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Parent and Offspring Performances of Different Genetic Groups of Chicken in Selected Economically-Important Traits Under Intensive Rearing System

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Abstract
This study investigated the performance of parent and offspring chickens from six genetic groups under an intensive rearing system, focusing on key economic traits. Using a Completely Randomized Design, 30 birds (6 roosters and 24 hens) were bred, and their offspring evaluated for productive traits (initial and final body weight, average daily gain [ADG], feed conversion ratio [FCR]), reproductive traits (fertility and hatchability), and aesthetic traits (egg size and yolk color). Data were analyzed using descriptive statistics, ANOVA, and Chi-square tests. Results showed that body weight differences among roosters became significant only by Week 20, with R1 showing superior growth and FCR, while R6 exhibited strong late-stage weight gain but poorer feed efficiency. Offspring outperformed parent lines in both growth and FCR, indicating genetic progress and possible hybrid vigor. Fertility was generally high, but hatchability varied significantly due to temperature-related hatching issues, suggesting post-fertilization losses. Most hens produced small eggs, though moderate numbers of medium-sized eggs were recorded, and yolk color differences were linked to genetic variation in pigment absorption. Egg size distribution showed significant genetic influence. These findings highlight the value of genetic selection, improved incubation management, and genotype-environment adaptation in enhancing productivity under intensive poultry systems.

Keywords: Chicken Genetics, Feed Conversion Ratio, Average Daily Gain, Egg Traits, Fertility, Hatchability, Intensive Rearing

Introduction

Poultry production remains a vital component of agricultural development and food security, particularly in developing countries like the Philippines. Chickens, being relatively easy to raise and requiring minimal investment, are integral to the livelihood of many rural households. They contribute not only to income generation but also to the availability of animal protein in the form of meat and eggs (Padhi, 2016) [51]. In the Philippines, a wide range of chicken genetic groups—both indigenous and crossbred—are raised under varying management systems. These genetic resources vary significantly in traits such as growth rate, egg production, disease resistance, and adaptability to local conditions (Valdez *et al*., 2015; Espina *et al*., 2020) [70, 24].

One of the major factors influencing poultry productivity is genetic potential. Differences in genetic composition account for the variability in economically important traits such as body weight, egg production, hatchability, and feed efficiency. For instance, local breeds like the Darag or Camarines chickens are known for their adaptability and resistance to diseases but generally exhibit slower growth and lower egg yields than commercial hybrids like the Plymouth Rock or White Leghorn (Yan, 2020; Gebre *et al*., 2023) [77, 29]. Studies such as those conducted by Faruque *et al*. (2016) [26] and Okeno *et al*. (2015) [49] affirm that breed-specific traits significantly affect performance and should be factored into breeding and management strategies.

In recent years, intensive rearing systems have gained attraction in the Philippines due to their potential to improve productivity by providing controlled environments, consistent feeding regimens, and optimized biosecurity. However, the genetic response of indigenous and crossbred chickens under such systems is still underexplored. According to Dapanas & Niepes (2024) [21], chickens raised under intensive systems showed improved growth rate, feed conversion ratio, and carcass yield compared to those raised in free-range settings. However, genetic group performance varied, emphasizing the need for genotype-specific management practices.

Moreover, quantitative and qualitative trait assessments have become indispensable tools in identifying superior breeds and improving selection programs. Studies such as those by Pandey *et al*. (2022) [52] and Alabi *et al*. (2019) [5] compared indigenous chicken breeds and highlighted differences in traits like body weight, egg weight, shell quality, and hatchability under intensive management conditions. These findings demonstrate the value of breed evaluation in tailoring genetic improvement programs. Similarly, Gebre *et al*. (2023) [29] found that crossbreeds between Sasso and Fayoumi outperformed their parent lines in growth and feed efficiency, suggesting that genetic hybrid vigor (heterosis) can be harnessed to boost productivity.

Despite the potential of genetic improvement, indigenous chickens continue to be preferred by many smallholder farmers due to their hardiness, foraging ability, and cultural value (Mtambo, 2020) [42]. Therefore, it becomes essential to strike a balance between improving performance and conserving genetic diversity. The challenge lies in determining which genetic groups exhibit favorable traits under intensive rearing systems and how such traits can be passed on to the next generation.

This study was conducted to evaluate the parent and offspring performance of different genetic groups of chicken in selected economically important traits under an intensive rearing system. By analyzing performance indicators such as growth rate, feed efficiency, reproductive traits, and survivability, the study aims to provide empirical data that can inform breeding strategies, optimize productivity, and support the sustainable development of the poultry sector in the Philippines.

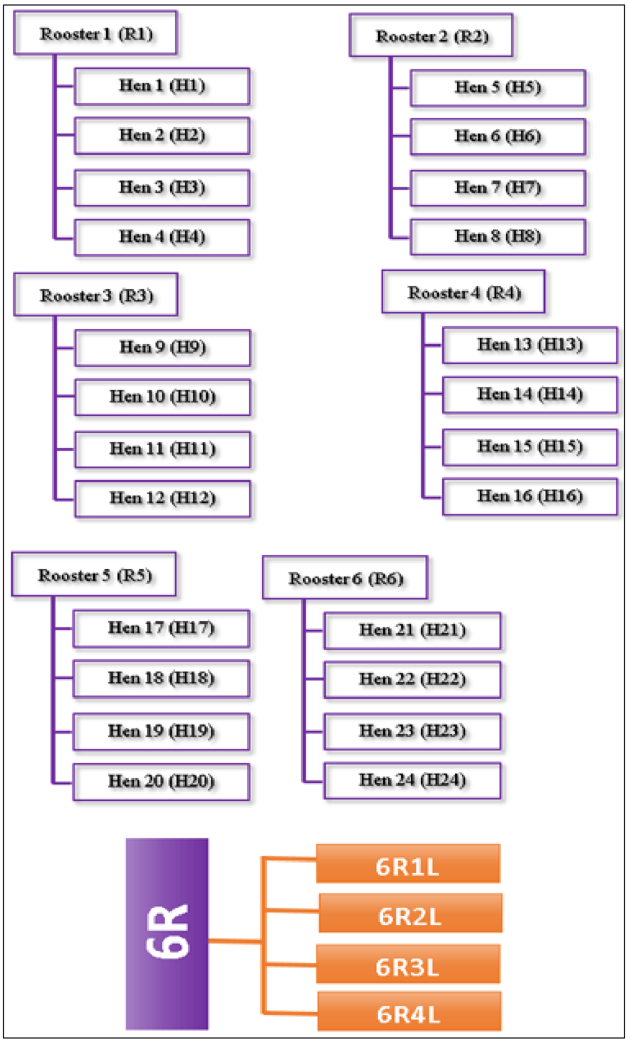
Methodology

This study was conducted from December 2023 to March 2024 at a poultry facility in Barangay Mendiola, Siniloan, Laguna, to evaluate the parent and offspring performances of different genetic groups of chickens in selected economically important traits under intensive rearing conditions.

A Completely Randomized Design (CRD) was used with thirty (30) parent stocks, composed of six (6) roosters and twenty-four (24) hens. Each rooster was randomly mated with four hens to produce six distinct genetic crosses. A nested mating design (half-sib and full-sib) was employed to estimate additive and total genetic variance among family lines.

All birds were housed in disinfected 1-square-meter cages equipped with PVC feeders and automatic water systems, and were subjected to the same feeding regimen, lighting schedule, and housing environment to minimize non-genetic variation. Roosters were given stag developer crumble and hens were fed layer mash during mating, while offspring received a three-phase commercial feeding program: chick booster (day 1–31), chick starter (day 32–90), and grower feeds (day 91–150).

Data collection focused on three categories of traits: productive (initial and final body weights, average daily gain, feed conversion ratio), reproductive (fertility and hatchability rates), and aesthetic (egg size and yolk color using a standardized Yolk Color Fan). All birds were individually tagged, and offspring were wing-banded to maintain accurate records throughout the 16-week rearing period. Data were analyzed using descriptive statistics (mean, standard deviation, and range), with one-way ANOVA applied to determine significant differences among genetic groups. Chi-square test was used for categorical data such as egg size distribution, with all tests evaluated at a 5% level of significance.



