age, the weight of T3 hybrid pullets was 1887 g/bird, and that of T4 hybrid pullets was 1815 g/bird; weight gain and FCR from 1 to 140 days old of T3 was 13.21 g/bird/day and 4.14 kg, and of T4 was 12.74 g/bird/day and 4.29 kg, respectively. These indicators of T3 compared to T4 have a clear difference ($P < 0.05$). T3 and T4 hybrid pullets meet the above criteria, which are inferior to those of pure Luong Phuong pullets, but are significantly improved compared to pure Choi pullets ($P < 0.05$). The heterosis of the above traits of T3 hybrid pullets is higher, while that of T4 hybrid pullets is lower than the average of their parents. From the above results, it can be concluded that hybrid pullets of T3 (♂ Choi x ♀ Luong Phuong) had better improvement in the above traits than hybrid pullets of T4 (♂Luong Phuong x ♀ Choi).

Keywords: Choi chicken; Luong Phuong chicken; two-way crossbreeding; hybrid pullet

Introduction

In raising breeding hens, raising pullets is the first important step because pullets have a significant influence on the production ability of later laying hens, including egg yield, egg volume, and egg quality. Therefore, many scientists have focused on research into the care regime and feeding program for pullets. For example, some studies focus on protein and amino acids in pullet diets (Christmas et al., 1982; Keshavarz and Jacson, 1992); energy for pullets (Summers et al., 1987, Hadinia et al., 2018: Lu et al., 2023); feed restriction program for pullets and pullet management (Bruggeman et al., 1999; de Beer and Coon, 2007; Zuidhof et al., 2015; Son et al., 2021); solutions to reduce the adverse effects of feed restriction on pullets (Morisey et al., 2014; Arrazola et al., 2020; Coello et al., 2023).

This project is part of a crossbreeding program between Choi chickens and Luong Phuong chickens, implemented by the Thai Nguyen University of Agriculture and Forestry. Choi chicken (also known as Noi chicken) is a colored feather chicken breed with low performance in terms of meat and egg production. However, Choi chicken meat is delicious, and the product has a much higher selling price than other colored feather chicken breeds. Therefore, it is still raised in farms. Luong Phuong chicken is an improved breed of chicken with colored feathers, capable of producing meat and eggs in higher quantities than Choi chicken. Therefore, a crossbreeding program was implemented between Choi chickens and Luong Phuong chickens. This project only studied the growth of hybrid pullets under care and feeding conditions recommended by previous studies, regardless of their affective factors.

Materials and Methods

Pure Luong Phuong (LP), pure Choi (C), Hybrid pullets of (♂C x ♀LP), and Hybrid pullets of (♂LP x ♀C) were used in this experiment (Figure 1).

Choi and Luong Phuong Chicken are meat-oriented chickens with colored feathers. Choi chicken has a low meat yield, but the product has a high selling price. Luong Phuong chicken has been selected and improved, resulting in a higher meat production ability compared to Choi chickens.

The experiment was conducted at the Center for Training and Research on Plant and Animal Breeding, Thai Nguyen University of Agriculture and Forestry, Vietnam.

The experiment included 4 treatments (T), namely T1: pure Luong Phuong (LP) pullets, T2: pure Choi (C) pullets, T3: Hybrid pullets of (♂C x ♀LP), abbreviated as T3(CxLP) and T4: Hybrid pullets of (♂LP x ♀C), abbreviated as T4(LPxC). Each experiment consisted of 100 one-day-old female chickens, replicated five times, and was terminated when the pullets were 140 days old. T1 and T2 were arranged to compare the results of hybrid chickens with those of their parents.

Pullets of all treatments were fed *libitum* (restricted feeding) according to the standards of pullets with meat-oriented color feather chickens. Chicken feed was divided into four stages; metabolic energy and protein ratio in the feed of the stages were as follows: from 1 - 28 days of age was 2,800 Kcal and 20%, from 29 - 49 days old was 2,600 Kcal and 18%, from 50 - 105 days old was 2,800 Kcal and 14%, from 106 - 140 days old was 2,800 Kcal and 15.5%. Pullets from all treatments were raised on rice husk floors and in open cages, with the same care and feeding regimen.

