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Characterization of Productive and Reproductive Performance of Broiler Grand Parent Stock Strains (Ross, Cobb, and Hubbard) During Growing and Laying Phases

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Abstract. Grandparent Stock (GPS) serves as the genetic cornerstone of broiler production, influencing performance at both Parent Stock and commercial levels. This study evaluated and compared the productive and reproductive traits of three major GPS broiler strains—Ross, Cobb, and Hubbard—under commercial tropical conditions in Indonesia. Data from 104,415 birds (83,102 females; 21,313 males) were collected from two national poultry companies between 2019 and 2022. Parameters included mortality, feed intake, body weight, uniformity, egg production, egg weight, and hatchability. Analysis of Variance (ANOVA) and Duncan's test were applied. Cobb showed the lowest mortality during the grower phase (0.30%) and the highest body weight uniformity (80.71%). Ross had the lowest mortality in the laying phase (0.479%) and the highest egg production (49.13%). Hubbard achieved the highest final body weight (4,727 g) and egg weight (64.85 g) but recorded the highest mortality during laying (0.870%). No significant differences were found in cumulative feed intake (132,750–134,786 g/bird) or hatchability (>94.7%) across strains. These results suggest Cobb is best for uniformity and survivability, Ross for egg productivity, and Hubbard for maximizing output, although requiring more intensive management. Strain selection should align with production priorities and local farm conditions, considering factors such as climate adaptability, resource availability, and long-term sustainability. The findings provide valuable insights for optimizing broiler breeding programs in tropical regions, enhancing genetic potential, and improving overall production efficiency.

Keywords*:* genetic source, strain selection, breeding sustainability, tropical conditions, broiler performance

Abstrak. Stock Grand Parent (GPS) berperan sebagai fondasi genetik dalam produksi ayam broiler, yang memengaruhi kinerja pada tingkat Parent Stock maupun komersial. Penelitian ini mengevaluasi dan membandingkan sifat produktif dan reproduktif tiga strain GPS broiler utama—Ross, Cobb, dan Hubbard—di bawah kondisi tropis komersial di Indonesia. Data dari 104.415 ekor ayam (83.102 betina; 21.313 jantan) dikumpulkan dari dua perusahaan unggas nasional antara tahun 2019 hingga 2022. Parameter yang diukur meliputi mortalitas, konsumsi pakan, bobot badan, keseragaman, produksi telur, bobot telur, dan daya tetas. Analisis menggunakan Analysis of Variance (ANOVA) dan uji Duncan. Cobb menunjukkan mortalitas terendah pada fase pertumbuhan (0,30%) dan keseragaman bobot badan tertinggi (80,71%). Ross memiliki mortalitas terendah selama fase bertelur (0,479%) serta produksi telur tertinggi (49,13%). Sementara itu, Hubbard mencapai bobot badan akhir tertinggi (4.727 g) dan bobot telur terberat (64,85 g), tetapi mencatat mortalitas tertinggi pada fase bertelur (0,870%). Tidak ditemukan perbedaan signifikan dalam konsumsi pakan kumulatif (132.750–134.786 g/ekor) maupun daya tetas (>94,7%) antar strain. Hasil ini menunjukkan bahwa Cobb paling unggul dalam keseragaman dan daya hidup, Ross dalam efisiensi reproduksi, dan Hubbard dalam output maksimal meskipun memerlukan manajemen lebih intensif. Pemilihan strain harus disesuaikan dengan prioritas produksi dan kondisi lokal, dengan mempertimbangkan faktor seperti adaptasi iklim, ketersediaan sumber daya, dan keberlanjutan jangka panjang. Temuan ini memberikan wawasan berharga untuk mengoptimalkan program pemuliaan broiler di wilayah tropis, meningkatkan potensi genetik, dan memperbaiki efisiensi produksi secara keseluruhan.