Legend: R – Rooster; **H** – Hen

Fig 1: Experimental layout

Description of the Genetic Groups of Parent Stocks

For this study, the selection of experimental chickens was based on breed variation, availability, and relevance to the research objectives. A total of six roosters were utilized, representing diverse crosses. To complement this diversity, twenty-four hens of various breeds were selected to ensure a broad genetic base for estimating the performance of the different genetic groups in economically important traits under the intensive rearing system.

Each rooster was assigned to mate with four hens, resulting in six distinct mating groups. This mating scheme was designed to facilitate the analysis of performance within and across groups. All chickens were housed and managed under a uniform intensive rearing system throughout the study. Standardized environmental conditions were maintained to minimize external influences, thereby allowing a more accurate assessment of the performance in the selected traits.

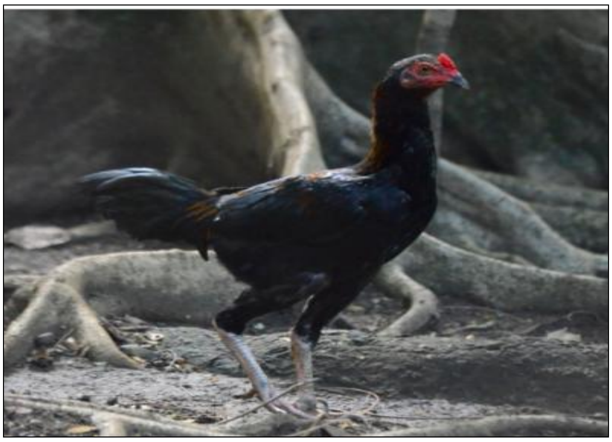


Plate 1: Rooster 1 (R1)

Rooster 1 *(R1)* weighed 1.45kg, with a height of 28.5cm, and a width of 11.5cm. It had black feathers, black shanks, and a single comb type.

Plate 2: Rooster 2 (R2)

Rooster 2 *(R2)* weighed 1.45kg, with a height of 35cm, and a width of 10cm. It had red feathers, with black on the tail, white shanks, and a carnation comb type.

Plate 3: Rooster 3 (R3)

Rooster 3 *(R3)* weighed 1.50kg, with a height of 40cm, and a width of 10cm. It had reddish feathers, with black on the tail, white shanks, and a carnation comb type.

Plate 4: Rooster (R4)

Rooster 4 *(R4)* weighed 1.45kg, with a height of 45cm, and a width of 11.5cm. It had greyish feathers, white shanks, and a carnation comb type.

Plate 5: Rooster 5 (R5)

Rooster 5 *(R5)* weighed 1.60kg, with a height of 45cm, and a width of 11.5cm with reddish feathers, with black on the tail, white shanks, and a carnation comb type.

Plate 6: Rooster 6 (R6)

Rooster 6 *(R6)* weighed 2.1kg, with a height of 45cm, and a width of 11.5cm. It has white feathers, white shanks, and a carnation comb type.

Plate 7: Hen 1 (H1)

Hen 1 *(H1)* weighed 1kg, with a height of 20cm and a width of 9cm. It had yellowish-brown plumage, gray shanks and a single comb. The beak color was observed to be either dark or light brown/gray upon acquisition.

Plate 8: Hen 2 (H2)

Hen 2 *(H2)* weighed 1.5kg, with a height of 35cm and a width of 11.5cm. It had reddish-brown feathers with white under-feathers, yellow shank, yellow beak, and a single comb type bright red upon acquisition.

Plate 9: Hen 3 (H3)

Hen 3 *(H3)* weighed 1.45kg, with a height of 25cm and a width of 10cm. It had yellowish-brown plumage, gray shanks and a single comb. The beak color was observed to be either dark or light brown/gray upon acquisition.

Plate 10: Hen 4 (H4)

Hen 4 *(H4)* weighed 1.30kg, with a height of 24cm and a width of 9cm. It had dark grey feathers, with a dark beak and dark shanks, and a single comb type upon acquisition.

Plate 11: Hen 5 (H5)

Hen 5 *(H5)* weighed 1.35kg, with a height of 25cm and a width of 9cm. It had yellowish-brown plumage, with gray shanks and a single comb. The beak color was observed to be either dark or light brown/gray upon acquisition.

Plate 12: Hen 6 (H6)

Hen 6 (H6) weighed 1.40kg, with a height of 20cm and a width of 10cm. Its plumage was predominantly white, accented with black feathers around the neck, tail, and wings. It has a distinctive rose comb, white feather, white beak, white shank, and a single comb type upon acquisition.

Plate 13: Hen 7 (H7)

Hen 7 *(H7)* weighed 1.30kg, with a height of 23cm and a width of 11cm. It had yellowish-brown plumage, gray shanks and a single comb. Its beak color was observed to be either dark or light brown/gray upon acquisition.

Plate 14: Hen 8 (H8)

Hen 8 *(H8)* weighed 1.45kg, with a height of 25cm and a width of 11.5cm. It had dark grey feathers, with dark beak and dark shanks, and a single type comb upon acquisition.

Plate 15: Hen 9 (H9)

Hen 9 (*H9*) weighed 1.42kg, with a height of 38cm and a width of 9cm. It had reddish-brown feathers with white under-feathers, yellow shanks and a yellow beak, and a bright red single comb type upon acquisition.

Plate 16: Hen 10 (H10)

Hen 10 (*H10*) weighed 1.45kg, with a height of 43cm and a width of 11cm. The plumage was black, with yellow shanks and yellow feet. There was also a reddish hue possibly on the toes and sides of the shanks. The beak was reddish-brown, or black color, and the comb was could be either a single or rose type.

Plate 17: Hen 11 (H11)

Hen 11 (*H11*) weighed 1.50kg, with a height of 20cm and a width of 9cm. It also had reddish-brown feathers, with white under-feathers, and yellow shank and yellow beak, and a bright red single comb type upon acquisition.

Plate 18: Hen 12 (H12)

Hen 12 (H12) weighed 1.45kg, with a height of 23cm and a width of 9.5cm. The plumage was predominantly white, accented with black feathers around the neck, tail, and wings. *It has a distinctive rose comb*, white feathers, white beak, white shanks, and a single comb type upon acquisition.

Plate 19: Hen 13 (H13)

Hen 13 (*H13*) weighed 1.55kg, with a height of 40cm. The plumage was black. The shanks and feet were yellow, with a possible reddish hue on the toes and sides of the shanks. The beak was reddish-brown, and the comb type was either a single or rose upon acquisition.

Plate 20: Hen 14 (H14)

Hen 14 (*H14*) weighed 1.30kg, with a height of 35cm, and a width of 9.5cm. The plumage was predominantly white, accented with black feathers around the neck, tail, and wings. It has a distinctive rose comb, white feathers, white beak, white shanks, and a single comb type upon acquisition.

Plate 21: Hen 15 (H15)

Hen 15 (*H15*) weighed 1.30kg, with a height of 35cm, and a width of 9.5cm. It had yellowish-brown plumage, gray shanks and a single comb type. The beak was either dark or light brown/gray upon acquisition.

Plate 22: Hen 16 (H16)

Hen 16 (*H16*) weighed 1.55kg, with a height of 38cm, and a width of 9.5cm. It also had dark grey feathers, with dark beak and dark shanks, and a single comb type upon acquisition.

Plate 23: Hen 17 (H17)

Hen 17 (*H17*) weighed 1.45kg, with a height of 35cm, and a width of 11.5cm. The plumage was black, with black shanks and black feet. The comb type was either single or rose upon acquisition.

Plate 24: Hen 18 (H18)

Hen 18 (*H18*) weighed 1.38kg, with a height of 35cm, and a width of 10.5cm. It had brown feathers with white under-feathers, yellow shanks, a yellow beak, and a bright red single comb type upon acquisition.

Plate 25: Hen 19 (H19)

Hen 19 (*H19*) weighed 1.56kg, with a height of 40cm, and a width of 9.5cm. The plumage was black, with black shanks and black feet, and the comb type was either single or rose upon acquisition.