Monitoring indicators include livability rate, body weight and weight gain, feed intake, feed conversion ratio, and calculation of heterosis.

Monitoring of indicators was applied according to Doan et al. (2011). Statistical processing was used according to Dzung et al. (2018).

Results and Discussion

- ***The livability rate***

The livability rate at 140 days old of Luong Phuong, Choi, Hybrid pullets of T3 (CxLP) and T4 (LPxC) was 93.40%, 86.40%, 93.60%, and 92.20%, respectively.

Other studies show that the livability rate of broiler Luong Phuong chickens at 70 days of age was 95 – 97% (Trung, 2017; Nhung, 2021), of Choi chickens at 140 days of age was 86.72% (Hoang, 2010), of F1 (Mia x Luong Phuong) and F1 (Ri x Luong Phuong) at 98 days of age was 93.80 and 94.90% (Quyen et al., 2020), At the exact age of broiler chickens in the above experiments, in this experiment the livability rate of pullets of Luong Phuong pullets at 70 days old was 96.20%, of Choi pullets at 140 days old was 86.40%, of T3(CxLP) and T4(LPxC) pullets at 98 days of age was 94.80 and 93.60%.

Research results on pullets show that the livability rate from 0 to 20 weeks of age of Grimaud pullets was 94.5% (Hoan, 2009), of Noi pullets was 93.48% (Thinh et al., 2020), of F1(Ninh Hoa x LV5) pullets is 96% (Tuyet et al., 2021), of Hac Phong pullets is 94% (Lan et al, 2022), of Mnu Hla Ale pullets was 92,5% (Hanh et al., 2024).

It can be seen that the pullets in this experiment had a high livability rate, equivalent to that of broiler chickens (compared at the same age) and pullets in the above study, which demonstrates that the care and feeding regime for the experimental pullets was appropriate.

- ***The weight of experimental pullets***

Pullets were weighed weekly; however, Table 1 only shows pullet weights every two weeks.

The weight of the chickens at 1 day old was significantly

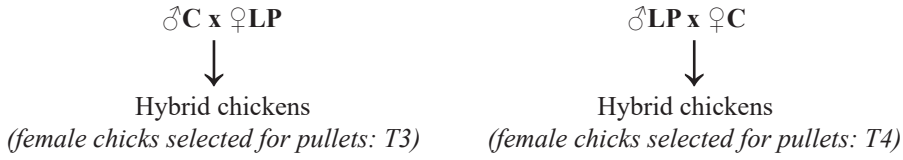

Fig. 1. Scheme of crossbreeding between Choi and Luong Phuong chickens

different among the treatments (P < 0.001), which is the main reason for the difference in chicken weight among the treatments in the subsequent stages.

The weight of both T3(CxLP) and T4(LPxC) pullets was smaller than that of Luong Phuong pullets and larger than that of Choi pullets at all stages. The differences in weight of T3(CxLP) pullets were statistically significant from 56 days of age compared to that of Luong Phuong pullets and Choi pullets (P < 0.01). Meanwhile, the weight of T4(LPxC) pullets was significantly different from 42 days old compared to Luong Phuong pullets and from 112 days of age compared to Choi pullets (P < 0.01–0.05). The weight of T3(CxLP) pullets was greater than that of T4(LPxC) pullets at all stages, but the difference was not statistically significant (P > 0.05), except for the weight at 1 day old.

The weight of pullets at 28 and 140 days of age is an essential basis for assessing chicken growth. According to Van et al. (2015), at 28 days of age, the pullet weight requirement for the colored feather chicken breed is approximately 400 g, and at 140 days, it is approximately 2000 g. In this research, at 28 days of age, only Luong Phuong pullets reached a weight of 400 g. Through monitoring, T3 (CxLP), T4 (LPxC), and Choi pullets reached this weight at 30, 32, and 34 days of age, respectively. At 140 days old, only Luong Phuong pullets reached a weight of 2000g; the weights of T3 (CxLP), T4 (LPxC), and Choi pullets were 113, 184, and 293g lower than the requirement, respectively. However, the first egg laying age of T3(CxLP), T4(LPxC), and Choi hens is about 2-4 weeks later than Luong Phuong hens (Dang et al., 2021; Kien et al., 2023). Therefore, according to estimates, hens in all four treatments will reach a weight of over 2 kg when laying eggs.