Kata kunci: sumber genetik, seleksi strain, pemuliaan keberlanjutan, kondisi tropis, kinerja broiler

Introduction

The global demand for high-quality animal protein continues to increase, particularly in developing countries like Indonesia, where poultry meat serves as the most accessible and affordable protein source for the population. Broiler chickens dominate Indonesia's poultry

industry owing to their rapid growth rate, short production cycles, and comparatively low production costs (OECD/FAO, 2024). The Indonesian poultry sector has experienced rapid expansion over the past decade, driven by consumer demand and improved farm management systems (Amrullah, 2024). This expansion is facilitated through a vertically integrated breeding pyramid comprising Grandparent Stock (GPS) at the apex, Parent Stock (PS) at the intermediate level, and commercial broilers at the base. Within this hierarchy, GPS assumes fundamental importance in establishing both the genetic merit and commercial performance of progeny (Houston et al., 2020).

Grand Parent Stock contributes significantly to the heritable traits expressed in PS and commercial broilers, particularly in terms of growth rate, feed conversion ratio (FCR), reproductive traits, and adaptability to tropical environments. However, in Indonesia, the sustainability of GPS breeding systems remains a significant challenge, as the country is still highly dependent on imported GPS from global breeding companies headquartered in the United States, United Kingdom, France, and the Netherlands. According to the Direktorat Statistik Peternakan, Perikanan, dan Kehutanan (2023), Indonesia imports more than 500,000 head of broiler GPS annually, ranging from 530,000 to 580,000 birds each year. These are then raised by national-scale breeding farms to produce PS, which are distributed throughout the archipelago. This high dependence on foreign genetic sources not only exposes the industry to biosecurity and supply risks but also hinders the development of a more self-reliant poultry breeding system (Ulfah and Darwati, 2023).

A pivotal strategy for enhancing sustainability and achieving genetic self-sufficiency involves identifying and selecting superior GPS strains adapted to Indonesia's tropical climate without compromising productivity or efficiency. The global broiler breeding market is currently dominated by three primary commercial strains: Cobb, Ross, and Hubbard, each with distinct performance characteristics under tropical conditions. Each strain is recognized for specific performance advantages—Cobb for uniformity and robustness, Ross for reproductive efficiency, and Hubbard for larger body and egg weights (Rocha et al., 2022; Vasdal et al., 2019). However, few scientific studies have comprehensively compared these GPS strains under field conditions in Indonesia, particularly with respect to both productive and reproductive traits across the growing and laying phases.

Most existing literature has focused on Parent Stock or commercial broilers (Paramayudha and Budhisatrio, 2024; Burnside and Neetesoon, 2025), leaving a significant research gap in understanding the performance variability at the GPS level within tropical environments. Given that GPS performance directly influences the productivity and economic viability of the entire broiler supply chain, comprehensive evaluations are needed to support data-driven strain selection, especially for long-term national breeding strategies. Therefore, this study aimed to evaluate and compare the productive and reproductive performance characteristics of broiler GPS strains Ross, Cobb, and Hubbard under commercial breeding conditions in Indonesia. These findings will provide a scientific basis for: (1) evidence-based strain selection, (2) optimized management protocols, and (3) establishing a more sustainable and efficient national poultry breeding program.

Materials and Methods

Study Design and Ethical Statement

This study employed a quantitative, exploratory-descriptive design based on an observational and non-experimental approach. The primary objective was to explore and compare the productive and reproductive

performance of three commercial broiler GPS strains Ross, Cobb, and Hubbard under practical breeding conditions in Indonesia. No experimental treatments or manipulations were applied during the study period. Instead, the research relied entirely on retrospective secondary data that had been systematically recorded over time by the production and technical teams at the farm level.

This study utilized retrospective analysis of existing production records without any experimental interventions or direct animal handling for research purposes. In accordance with international standards for observational research using agricultural data [cite specific guidelines if available, e.g., OIE Terrestrial Animal Health Code], formal approval from an Institutional Animal Care and Use Committee (IACUC) was not required. All data were collected as part of routine farm operations under standard animal welfare protocols, with no additional procedures performed that might affect animal wellbeing. The research complied fully with national regulations on agricultural data use and institutional policies governing secondary data analysis in livestock production systems.