Plate 26: Hen 20 (H20)

Hen 20 (*H20*) weighed 1.35kg, with a height of 38cm, and a width of 10.5cm. It also had yellowish-brown plumage, gray shanks and a single comb type. The beak was either dark or light brown/gray upon acquisition.

Plate 27: Hen 21 (H21)

Hen 21 (*H21*) weighed 1.65kg, with a height of 32cm, and a width of 9.5cm. The plumage was predominantly white, accented with black feathers around the neck, tail, and wings. It has a distinctive rose comb**,** white feathers, white beak, white shanks, and a single comb type upon acquisition.

Plate 28: Hen 22 (H22)

Hen 22 (*H22*) weighed 1.57kg, with a height of 35cm, and a width of 10.5cm. It had yellowish-brown plumage, gray shanks and a single comb type. The beak was either dark or light brown/gray upon acquisition.

Plate 29: Hen 23 (H23)

Hen 23 (*H23*) weighed 1.5kg, with a height of 34cm, and a width of 10.5cm. The plumage was predominantly white, accented with black feathers around the neck, tail, and wings. It has a distinctive rose comb**,** white feathers, white beak, white shanks, and a single comb type upon acquisition.

Plate 30: Hen 24 (H24)

Hen 24 (*H24*) weighed 1.5kg, with a height of 40cm, and a width of 11.5cm. The beak was black, with black feathers and black shanks, and a single comb type upon acquisition.

Results and Discussion

Initial and weekly body weight of the roosters

Observations of weekly body weight for six genetic rooster groups (R1 through R6) under intensive rearing conditions demonstrated consistent growth throughout a 20-week study period (Table 1). Starting weights ranged from 1450g for groups R1, R2, and R4, up to 2100g for R6. Each group exhibited steady weight increases week-over-week. By the study's conclusion at week 20, average body weights fell between 2850g and 3200g. Notably, the spread of individual weights within groups progressively tightened, suggesting less variation among the roosters as they matured. This trend aligns with prior poultry growth studies that indicate a stabilizing effect as animals approach maturity (Gonzales *et al*., 2017).

Statistical analysis showed no significant differences in weekly body weights among the genetic groups during the initial period extending through week 19. However, a clear and significant difference emerged at week 20. This indicates that while early growth is similar, distinct growth patterns become apparent among the genetic groups as they reach maturity, consistent with previous reports on genetic variability in growth traits (Zhang *et al*., 2021) [80].

Across the groups, mean body weight varied considerably, with group R6 consistently exhibiting the highest weights. This may suggest superior genetic growth potential, possibly influenced by inherent genetic factors or heterosis effects, as highlighted by Amusan *et al*. (2020) [8]. The progressive reduction in weight variation observed over the rearing period is consistent with the findings of Dapanas & Niepes (2024) [21], who similarly noted reduced growth variability in maturing chickens under intensive rearing conditions.

The consistent increase in body weight throughout the study aligns with established poultry growth patterns, characterized by an accelerated growth rate in early weeks before leveling off as chickens approach their mature size (Quintana *et al*., 2023). The absence of significant differences during the initial weeks can likely be attributed to uniform management practices, including feeding and environmental conditions, which effectively minimize external variation. This emphasizes the growing influence of genetic factors as roosters approach maturity (Chu *et al*., 2019) [18].

These findings underscore the crucial role of both genetic selection and management practices in optimizing growth performance across different genetic groups of chickens raised in intensive systems. The significant differences observed at week 20 suggest that specific developmental stages are particularly important for genetic influences on growth to become more pronounced, a key consideration for breeding programs focused on improving economically valuable traits.

Table 1: Initial and weekly body weight of the roosters (grams)

Period	R1	R2	R3	R4	R5	R6
Initial	1450.0	1450.0	1500.0	1450.0	1600.0	2100.0
W1	1532.0	1518.0	1566.0	1514.0	1665.0	2135.0
W2	1618.0	1595.0	1631.0	1576.0	1719.0	2175.0
W3	1704.0	1662.0	1695.0	1646.0	1777.0	2220.0
W4	1776.0	1734.0	1756.0	1715.0	1837.0	2262.0
W5	1859.0	1798.0	1827.0	1777.0	1898.0	2305.0
W6	1939.0	1873.0	1895.0	1846.0	1951.0	2343.0
W7	2013.0	1949.0	1956.0	1901.0	2010.0	2378.0
W8	2083.0	2017.0	2015.0	1957.0	2070.0	2423.0
W9	2162.0	2077.0	2085.0	2013.0	2132.0	2461.0
W10	2238.0	2143.0	2146.0	2081.0	2186.0	2506.0
W11	2321.0	2203.0	2205.0	2145.0	2245.0	2546.0
W12	2398.0	2267.0	2267.0	2212.0	2301.0	2585.0
W13	2477.0	2340.0	2335.0	2275.0	2354.0	2622.0
W14	2559.0	2402.0	2394.0	2345.0	2407.0	2667.0
W15	2630.0	2466.0	2459.0	2414.0	2466.0	2707.0
W16	2714.0	2533.0	2527.0	2469.0	2519.0	2743.0
W17	2789.0	2597.0	2589.0	2525.0	2582.0	2778.0
W18	2873.0	2669.0	2649.0	2587.0	2635.0	2818.0
W19	2944.0	2732.0	2720.0	2649.0	2693.0	2861.0
W20	3200.0	3000.0	2920.0	2850.0	2900.0	3000.0

Legend: R – Rooster, W – Week

Performance of parent roosters from 5 to 11 months of age

Table 2 presents the performance of parent roosters (R1 to R6) from 5 to 11 months of age for initial and final body weight, average daily gain (ADG), and feed conversion ratio (FCR) under intensive rearing conditions. Notable differences in growth and efficiency among the genetic lines of the roosters can be observed.

The initial body weights ranged from 1,450g (R1, R2, R4) to 2,100g (R6), while final weights ranged between 2,850g (R4) and 3,200g (R1). The mean of the initial weight across all roosters was 1,591.7 ± 255.8g, while the final weight was 2,978.3 ± 123.4g. The values reflect weight gains across the lines of the roosters, although the degree of gain and efficiency are significantly different.

R1 had the highest average daily gain (ADG) of (11.7 g/day), followed by R2 (10.3 g/day), while R6 had the lowest (6.0 g/day). R1 displayed the best growth rate having the highest final body weight, while the lowest FCR among the roosters.

R1 performed the best in terms of feed conversion ratio (FCR) garnering an FCR of 12.0, which indicates that R1 required the least amount of feed to gain one unit of body weight. In contrast, R6 recorded the poorest despite having the highest initial body weight, recording an FCR value of 23.3, which indicates inefficiency in converting feed into body mass. The mean FCR across the rooster lines was 15.8 ± 4.0, indicating a moderate feed efficiency with significant variation among genetic groups of the roosters.

The findings highlight the influence of genetic background on growth performance and feed utilization efficiency. The superior performance of R1 aligns with results from Zerehdaran *et al.* (2016) [78], who emphasized the role of selective breeding in enhancing growth rate and feed efficiency in meat-type poultry. Similarly, Melesse *et al.* (2019) [43] demonstrated that genotype significantly affects both weight gain and feed efficiency, particularly under uniform management conditions, as applied in this study.

The resulting FCR and ADG values of R6 despite having a high starting weight suggest a possible genetic predisposition toward earlier maturation or probably due to less efficient nutrient utilization. This observation supports the findings of Chen *et al.* (2021) [15], who reported that heavier breeds may show reduced marginal growth efficiency, especially when feed is not specifically formulated for their metabolic needs.

Overall, Table 2 provides a clear picture of performance variability among genetic groups of the roosters, supporting the need for genotype-specific selection strategies in breeding programs. Efficient genetic lines like R1 should be prioritized in breeding for economically significant traits, especially under intensive production systems where feed cost is a major concern.