Research results on pullets show that the body weight at 20 weeks of age of Thai Chọi pullets was 1704,0 g/bird (Thịnh et al, 2020), of Noi pullets was from 1601,7 to 1629,2 g/bird (Khang et al, 2020), and from 1575,3 to 1590,2 g/bird (Dang et al, 2021), and of ZL pullets at 19 weeks of age was from 1660,3 to 1742,7 g/bird (Sơn et al, 2021). The body weight at 20 weeks of age of F1CLP and F1LPC pullets in this experiment was higher than that of pullets in the above research.

- ***The weight gain of experimental pullets***

The weight gain of pullets at two weeks of age is presented in Table 2.

Table 1. The weight of pullets at different age stages (g/chicken)

Days old	LP	Chọi	T3(Cx LP)	T4(LPxC)	SEM	P
1	38^{a}	32^{b}	37^{a}	33^{b}	1.341	0.000
14	213	174	194	183	2.640	0.102
28	411^{a}	342^{b}	376^{ab}	359^{ab}	5.770	0.002
42	598 ^{a}	500^{b}	549^{ab}	525^{b}	6.263	0.029
56	788^{a}	661^{c}	726^{b}	695^{bc}	7.496	0.006
70	982^{a}	826^{c}	907^{b}	870^{bc}	9.619	0.002
84	1178 ^{a}	993 ^{c}	1090^{b}	1047^{bc}	10.613	0.002
98	1381 ^{a}	1165^{c}	1282 ^{b}	1232 ^{bc}	12.651	0.005
112	1587 ^{a}	1341 ^{c}	1478 ^{b}	1421 ^{b}	15.594	0.014
126	1798 ^{a}	1522 ^{c}	1680 ^{b}	1616 ^{b}	18.445	0.001
140	2014 ^{a}	1707 ^{c}	1887 ^{b}	1815 ^{b}	19.969	0.002

Note: Numbers with different subscription letters in the same row are significantly different (p < 0.05 - 0.001)

Table 2. The weight gain of pullets at age stages (g/bird/day)

Age stages	LP	Chọi	TT3(Cx LP)	T4(LPxC)	SEM	P
1 – 14	12.50^{a}	10.14^{c}	11.21^{b}	10.71^{bc}	0.108	0.007
15 – 28	14.14^{a}	12.00^{c}	13.00^{b}	12.57^{bc}	0.258	0.002
29 – 42	13.36^{a}	11.29^{c}	12.36^{b}	11.86^{bc}	0.242	0.002
43 – 56	13.57^{a}	11.50^{c}	12.64^{b}	12.14^{bc}	0.277	0.027
57 – 70	13.86 ^{a}	11.79 ^{c}	12.93 ^{b}	12.50 ^{bc}	0.300	0.012
71 – 84	14.00 ^{a}	11.93 ^{c}	13.07 ^{b}	12.64 ^{bc}	0.412	0.001
85 – 98	14.50 ^{a}	12.29 ^{c}	13.71 ^{b}	13.21 ^{bc}	0.475	0.000
99 – 112	14.71 ^{a}	12.57 ^{c}	14.00 ^{b}	13.50 ^{bc}	0.554	0.005
113 – 126	15.07 ^{a}	12.93 ^{c}	14.43 ^{b}	13.93 ^{bc}	0.682	0.000
127 – 140	15.43 ^{a}	13.22 ^{c}	14.79 ^{b}	14.29 ^{bc}	0.753	0.001
1 – 140	14.11 ^{a}	11.96 ^{c}	13.21 ^{b}	12.74 ^{bc}	0.662	0.024

Note: Numbers with different subscription letters in the same row are significantly different (p < 0.05 - 0.001)

The weight gain of broiler chickens increases as the age rises until the weight gain reaches a peak, then it gradually decreases with the age of the chicken. The weight gain of pullets does not entirely follow the above rule; it primarily depends on the amount of feed provided to pullets and the energy concentration and protein ratio in the feed at each stage of rearing. In this experiment, from 1 to 14 days old, chickens were fed *ad libitum*; from 15 to 140 days old, they were fed *libitum* (restricted feeding).