Study Location and Duration

The study was conducted at two large-scale commercial poultry breeding companies in Indonesia, namely PT Berdikari Persero and PT Panca Patriot Prima. Both companies manage Grand Parent Stock (GPS) broiler breeding units and operate in the Jatisari Village, Purwodadi Subdistrict, Pasuruan Regency, located in East Java Province. The study region exhibits a characteristic tropical monsoon climate (Köppen-Geiger classification Am), with mean annual temperatures of 28.3°C ± 2.1°C (range: 24-32°C) and relative humidity maintained at 80.4% ± 5.3% throughout the production cycle. Research sites were located in lowland rice-growing ecosystems (elevation: 10-50 masl), representing Indonesia's predominant agroecological zone for commercial poultry operations. This selection criterion ensured optimal conditions for intensive production, including: (1) minimal topographic variation (<2% slope), (2) proximate access to water resources (<500 m from irrigation channels), and (3) established feed supply chains within a 15-km radius. Stocking densities averaged 6 to 7 birds per square meter, calculated by dividing the total number of birds placed by the net floor area of each pen, excluding feeder and drinker spaces. The data collection covered a four-year period, from 2019 to 2022, encompassing the full production cycles of GPS from the grower phase through the laying phase. During this time, operational data were routinely recorded by the farm's technical teams and served as the primary source of information for performance evaluation.

Animal Population and Strain Distribution

This study analyzed a total of 104,415 broiler Grand Parent Stock (GPS) chickens, which included 83,102 females and 21,313 males. The birds represented three globally recognized commercial strains: Cobb, Ross, and Hubbard, each of which is widely utilized in the broiler breeding industry due to their distinctive genetic profiles and performance characteristics. The study population comprised 104,415 broiler grandparent stock (GPS) birds distributed across three commercial strains: Cobb (23,734 females, 5,982 males), Ross (16,302 females, 3,831 males), and Hubbard (43,066 females, 11,500 males). These flocks were maintained under standardized commercial management protocols at two vertically integrated breeding operations in East Java, Indonesia, representing typical large-scale production systems in tropical environments.

To ensure a comprehensive and unbiased assessment of strain performance, the study employed a total enumeration approach, whereby the entire recorded population during the 2019–2022 production period was included

in the analysis. This total enumeration approach obviated sampling requirements while enabling comprehensive assessment of complete production cycle parameters across all strains, thereby preserving the full spectrum of biological variability and ensuring population-level representativeness. The use of total population data provides a more robust foundation for comparative analysis and strengthens the validity of the conclusions drawn from the observed differences among strains.

Parameters Observed

The study focused on evaluating key productive and reproductive performance parameters of broiler Grand Parent Stock (GPS) across both the growing phase and the laying phase, in order to assess strain-level differences under commercial breeding conditions. During the grower period (0 to 25 weeks of age), the following parameters were observed: depletion rate), defined as the percentage of birds that died or were culled; cumulative feed intake, representing the total amount of feed consumed per bird over the growing period; actual body weight (BW ACT), which reflects the final weight attained by the birds; and body weight uniformity, calculated as the proportion (%) of individual birds whose body weight fell within ±10% of the mean body weight of their respective strain group, indicating the degree of growth consistency.

During the laying phase (weeks 26-69), reproductive performance was evaluated through three key metrics: (1) daily egg production rate (% hen-day production), (2) hatchability (% of fertile eggs producing viable chicks), and (3) mean egg weight (g). These parameters were selected for their established correlations with both biological efficiency (fertilization success, embryonic development) and commercial value (grade A egg percentage, chick quality at hatch). Furthermore, chick weight at hatch was measured as an indirect indicator of egg nutrient content and overall embryonic development. Collectively, these parameters offer a comprehensive assessment of each strain's biological efficiency and suitability for commercial breeding operations under tropical conditions.

Data Source and Collection

Data utilized in this study were sourced from internal production records maintained by the technical and operational teams of two participating Grandparent Stock (GPS) broiler breeding companies. These records were systematically documented in standardized formats, comprising weekly tabulations and aggregated production summaries encompassing both the grower and laying phases. These records encompassed performance indicators routinely monitored as part of the companies' standard operating procedures (SOP) for production management and quality control. Data validity was ensured through regular on-site verification and supervision by farm technicians and veterinarians, who followed internal audit protocols to maintain data consistency, reliability, and traceability throughout the observation period.