Table 2: Performance of parent roosters from 5 to 11 months of age

Rooster	Initial Body Weight at 5 months (g)	Final Body Weight at 11 months (g)	Average Daily Gain (g)	Feed Conversion Ratio (FCR)
R1	1450.0	3200.0	11.7	12.0
R2	1450.0	3000.0	10.3	13.5
R3	1500.0	2920.0	9.5	14.8
R4	1450.0	2850.0	9.3	15.0
R5	1600.0	2900.0	8.7	16.2
R6	2100.0	3000.0	6.0	23.3
Mean ± SD	1591.7 ± 255.8	2978.3 ± 123.4	9.2 ± 1.9	15.8 ± 4

Legend: R – Rooster

Table 3 details the weekly body weight progression of parent hens across 24 distinct genetic combinations. These combinations were derived from mating six rooster lines (R1 to R6) with four hen lines each (H1 to H24) and were raised under intensive rearing conditions over a 20-week period. The data consistently show an increase in body weight across all groups; however, significant variations in growth performance were evident among the diverse genetic combinations.

Initial body weights exhibited a broad range, from 1050g to 2050g, reflecting the inherent genetic differences present in the hens at the outset of the rearing period. By week 20, final body weights spanned from 1440g to 3060g, indicating substantial divergence in growth potential among the combinations. These variations strongly suggest that the genetic makeup of both the sires and dams had a considerable influence on growth outcomes.

On average, the hens demonstrated consistent weekly gains culminating to a significant increase at week 20. This outcome indicates that the birds adapted effectively to the intensive rearing system, successfully expressing their growth potential under uniform environmental and nutritional management.

Certain crossbreeds, particularly those involving the R4 rooster line (e.g., R4xH13 and R4xH14), consistently displayed superior growth throughout the trial, achieving weights above 2900g by the period's end. Conversely, combinations such as R5xH18 and R6xH22 recorded comparatively lower terminal weights, remaining closer to the lower end of the range (around 1440–1860g). These contrasting results reinforce the significant influence of specific genetic pairings on overall growth efficiency.

The observed growth patterns align with prior research highlighting the pivotal role of genetic background in determining performance traits in poultry. Studies by Dominguez *et al.* (2016) [22] and Moreki & Chiripasi (2022) [45] have demonstrated that even within comparable management systems, certain genotypes can markedly outperform others. Similarly, Chen *et al.* (2019) [16] underscored how intensive rearing conditions can amplify genetic differences, enabling superior lines to express their growth advantages more distinctly.

Furthermore, these differences may also reflect genotype-by-environment interactions, where specific sire lines (notably R4 and R1) appear better suited to intensive production settings, potentially due to enhanced feed utilization or metabolic efficiency, as suggested by Grobbelaar (2021) [30].

In summary, these results demonstrate that strategic mating combinations can significantly impact growth performance in parent hens. Crosses involving high-performing rooster lines like R4 and R1 show promise for selection in breeding programs aimed at improving body weight and meat yield under intensive rearing systems. Conversely, combinations exhibiting lower performance might be more appropriate for alternative production strategies, such as dual-purpose or smallholder settings.

Table 3: Initial and weekly body weight of the hens in grams

Week	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16	H17	H18	H19	H20	H21	H22	H23	H24
Initial	1450.0	1200.0	1250.0	1350.0	1150.0	1350.0	1200.0	1850.0	1500.0	1250.0	1150.0	1250.0	1750.0	2050.0	1400.0	1650.0	2050.0	1600.0	1500.0	1750.0	1300.0	1050.0	1450.0	1600.0
W1	1490.0	1240.0	1290.0	1390.0	1190.0	1390.0	1240.0	1890.0	1540.0	1300.0	1200.0	1300.0	2250.0	2100.0	1450.0	1690.0	2090.0	1640.0	1540.0	1790.0	1340.0	1090.0	1490.0	1640.0
W2	1540.0	1280.0	1330.0	1430.0	1240.0	1440.0	1290.0	1940.0	1580.0	1340.0	1240.0	1350.0	2300.0	2140.0	1490.0	1740.0	2130.0	1680.0	1590.0	1840.0	1380.0	1130.0	1530.0	1690.0
W3	1580.0	1330.0	1370.0	1480.0	1280.0	1480.0	1330.0	1980.0	1630.0	1380.0	1240.0	1390.0	2350.0	2190.0	1530.0	1780.0	2180.0	1730.0	1630.0	1880.0	1430.0	1170.0	1570.0	1740.0
W4	1630.0	1370.0	1420.0	1520.0	1320.0	1520.0	1370.0	2020.0	1670.0	1420.0	1280.0	1440.0	2390.0	2230.0	1570.0	1820.0	2220.0	1770.0	1670.0	1920.0	1470.0	1170.0	1620.0	1780.0
W5	1670.0	1410.0	1460.0	1560.0	1360.0	1560.0	1420.0	2070.0	1720.0	1470.0	1330.0	1480.0	2430.0	2270.0	1620.0	1860.0	2260.0	1810.0	1710.0	1960.0	1510.0	1220.0	1660.0	1820.0
W6	1710.0	1450.0	1500.0	1610.0	1400.0	1600.0	1460.0	2110.0	1760.0	1510.0	1370.0	1520.0	2470.0	2320.0	1660.0	1910.0	2300.0	1850.0	1750.0	2000.0	1560.0	1260.0	1700.0	1860.0
W7	1760.0	1490.0	1540.0	1650.0	1450.0	1650.0	1500.0	2150.0	1800.0	1550.0	1410.0	1560.0	2520.0	2360.0	1700.0	1950.0	2350.0	1890.0	1800.0	2050.0	1600.0	1300.0	1740.0	1910.0
W8	1800.0	1540.0	1590.0	1700.0	1490.0	1690.0	1550.0	2190.0	1840.0	1600.0	1460.0	1610.0	2560.0	2400.0	1750.0	1990.0	2390.0	1940.0	1840.0	2090.0	1640.0	1340.0	1790.0	1950.0
W9	1840.0	1580.0	1630.0	1740.0	1530.0	1730.0	1590.0	2230.0	1880.0	1640.0	1500.0	1650.0	2600.0	2440.0	1790.0	2030.0	2430.0	1990.0	1880.0	2130.0	1680.0	1380.0	1830.0	1990.0
W10	1880.0	1630.0	1680.0	1780.0	1580.0	1770.0	1640.0	2270.0	1920.0	1680.0	1540.0	1690.0	2640.0	2490.0	1830.0	2080.0	2470.0	2030.0	1930.0	2170.0	1720.0	1430.0	1870.0	2030.0
W11	1920.0	1670.0	1720.0	1820.0	1620.0	1820.0	1680.0	2320.0	1970.0	1720.0	1580.0	1730.0	2680.0	2530.0	1870.0	2120.0	2520.0	2070.0	1970.0	2220.0	1770.0	1480.0	1920.0	2080.0
W12	1960.0	1710.0	1760.0	1870.0	1670.0	1860.0	1720.0	2360.0	2010.0	1760.0	1620.0	1770.0	2730.0	2570.0	1910.0	2160.0	2560.0	2120.0	2010.0	2260.0	1810.0	1520.0	1960.0	2120.0
W13	2010.0	1760.0	1810.0	1910.0	1710.0	1900.0	1760.0	2400.0	2050.0	1810.0	1660.0	1810.0	2770.0	2610.0	1950.0	2210.0	2600.0	2160.0	2060.0	2300.0	1850.0	1560.0	2000.0	2160.0
W14	2060.0	1800.0	1850.0	1950.0	1750.0	1940.0	1810.0	2450.0	2090.0	1850.0	1700.0	1860.0	2810.0	2650.0	2000.0	2250.0	2650.0	2200.0	2100.0	2340.0	1890.0	1610.0	2050.0	2210.0
W15	2110.0	1850.0	1890.0	1990.0	1790.0	1990.0	1850.0	2490.0	2140.0	1890.0	1750.0	1900.0	2850.0	2690.0	2040.0	2290.0	2690.0	2250.0	2140.0	2390.0	1940.0	1650.0	2090.0	2260.0
W16	2150.0	1890.0	1930.0	2040.0	1840.0	2030.0	1890.0	2530.0	2180.0	1930.0	1790.0	1940.0	2890.0	2730.0	2080.0	2330.0	2730.0	2290.0	2180.0	2430.0	1980.0	1690.0	2130.0	2300.0
W17	2190.0	1930.0	1980.0	2080.0	1880.0	2070.0	1930.0	2570.0	2220.0	1970.0	1830.0	1980.0	2930.0	2770.0	2120.0	2370.0	2770.0	2330.0	2230.0	2470.0	2020.0	1730.0	2180.0	2340.0
W18	2230.0	1970.0	2020.0	2120.0	1920.0	2110.0	1970.0	2610.0	2260.0	2010.0	1870.0	2020.0	2970.0	2810.0	2160.0	2410.0	2810.0	2370.0	2270.0	2520.0	2070.0	1780.0	2220.0	2390.0
W19	2280.0	2020.0	2060.0	2170.0	1960.0	2150.0	2020.0	2650.0	2300.0	2050.0	1910.0	2060.0	3020.0	2850.0	2210.0	2450.0	2860.0	2420.0	2310.0	2560.0	2110.0	1820.0	2270.0	2430.0
W20	2320.0	2060.0	2100.0	2210.0	2000.0	2200.0	2070.0	2700.0	2350.0	2100.0	1960.0	2110.0	3060.0	2900.0	2250.0	2500.0	2900.0	2460.0	2360.0	2600.0	2150.0	1860.0	2310.0	2470.0