Although chickens were fed *ad libitum* from 1 to 14 days of age, their weight gain was not high, ranging from 10.14 to 12.50 g/bird/day, because the experimental chickens were slow-growing breeds and female.

During the 15- to 28-day period, the pullet's weight gain was not significantly higher than in the previous period, at only 12.00–14.14 g/bird/day. That's because pullets were fed a limited amount of feed, only 29.5g of feed or 82.6 kcal ME/bird/day.

For slow-growing colored broiler chicken breeds, the growth spurt typically occurs between 29 and 49 days of age. To control pullets growing too fast at this stage, the energy and protein in feed were reduced (reducing 200 kcal ME/kg and 2% protein in feed compared to those of the previous stage). That is why the weight gain of chickens at this stage was lower than at the last stage.

The weight gain of chickens in the period from 50 to 84 days of age was greater than in the previous period because the metabolic energy in feed was higher than in the last period (increasing 200 kcal ME/kg of feed). However, the weight gain of the chickens was limited due to the insufficient amount of feed, which did not meet their energy and protein needs for growth. For example, at 57 – 70 days old, feed intake of broiler Luong Phuong was 98.9g, including 306.6 kcal ME/bird/day (Kien and Hoan, 2023), while that of Luong Phuong pullet was 47.5g, including 133.0 kcal ME/bird/day, equivalent to about 48.0% of feed and 43.4% of ME compared to the amount of feed and ME that Luong Phuong broiler received.

The amount of feed given to pullets from 85 days of age onwards increased significantly more than in the previous period. From 105 days of age onwards, the protein ratio in the feed increased by 1.5% compared to the last period. Therefore, the weight gain of chickens increased significantly compared to the previous period. The average weight gain of Luong Phuong pullets at stage from 85 - 140 days of age achieved 14.93g/bird/day or 104.5 g/bird/week. The weight gain of chickens from other treatments also showed similar development to that of Luong Phuong chickens.

The weight gain of T3(CxLP) and T4(LPxC) hybrid pullets was smaller than that of Luong Phuong pullets at all stages ($P < 0.05 - 0.001$). The weight gain of T3(CxLP) and T4(LPxC) hybrid pullets was larger than that of Choi pullets at all stages. However, there is only a statistically significant difference between T3 and Choi pullets ($P < 0.05$ to 0.001).

Research results on pullets show that the weight gain from 0 to 20 weeks of age of Grimaud pullets was 14,5 g/bird/day (Hoan, 2009), of Thai Chọi pullets was 12,2 g/bird/day (Thịnh et al, 2020), of Noi pullets was from 11,0 to 11,4 g/bird/day (Khang et al, 2020; Dang et al, 2021), of ZL pullets was from 12,0 to 12,8 g/bird/day (Son et al, 2021). The weight gain of pullets in this experiment was about 12 to 14 g/bird/day, quite similar to the results of the above studies (not much higher or lower).

- ***Feed intake of experimental pullets***

The pullets in the treatments were fed *ad libitum* from 1 to 14 days of age, so the pullets in different treatments received varying amounts of feed. In the following stages, from 15 to 140 days old, the pullets of the treatments were fed *libitum* with the same amount of feed, ensuring the pullets received the same amount of feed. Luong Phuong, Choi, T3(CxLP), T4(LPxC) chickens' feed intake at the period from 1 to 14 days of age was 293, 260, 272, and 266 g/bird, respectively, and at the period from 15 to 140 days of age, it was 7378 g/chicken for all four treatments. Overall, from 1 to 140 days old, the amount of feed received by Luong Phuong, Choi, T3(CxLP), T4(LPxC) pullets was 7671, 7638, 7650, and 7644g/bird, respectively. The amount of feed for pullets in each period is presented in Table 3. This is the basis for explaining "the weight gain of experimental chickens" in Table 2.