Legend: H – Hen, W – Week

Table 4 provides key performance metrics for 24 parent hens. These birds resulted from matings between six genetic rooster lines (R1–R6) and four specific hens from a pool of twenty-four for each rooster. The offspring from each line formed four family subgroups, all reared under an intensive production system. The traits detailed include body weight development, average daily gain (ADG), and feed conversion ratio (FCR). These measurements are crucial for assessing productivity and efficiency in poultry, particularly since feed expenses typically represent the largest cost in commercial farming.

Across the hens, initial body weight was approximately 1,462.5g, progressing to a final weight of about 2,333.3g after 150 days of rearing. This resulted in an overall average daily gain (ADG) of roughly 5.81g/day, indicating moderate overall growth. While most hens achieved ADG values between 5.40 and 5.80g/day, when R4L1 was a distinct outlier, exhibiting a significantly higher ADG of 8.73g/day. This divergence points to either a notable genetic advantage or the influence of particularly favorable localized environmental conditions impacting this specific individual.

In terms of feed conversion ratio (FCR), which measures feed efficiency, the collective result was around 24.3. A lower FCR signifies better efficiency. Strikingly, only hen H13 demonstrated a substantially superior FCR of 16.03, sharply contrasting with the other hens whose FCR values clustered tightly between 24.14 and 25.93. This significant difference highlights the substantial potential of mating with rooster R4, particularly the R4xH13 combination, as a prime candidate for genetic selection aimed at improving feed efficiency in future generations.

These findings are consistent with the research of Wang *et al*. (2017) [71], who underscored genetic variation as a critical determinant of feed efficiency and growth rate in intensively reared layer and dual-purpose hens. Furthermore, Rimoldi *et al*. (2019) [54] reported that ADG in hens is strongly influenced by both their genetic makeup and environmental consistency, with genotype-environment interactions explaining much of the observed performance disparities. In this study, despite a standardized feeding regimen (150g/day), the clear differences in FCR indicate fundamental genetic variations in how these hens metabolize nutrients. The results align with Yakubu *et al*. (2020) [74], who identified feed efficiency as a highly heritable trait across various hen populations, making it a compelling target for selection in breeding programs aimed at boosting production. While the study observed a largely consistent FCR across most families, suggesting a stable average for this trait, the remarkable efficiency demonstrated by H13 highlights a compelling illustration of the benefits of identifying and utilizing superior sublines in ongoing genetic improvement efforts.

Table 4: Performance of parent hens in body weight (grams)

Hen ID	Initial Body Weight at 5 months (g)	Final Body Weight at 11 months (g)	Average Daily Gain (g/day)	Feed Conversion Ratio (FCR)
H1	1450.0	2320.0	5.80	24.14
H2	1200.0	2060.0	5.73	24.42
H3	1250.0	2100.0	5.67	24.71
H4	1350.0	2210.0	5.73	24.42
H5	1150.0	2000.0	5.67	24.71
H6	1350.0	2200.0	5.67	24.71
H7	1200.0	2070.0	5.80	24.14
H8	1850.0	2700.0	5.67	24.71
H9	1500.0	2350.0	5.67	24.71
H10	1250.0	2100.0	5.67	24.71
H11	1150.0	1960.0	5.40	25.93
H12	1250.0	2110.0	5.73	24.42
H13	1750.0	3060.0	8.73	16.03
H14	2050.0	2900.0	5.67	24.71
H15	1400.0	2250.0	5.67	24.71
H16	1650.0	2500.0	5.67	24.71
H17	2050.0	2900.0	5.67	24.71
H18	1600.0	2460.0	5.73	24.42
H19	1500.0	2360.0	5.73	24.42
H20	1750.0	2600.0	5.67	24.71
H21	1300.0	2150.0	5.67	24.71
H22	1050.0	1860.0	5.40	25.93
H23	1450.0	2310.0	5.73	24.42
H24	1600.0	2470.0	5.80	24.14

* Total feed consumed by each hen was 150g per day (22,500g in 150 days)

Average initial and weekly body weight of the F_1 chickens from the different mating combinations

Table 5 presents the weekly body weight development of chicken offspring reared under intensive conditions. The growth data, spanning from hatch to 20 weeks, provides a detailed view of how different genetic pairings influence growth performance over time.

In the initial week post-hatch, chick weights across all groups were remarkably similar, ranging narrowly from 21.1g to 30.5g. This early uniformity suggests that shared environmental conditions and maternal care, rather than inherent genetic factors, primarily shaped initial development. Such consistency is typical, as genetic differences in growth potential often require time to manifest fully.

By the second week, however, clearer distinctions in growth began to emerge. Subsequently, the data indicates a gradual separation in body weights among the genetic groups, signifying that genetic influence started to play a more pronounced role in shaping growth trajectories. Over the ensuing weeks, these differences became increasingly evident.

Notably, certain crosses consistently demonstrated superior body weight gains throughout the study. Groups such as R1xH2, R2xH1, and R6xH2 exhibited more robust growth, with some achieving final weights exceeding 2900g by week 20. Conversely, combinations like R3xH4 and R5xH3 displayed more modest growth, culminating in significantly lower weights by the trial's conclusion. These patterns underscore the joint contribution of both sire and dam to the offspring's growth potential, necessitating consideration of both in breeding strategies.

While many groups followed a steady growth path, there were also periods where weight differences narrowed or growth appeared to stabilize across groups. These phases may reflect common developmental milestones, nutritional constraints, or physiological processes that temporarily overshadow genetic differences.

Interestingly, certain weeks exhibited broader weight variability than others. These fluctuations likely reflect natural differences in the rate at which each group attained specific growth milestones, such as muscle development or the onset of maturity. Such variation, even under tightly controlled rearing conditions, suggests that particular genotypes may be better adapted to intensive production environments, utilizing consistent feed and management more efficiently.

Overall, the data emphasizes the critical importance of evaluating growth over time rather than relying solely on single-point measurements. Some groups that exhibited average early growth outperformed others, reinforcing the principle that genetic potential unfolds differently depending on both genetic background and age. This reinforces findings from previous studies, which suggest that growth traits in chickens are influenced by multiple genes that can act at distinct stages of development.