Table 3. Feed intake of pullets at different age stages (g/bird)

Period (days old)	Feed fed (g/bird/day)	Increased feed (g/bird/day)	ME (kcal/ kg) and protein (%) in feed
1 – 14	19.50	-----	From 1 – 28 days old: 2800 Kcal, 20%
15 – 28	29.50	10.0	
29 – 42	35.50	6.0	From 29 – 49 days old : 2600 Kcal, 18%
43 – 56	41.50	6.0	
57 – 70	47.50	6.0	From 50 – 105 days old: 2800 Kcal, 14%
71 – 84	54.00	6.5	
85 – 98	63.50	9.5	
99 – 112	73.50	10.0	
113 – 126	85.00	11.5	From 106 – 140 days old : 2800 Kcal, 15.5%
127 – 140	97.00	12.0	
1 – 140	54.79		

Note: Period from 1 to 14 days old: 19.50 g/bird/day is the average of 4 treatments; From 15–29 days old: 29.50 g/chicken/day is the average of the two periods 15–21 and 22–28 days old, the following data are also calculated similarly

Table 3 shows that, during the period from 29 to 49 days of age, the metabolic energy in pullet feed decreased by 200 kcal ME/kg compared to the previous period. This is the main reason for the low growth rate of pullets at this stage (see Table 2). From 50 days of age onwards, the energy in feed increases by 200 kcal ME/kg. Especially from 85 days of age onwards, the amount of feed fed to pullets increased significantly more than in the previous period.

The amount of feed given to pullets at the age of 113–140 days was almost equivalent to the amount of feed received by broilers during the same period. Therefore, chicken weight gain increased significantly at this stage (see Table 2).

The relationship between limited feeding of pullets and their weight gain is illustrated in the following example. During 29 - 42 days of age, Luong Phuong and Choi broiler chickens were fed *ad libitum*, Luong Phuong broiler received 296.83 kcal ME/bird/day, the weight gain was 36.36g/bird/day; Choi broiler received 169.97kcal ME/bird/day, the weight gain was 17.14g/bird/day (Kien and Hoan, 2023). At the same period, pullets of all treatments in this experiment were fed *libitum* with the same complete mixed feed and the same amount of feed, so the pullets received the same 92.30 kcal ME/bird/day for all four treatments. However, the weight gain of pullets varied among treatments; the weight gain of Luong Phuong pullets was 13.36g/bird/day, while that of Choi pullets was 11.29g/bird/day. Thus, Luong Phuong pullet was provided with about 31.1% energy and gained weight by 36.74% compared to Luong Phuong broiler chicken. Choi pullets received approximately 54.3% of the energy and gained weight by 65.87% compared to Choi broiler chickens.

The above example demonstrates that it is possible to increase the weight of F1CLP and F1LPC pullets at 140 days of age by increasing the amount of feed or the nutritional concentration of the feed for F1CLP and F1LPC pullets compared to the standards in Table 3.

- ***Feed conversion ratio***

The feed conversion ratio for weight gain of pullets at each two-week age is presented in Table 4.

Table 4 shows that the feed conversion ratio for weight gain of pullets increases with age stages regardless of whether the concentration of metabolic energy and protein ratio in the feed increases or decreases at each stage.

The feed conversion ratio for weight gain of T3 and T4 hybrid pullets was always greater than that of Luong Phuong pullets from the period of 15 to 140 days of age ($P < 0.001$).

The feed conversion ratio for weight gain of T3 hybrid pullets was smaller than that of Choi pullets from 15 to 140 days of age, and that of T4 hybrid pullets was smaller than that of Choi pullets from 43 to 140 days of age, with $P < 0.001$. Overall, for the entire period (from 1 to 140 days of age), the average feed conversion ratio for weight gain in pullets across different treatments was significantly different ($P < 0.001$).

The feed conversion ratio for weight gain of T3 hybrid pullets was smaller than that of T4 hybrid pullets from 85 days of age onwards, with $P < 0.001$. Thus, the feed utilization efficiency of hybrid pullets of T3(CxLP) was higher than that of hybrid pullets of T4(LPxC).

The feed conversion ratio for weight gain of pullets of other chicken breeds was as follows: of Grimaud pullets was 4.57 kg (Hoan, 2009), of Thai Choi pullets was 5,31 kg (Thinh et al, 2020), of ZL pullets was 4.62 - 4.64 kg (Son et al, 2021). The feed conversion ratio for weight gain of pullets in the experiment ranged from 3.88 to 4.56 kg, which is equivalent to or smaller than the results of the above studies.

Heterosis of some crossed pullet traits

The heterosis of some traits, such as weight, weight gain, and feed conversion ratio, of T3 and T4 hybrid pullets is presented in Table 5.

Table 4 Feed conversion ratio for weight gain of pullets at age stages (kg/kg)

Age stages	LP	Chọi	F1 Cx LP	F1 LPxC	SEM	P
1 – 14	1.67^{b}	1.83^{a}	1.73^{ab}	1.77^{ab}	0.018	0.000
15 – 28	2.09^{c}	2.46^{a}	2.27^{b}	2.35 ^{ab}	0.021	0.000
29 – 42	2.66^{c}	3.14^{a}	2.87 ^{b}	2.99 ^{ab}	0.075	0.000
43 – 56	3.06^{c}	3.61^{a}	3.28 ^{b}	3.42 ^{b}	0.104	0.000
57 – 70	3.43^{c}	4.03^{a}	3.67 ^{b}	3.80^{b}	0.130	0.000
71 – 84	3.86^{c}	4.53^{a}	4.11^{b}	4.27^{b}	0.143	0.000
85 – 98	4.38^{d}	5.17^{a}	4.63 ^{c}	4.81^{b}	0.155	0.000
99 – 112	5.00^{d}	5.85^{a}	5.25^{c}	5.44 ^{b}	0.174	0.000
113 – 126	5.64^{d}	6.57^{a}	5.89 ^{c}	6.10 ^{b}	0.193	0.000
127 – 140	6.29 ^{d}	7.34^{a}	6.56 ^{c}	6.79 ^{b}	0.201	0.000
1 – 140	3.88^{c}	4.56^{a}	4.14^{b}	4.29^{b}	0.149	0.000

Note: Numbers with different subscription letters in the same row are significantly different ($p < 0.001$)

Table 5. The heterosis of some traits of the crossed pullets

Traits	T3(CxLP) (1)	T4(LPxC) (2)	(1 + 2)/2
Weight at 140 days old	1.42	- 2.39	- 0.48
Weight gain (1–140 days old)	1.34	- 2.26	- 0.46
FCR (1–140 days old)	-1.90	1.66	-0.36

The heterosis of the weight trait of T3 hybrid pullets at 140 days old had a positive value, while that of T4 hybrid pullets had a negative value. The heterosis of the weight gain trait from 1 to 140 days of age in T3 hybrid pullets had a positive value, whereas that of T4 hybrid pullets had a negative value. In contrast to the above traits, if the FCR trait has a negative value, it is good and expected. The heterosis of the FCR trait from 1 to 140 days of age in T3(CxLP) pullets had a negative value (indicating a beneficial effect), whereas T4(LPxC) pullets had a positive value.

Conclusion

The weight hybrid pullets of T3(CxLP) and T4(LPxC) at 140 days of age was 1887g and 1815g, weight gain and FCR from 1 - 140 days of age of T3 hybrid pullets were 13.21g/bird/day and 4.14kg, of T4 hybrid pullets were 12.74 g/bird/day and 4.29 kg, respectively. Hybrid pullets of T3 and T4 meet the above criteria, which are inferior to those of pure Luong Phuong pullets, but are significantly improved compared to Choi pullets. The heterosis of the above traits in T3 hybrid pullets was higher, while that of T4 was lower than the average of its parents. From the above results, it can be concluded that hybrid pullets of T3(CxLP) have more improvement in the above traits than hybrid pullets of T4(LPxC).

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