These insights are valuable for breeding programs aiming to enhance meat yield and growth efficiency. Identifying line combinations with strong, consistent performance under intensive systems can inform selection decisions. Conversely, combinations exhibiting slower or more variable growth may be more suitable for dual-purpose roles or alternative production settings where different traits are prioritized

Table 5: Average initial and weekly body weight of the F_1 chickens from the different mating combinations

Age	Mating Combinations																							
	R1x H1	R1x H2	R1x H3	R1x H4	R2x H5	R2x H6	R2x H7	R2x H8	R3x H9	R3x H10	R3x H11	R3x H12	R4x H13	R4x H14	R4x H15	R4x H16	R5x H17	R5x H18	R5x H19	R5x H20	R6x H21	R6x H22	R6x H23	R6x H24
(Day old)	21.1	30.5	27.1	21.1	30.5	21.1	24.4	24.4	27.1	24.4	30.5	26.3	25.5	27.1	21.1	21.1	30.5	21.1	30.5	30.5	21.1	30.5	30.5	27.1
W1	45.5	55.5	50.5	45.5	55.5	45.5	45.6	45.6	50.5	45.6	55.5	45.1	46.0	49.0	45.5	45.5	56.0	46.0	55.5	55.5	45.5	55.5	55.5	50.5
W2	50.1	60.0	70.2	50.1	60.0	50.1	65.7	65.7	70.2	65.7	60.0	65.6	53.0	55.5	50.1	50.1	55.5	51.0	60.0	60.0	50.1	60.0	60.0	70.2
W3	60.5	75.5	80.1	60.5	75.5	60.5	75.6	75.6	80.1	75.6	75.5	70.5	63.0	62.0	60.5	60.5	60.0	61.0	75.5	75.5	60.5	75.5	75.5	80.1
W4	68.8	85.5	85.2	68.8	85.5	68.8	80.5	80.5	85.2	80.5	85.5	80.1	69.0	70.0	68.8	68.8	75.5	69.0	85.5	85.5	68.8	85.5	85.5	85.2
W5	75.1	90.2	95.5	75.1	90.2	75.1	90.1	90.1	95.5	90.1	90.2	89.6	73.0	76.0	75.1	75.1	85.5	75.1	90.2	90.2	75.1	90.2	90.2	95.5
W6	88.0	100.5	110.6	88.0	100.5	88.0	100.6	100.6	110.6	100.6	100.5	100.1	89.0	90.0	88.0	88.0	90.2	88.0	100.5	100.5	88.0	100.5	100.5	110.6
W7	108.5	150.5	150.5	108.5	150.5	108.5	120.0	120.0	150.5	120.0	150.5	145.0	108.0	110.0	108.5	108.5	101.0	109.0	150.5	150.5	108.5	150.5	150.5	150.5
W8	120.3	175.5	180.6	120.3	175.5	120.3	175.5	175.5	180.6	175.5	175.5	180.0	122.0	121.0	120.3	120.3	151.0	121.0	175.5	175.5	120.3	175.5	175.5	180.6
W9	300.5	450.5	400.0	300.5	450.5	300.5	380.0	380.0	400.0	380.0	450.5	400.0	312.0	310.0	300.5	300.5	176.0	301.0	450.5	450.5	300.5	450.5	450.5	400.0
W10	345.0	500.1	510.3	345.0	500.1	345.0	500.0	500.0	510.3	500.0	500.1	500.5	355.0	350.0	345.0	345.0	451.0	346.0	500.1	500.1	345.0	500.1	500.1	510.3
W11	400.6	550.0	600.0	400.6	550.0	400.6	580.0	580.0	600.0	580.0	550.0	620.0	405.0	402.0	400.6	400.6	500.0	401.0	550.0	550.0	400.6	550.0	550.0	600.0
W12	900.2	1000.1	1000.0	900.2	1000.0	900.2	980.0	980.0	1000.1	980.0	1000.0	1000.2	900.0	910.0	900.2	900.2	1000.0	901.0	1000.0	1000.0	900.2	1000.0	1000.0	1000.0
W13	1500.0	1900.0	1500.0	1500.0	1900.0	1500.0	1300.0	1300.0	1500.0	1300.0	1900.0	1300.0	1500.0	1510.0	1500.0	1500.0	1900.0	1500.0	1900.0	1900.0	1500.0	1900.0	1900.0	1500.0
W14	1600.0	2100.0	1550.0	1600.0	2100.0	1600.0	1450.0	1450.0	1550.0	1450.0	2100.0	1500.0	1600.0	1620.0	1600.0	1600.0	2100.0	1600.0	2100.0	2100.0	1600.0	2100.0	210.0	1550.0
W15	1900.0	2350.0	1600.0	1900.0	350.0	1900.0	1500.0	1500.0	1600.0	1500.0	2350.0	1760.0	1900.0	1900.0	1900.0	1900.0	2350.0	1900.0	2350.0	2350.0	1900.0	2350.0	2350.0	1600.0
W16	2100.0	2550.0	1750.0	2100.0	2550.0	1930.0	1650.0	1650.0	1750.0	1650.0	2550.0	1800.0	2100.0	2100.0	2100.0	2100.0	2550.0	2100.0	2550.0	2550.0	2100.0	2550.0	2550.0	1750.0
W17	2190.0	2600.0	2200.0	2190.0	600.0	1960.0	1800.0	1800.0	2200.0	1800.0	2600.0	2100.0	2200.0	2200.0	2190.0	2190.0	2600.0	2190.0	2600.0	2600.0	2190.0	2600.0	2600.0	2200.0
W18	2230.0	2650.0	2400.0	2230.0	2650.0	1980.0	1900.0	1900.0	2400.0	1900.0	2650.0	2350.0	2300.0	2350.0	2230.0	2230.0	2650.0	2230.0	2650.0	2650.0	2230.0	2650.0	2650.0	240.0
W19	2270.0	2750.0	2550.0	2270.0	2750.0	2090.0	2500.0	2500.0	2550.0	2500.0	2750.0	2480.0	2450.0	2580.0	2270.0	2270.0	2750.0	2400.0	2750.0	2750.0	2270.0	2750.0	2750.0	2550.0
W20	2320.0	2920.0	2700.0	2320.0	3050.0	2110.0	2750.0	2750.0	2880.0	2750.0	3050.0	2800.0	2650.0	2700.0	2320.0	2400.0	2920.0	2750.0	2920.0	2920.0	2320.0	2920.0	2920.0	2700.0

Performance of offspring from one to 150 days of age

Table 6 provides a comprehensive overview of the body weight and growth performance of chicken offspring from 24 distinct genetic crosses (R1xH1 to R6xH24), all reared under intensive management. The table summarizes critical productivity indicators including initial body weight at hatch, final body weight at 150 days, average daily gain (ADG), and feed conversion ratio (FCR).

At hatch, initial body weights were relatively uniform across groups, ranging from 21.1g to 30.5g, with an overall average of 26.05g. These early weight differences likely reflect both genetic background and maternal influence. However, as the birds matured, genetic effects became increasingly evident. By 150 days, final body weights varied considerably, spanning from 2110g in crosses like F4 and F6 to 3050g in F5 and F11. On average, offspring achieved a final body weight of approximately 2692.92g, though certain crosses clearly outperformed others. These findings align with Gebre *et al*. (2023), who underscored the role of genotype in determining early and final growth performance under standardized environments.

Certain crosses, such as F5 (R2xH5) and F11 (R3xH11), exhibited exceptional growth, achieving the highest final weights, and recording the highest average daily gains of 20.13g/day. In contrast, crosses like F4 (R1xH4) and F6 (R2xH6) demonstrated considerably slower growth rates, averaging merely 13.93g/day. These disparities occurred despite all birds being raised under identical environmental conditions, emphasizing the substantial impact of genetic makeup on growth performance. This observation supports Ngeno *et al*. (2019)'s [47] conclusion that crossbreeding can enhance growth rates and adaptability by leveraging hybrid vigor.

Feed conversion ratio (FCR), a key efficiency metric, also varied notably among the groups. The most efficient crosses were F5, F11, and F2, all achieving FCRs below the group average of 7.90. These birds more effectively converted feed into body mass, rendering them particularly valuable from an economic production standpoint. Conversely, less efficient groups like F4 and F6 exhibited FCRs close to 10, indicating they required substantially more feed for similar or even lower weight gains. This trend is consistent with findings of Sell-Kubiak *et al*. (2017) [59], who emphasized that selecting for both low FCR and high ADG can significantly improve production efficiency and reduce feed costs—a critical factor given that feed typically constitutes 60–70% of total production expenses (Khalil *et al*., n.d).

Overall, crosses involving Rooster 2 (R2) and Rooster 3 (R3) when paired with high-performing hens tended to yield the best results in terms of both growth and feed efficiency. This highlights the promising potential of these combinations for future breeding programs. Conversely, some combinations, such as R1xH4 and R2xH6, consistently demonstrated lower growth rates and higher feed intake, suggesting limited suitability for intensive systems without targeted genetic improvement. This variation in performance under uniform conditions reflects the significant role of genotype–environment interactions (G x E), as discussed by Yakubu *et al*. (2016) [75], who reported that traits like ADG and FCR are moderately to highly heritable and responsive to selection.

These findings reinforce prior research emphasizing the crucial role of genetic combinations in optimizing growth and feed utilization. Even under identical rearing conditions, the performance varied substantially, underscoring the importance of meticulously selecting parent lines in poultry breeding. The results also highlight clear opportunities to enhance productivity through targeted selection of sires and dams that consistently produce fast-growing, feed-efficient offspring.

In conclusion, Table 6 clearly demonstrates that genetic selection plays a pivotal role in achieving desirable growth and efficiency outcomes. Crosses like F5 and F11 represent valuable breeding candidates for meat production under intensive systems, while lower-performing lines may benefit from genetic enhancement or may be better suited to alternative rearing environments.

Table 6: Performance of offspring from one to 150 days of age

Offspring ID	Crosses	Initial Body Weight (g) at Day Old	Final Body Weight (g) at 150 Days	Average Daily Gain (g/day)	FCR (Feed/Gain)
O1	R1Xh1	21.1	2320	15.33	9.13
O2	R1Xh2	30.5	2920	19.26	7.19
O3	R1Xh3	27.1	2700	17.82	7.78
O4	R1Xh4	21.1	2110	13.93	9.95
O5	R2Xh5	30.5	3050	20.13	6.89
O6	R2Xh6	21.1	2110	13.93	9.95
O7	R2Xh7	24.4	2750	18.17	7.64
O8	R2Xh8	24.4	2750	18.17	7.64
O9	R3Xh9	27.1	2880	19.02	7.29
O10	R3Xh10	24.4	2750	18.17	7.64
O11	R3Xh11	30.5	3050	20.13	6.89
O12	R3Xh12	26.3	2800	18.49	7.50
O13	R4Xh13	25.5	2650	17.50	7.92
O14	R4Xh14	27.1	2700	17.82	7.78
O15	R4Xh15	21.1	2320	15.33	9.05
O16	R4Xh16	21.1	2400	15.86	8.75
O17	R5Xh17	30.5	2920	19.26	7.19
O18	R5Xh18	21.1	2750	18.19	7.64
O19	R5Xh19	30.5	2920	19.26	7.19
O20	R5Xh20	30.5	2920	19.26	7.19
O21	R6Xh21	21.1	2320	15.33	9.05
O22	R6Xh22	30.5	2920	19.26	7.19
O23	R6Xh23	30.5	2920	19.26	7.19
O24	R6Xh24	27.1	2700	15.33	7.86
Average		26.05	2692.92	17.68	7.90

Distribution of the eggs of the hens at 6 months of age

Table 7 displays the descriptive statistics for egg size from hens across various genetic lines, all raised under intensive conditions. Eggs were sorted into standardized commercial categories based on weight: Small (42–47g) and Medium (48–53g). The results indicate that the hens produced an average of 12.75 small eggs, and 4.67 medium eggs each. These figures suggest that the majority of eggs laid by the evaluated genetic groups fell within the small-size category.

The predominance of small-sized eggs in this study points to a potential influence of both genetic and physiological factors. Previous research consistently shows that genotype significantly impacts egg size. For example, Ahmad *et al*. (2018) [3] reported that a chicken's genetic line substantially affects egg weight and size distribution in laying hens. They observed that local and indigenous breeds typically produce smaller eggs compared to commercial layers. This aligns with the trend seen in the current study, particularly if the genetic groups examined include native or improved local breeds.

Egg size in this study appears to be primarily influenced by genetic and physiological factors, even within controlled intensive systems. Thus, the egg size is dependent on the genetic groups of the chicken. This aligns with research of Yakubu *et al*. (2017) [76], who found a correlation between body weight and age at sexual maturity and egg size;

heavier hens typically lay larger eggs, while those that mature earlier tend to produce smaller eggs initially. The uniform environmental conditions of intensive rearing likely minimized non-genetic influences, further supporting that genetic background is the main driver of the observed egg size patterns. While feed quality and nutrient intake are known to affect egg weight, variations in egg size may not be nutrition-driven given the controlled feeding, though the controlled quantity of feeding in this study may have some influence to the resulting sizes. As Tadesse *et al*. (2020) [67] highlighted in their research, a hen's genetic potential largely determines consistent medium or large egg production, even with optimal feeding. Although certain individuals, such as H4, H9, and H20, produced more medium eggs, the overall moderate standard deviation suggests that selective breeding could effectively enhance medium-sized egg production in these populations raising the performance of the hens in this economically-important trait.

Under intensive rearing conditions, the studied genetic groups primarily produced smaller eggs. However, the moderate output of medium-sized eggs in certain lines suggests an inherent genetic capacity for improvement. These findings therefore support implementing genetic selection strategies to enhance egg size, aligning with the broader objective of improving economically valuable traits in chickens.

Table 7: Distribution of the eggs of the hens at 6 months of age

Hen ID	Egg Size	
	Small	Medium
H1	15	0
H2	13	3
H3	16	2
H4	11	8
H5	13	6
H6	12	6
H7	19	1
H8	16	2
H9	12	7
H10	17	3
H11	16	3
H12	14	5
H13	8	5
H14	11	6
H15	11	7
H16	10	6
H17	9	0
H18	11	3
H19	8	2
H20	11	8
H21	16	6
H22	8	6
H23	15	1
H24	14	2
Average	12.75	4.67

$x^2 = 1310.63$	P-value = <0.005

Legend:

Pewee	: 41 below grams
Small	: 42 -47 grams
Medium	: 48-53 grams
Large	: 54-60grams
x-Large	: 61-66 grams
Jumbo	: 67 and above

Performance of Hens in terms of yolk color

Table 8 illustrates the distribution of yolk color in eggs laid by hens from various rooster–hen crosses under intensive management. In this study, yolk coloration was categorized into two distinct types: yellow yolk (YY) and pale yolk (PY). On average, each hen produced approximately 10 yellow-yolked eggs and 7 pale-yolked eggs, indicating a general tendency toward more intensely pigmented yolks within the flock.

Interestingly, several crosses, including R2xH5, R2xH8, R4xH15, and R1xH3, stood out for their impressive production of yellow-yolked eggs. Specifically, hens H5 and H8 both laid 16 yellow-yolked eggs, while H3 and H15 produced 13 and 16, respectively. These results suggest that these specific genetic combinations may have a greater capacity for carotenoid absorption and deposition, resulting in more vibrantly pigmented yolks.

Conversely, hens such as H17, H18, and H19 produced significantly more pale-yolked eggs. H17 laid 17 pale-yolked eggs and none with yellow yolks, while H18 and H19 produced 14 and 16 pale-yolked eggs, respectively. These patterns may indicate a limited genetic efficiency in pigment uptake or conversion pathways within these hens, even with a consistent feed supply.

As Pappas *et al*. (2019) [53] noted, yolk pigmentation is closely tied to a hen's ability to absorb and deposit carotenoids from her diet—a trait profoundly influenced by both genetic background and nutritional availability. Even in standardized feeding systems, genetic differences can lead to variations in how effectively hens utilize dietary pigments. Grčević *et al*. (2020) [32] further emphasized that hens with certain genotypes might possess superior enzymatic profiles, enabling more efficient carotenoid metabolism and subsequent deposition into the yolk.

While feed remains a crucial factor, including natural or synthetic pigment additives can be beneficial (Abdel-Azeem *et al*., 2022) [1], achieving long-term improvements in yolk color is more sustainably accomplished through genetic selection. Some family lines may inherently possess better lipid metabolism and carotenoid assimilation capabilities, as described by Oliveira *et al*. (2021) [50]. These physiological advantages could explain the consistent performance of hens like H5, H8, and H15, even though they consumed the same diet as their counterparts.

The observed variability in yolk coloration among hens, despite uniform environmental and nutritional conditions, highlights the significant role of genotype in nutrient utilization. In intensive production systems where feed composition is largely consistent, such variation underscores the value of selecting for yolk color traits in breeding programs. Incorporating yolk pigmentation into selection criteria can enhance both egg quality and market appeal, especially in regions where yolk color strongly influences consumer preference.

Table 8: Performance of Hens in terms of yolk color

Hen ID	Yolk Color	
	Yellow Yolk	Pale Yolk
H1	6	9
H2	10	6
H3	13	5
H4	13	6
H5	16	3
H6	7	11
H7	14	6
H8	16	2
H9	13	6
H10	14	6
H11	12	7
H12	11	8
H13	12	1
H14	13	4
H15	16	2
H16	7	9
H17	0	17
H18	3	14
H19	1	16
H20	4	12
H21	11	5
H22	9	4
H23	14	5
H24	11	7
Average	10.25	7.12

Legend:

PY : Pale Yolk
YY : Yellow Yolk

Performances of the Parent Hens Interms of Egg Fertility and Hatchability

Table 9 presents the fertility and hatchability performance of eggs collected from various genetic lines and families of hens raised under intensive conditions. The data shows a generally high rate of fertilization across all lines, with an overall average fertility percentage of 90.35%. However, the average hatchability percentage was considerably lower at 36.86%. This noticeable difference between fertility and hatchability, despite a consistent number of fertile eggs selected for incubation (13 eggs per line), points to significant post-fertilization developmental losses. These losses are likely due to factors like embryo mortality, potentially influenced by issues with incubation management, such as the reported electricity outages during the experimental period. Genetic incompatibility may have also played a role in the reduced hatchability rate.

While some hens, such as H3, H10, H13, and H22, showed exceptional fertility at 100%, their varied hatchability rates (H3: 23.08%, H10: 38.46%, H13: 23.08%, H22: 61.54%) suggest that factors beyond successful fertilization critically impact embryo survival. For instance, H13 and H22 both had perfect fertility, but H22 had a much better hatchability rate than H13. In contrast, hens like H2, H4, and H19 consistently exhibited both low fertility and poor hatchability (H2: 84.21% fertility, 15.38% hatchability; H4: 90.48% fertility, 15.38% hatchability; H19: 89.47% fertility, 15.38% hatchability). This may indicate underlying genetic weaknesses in the reproductive or embryonic traits of these parent hens or their specific mating combinations.

These findings clearly indicate that fertility alone does not guarantee hatching success; embryonic development and viability are crucial stages influenced by both genetic and environmental elements. This aligns with the findings of Wondmeneh *et al*. (2017) [73], who observed that maternal genetics, egg quality, and incubation protocols significantly affect hatchability, even when fertility is good. Similarly, Chaudhary *et al*. (2018) [14] highlighted the impact of egg handling, shell quality, and storage duration on embryonic mortality in intensive systems, as well as the role of genetic background in embryonic resilience—consistent with the differences seen across lines in this study. Furthermore, Setioko and Panjono (2021) [60] noted varied hatchability outcomes in indigenous chicken lines due to genetic heterogeneity and differences in internal egg quality, even when fertility was uniform. This reinforces the idea that genetic group differences significantly influence overall reproductive efficiency.

The data indicate that while fertility rates are generally acceptable across the genetic lines studied, the considerable variability in hatchability points to a critical area for improvement. It suggests that future selection efforts should extend beyond just fertilization traits to also prioritize embryo viability and successful incubation outcomes. This becomes especially important in intensive rearing systems, where controlled environmental conditions allow genetic factors to exert a more pronounced influence on reproductive success.

Table 9: Performances of the parent hens interms of egg fertility and hatchability

Hen ID	Crosses	No. of eggs collectedin *29days (Aug-25Sept 22,2024)	No. of fertile eggs	Fertile Eggs for incubation	Fertility Rate (%)	Chicks Hatched at 21 days	Hatchability Rate (%)
H1	R1xH1	20	15	13	75.00	3	23.08
H2	R1xH2	19	16	13	84.21	2	15.38
H3	R1xH3	18	18	13	100.00	3	23.08
H4	R1xH4	21	19	13	90.48	2	15.38
H5	R2xH5	20	19	13	95.00	8	61.54
H6	R2xH6	22	18	13	81.82	7	53.85
H7	R2xH7	21	20	13	95.24	8	61.54
H8	R2xH8	19	18	13	94.74	7	53.85
H9	R3xH9	23	19	13	82.61	2	15.38
H10	R3xH10	20	20	13	100.00	5	38.46
H11	R3xH11	22	19	13	86.36	3	23.08
H12	R3xH12	22	19	13	86.36	6	46.15
H13	R4xH13	13	13	13	100.00	3	23.08
H14	R4xH14	19	17	13	89.47	5	38.46
H15	R4xH15	20	18	13	90.00	5	38.46
H16	R4xH16	18	16	13	88.89	5	38.46

H17	R5xH17	18	17	13	94.44	5	38.46
H18	R5xH18	18	17	13	94.44	3	23.08
H19	R5xH19	19	17	13	89.47	2	15.38
H20	R5xH20	20	17	13	85.00	3	23.08
H21	R6xH21	19	16	13	84.21	8	61.54
H22	R6xH22	13	13	13	100.00	8	61.54
H23	R6xH23	20	19	13	95.00	7	53.85
H24	R6xH24	21	18	13	85.71	5	38.46
Average		19.38	17.42	13	90.35	4.79	36.86

Legend; R- Rooster H - Hen

Effect of Generation and Trait Type on Chicken Performance (ADG and FCR)

A two-way ANOVA with replication was performed to assess if generation (parent vs. offspring) and trait type (Average Daily Gain [ADG] and Feed Conversion Ratio [FCR]) significantly impacted chicken performance in an intensive rearing environment. The summary statistics and ANOVA results are presented below.

Offspring demonstrated significantly improved performance compared to their parents, exhibiting both higher growth rates and more efficient feed conversion. The average daily gain (ADG) for offspring was more than triple that of the parents, while their feed conversion ratio (FCR) was reduced by over two-thirds. This substantial difference reflects a clear genetic improvement in performance across generations.

Table 10: Performance Summary by Generation and Trait

Group	ADG (g/day) Mean ± SD	FCR Mean ± SD
Parent hen (5 to 11 months of age)	5.81 ± 0.63	24.31 ± 1.82
Offspring (0 to 5 months of age)	17.68 ± 1.91	7.90 ± 0.91

Conclusion

Under intensive rearing conditions, genetic background significantly influenced growth, feed efficiency, and reproductive traits in both parent stocks and their offspring. Roosters R1 and R6 showed potential for selective breeding with R1 for its feed efficiency and R6 for late-stage weight gain. Hens mated with R1 and R4 produced superior offspring, while H13 stood out for growth and feed conversion. Offspring exhibited stronger performance than parent lines, indicating genetic progress and possible hybrid vigor. Variations in egg traits, yolk color, and hatchability further underscore the role of genetics in optimizing both meat and egg production. These findings support the use of family- and trait-based selection to enhance productivity in poultry breeding programs.

Recommendation

Based on the study's findings, it is recommended to prioritize Rooster R1 in breeding programs for its superior feed conversion ratio and final body weight, with R6 also considered for its strong late-stage growth. Hens H13 and H11 showed promising traits and should be included in selection. Crossbreeding efforts should focus on combinations involving Roosters R2 and R3, which consistently produced offspring with excellent growth and efficiency. Poor-performing crosses like R1×H4 and R2×H6 should be avoided or improved. To enhance reproductive traits, proper incubation management, balanced nutrition, and the selection of optimal rooster-hen combinations for better egg size and yolk color are advised. Long-term performance monitoring is crucial, as genetic differences became more apparent after Week 20. Finally, future research should explore molecular tools for precise selection, test genetic lines under varied environments, and investigate nutrition-based strategies to further improve productivity.

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