Statistical Analysis

All statistical analyses in this study were performed using R Studio (Posit Team, 2025), a widely used open-source statistical computing platform (Field et al., 2012). The analysis employed several essential R packages, including *readxl* (Wickham and Bryan, 2025) for data import, *dplyr* (Wickham et al., 2025) for data manipulation, and *agricolae* (de Mendiburu, 2025) for performing Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT). The analysis focused on evaluating differences in performance traits among the three broiler Grand Parent Stock (GPS) strains Ross, Cobb, and Hubbard. Initially, descriptive statistics were calculated for each parameter

using base R functions to determine the mean, standard deviation, minimum, and maximum values. To assess whether strain had a significant effect on each parameter, a one-way ANOVA model was applied individually to each response variable. The general statistical model used for the ANOVA was:

$$Y_{ij} = \mu + S_i + \varepsilon_{ij}$$

Where Y_{ij} is the observed value of the j-th observation in the i-th strain group. μ is the overall population mean. S_i is the fixed effect of the i-th strain (Ross, Cobb, or Hubbard). ε_{ij} is the random error associated with the observation, assumed to be normally distributed with a mean of 0 and constant variance (σ^2). Each parameter (body weight, egg production, hatchability) was analyzed independently using this model. When the ANOVA results indicated a significant difference among strains (p-value < 0.05 or < 0.01), the analysis was followed by a post hoc test using Duncan's Multiple Range Test (DMRT) from the agricolae package. Pairwise comparisons between strain means were conducted to identify statistically distinct groups. Statistical inferences were made at two significance levels—α = 0.05 (5%) and α = 0.01 (1%)—depending on the required level of confidence. The interpretation of results integrated statistical significance with biological relevance, ensuring that the conclusions were both mathematically robust and practically meaningful within the context of commercial broiler breeding under tropical conditions.

Results and Discussion

The growth phase is critical for establishing flock uniformity, enhancing survival, and ensuring optimal preparation for the reproductive cycle. The results showed significant variation in depletion and body weight uniformity among strains, whereas feed intake and body weight did not differ significantly (Table 1).

The grower phase performance revealed significant differences among strains, particularly in mortality (depletion rate) and body weight uniformity. Cobb exhibited the lowest depletion rate at 0.30%, which was significantly lower than Hubbard (0.56%) and Ross (0.41%) (P < 0.05). These values are well below the maximum acceptable threshold of 5% for commercial broiler breeding (Bell and Weaver, 2012), and even surpass the internal strain standards of <1% mortality during the grower period. The superior early survivability of Cobb likely reflects a favorable combination of genetic robustness, enhanced disease resistance, and efficient physiological adaptation to the rearing environment. This result further supports previous reports on Cobb's resilience under intensive commercial systems, especially within challenging tropical conditions (Cobb-Vantress, 2022). In contrast, while Hubbard and Ross still maintained acceptable mortality rates, their relatively higher depletion may indicate increased sensitivity to environmental or management-related stressors during the early rearing phase.

Table 1. Performance of broiler Grandparent Stock (GPS) strains during the grower phase

Parameter	Cobb (n = 200)	Hubbard (n = 346)	Ross (n = 146)
Depletion (%)	0.30 ± 0.28^{b}	0.56 ± 0.53^{a}	0.41 ± 0.39^{b}
Feed intake (g/bird/week)	74.27 ± 27.60^{A}	78.94 ± 38.93^{A}	72.75 ± 26.05^{A}
Body weight (g)	1833.23 ± 1031.79^{A}	1799.93 ± 976.37^{A}	1742.39 ± 965.56^{A}
Body weight uniformity (%)	80.71 ± 2.81^{a}	78.38 ± 10.41^{b}	78.44 ± 2.69^{b}

Note: Values are presented as mean ± standard deviation. Superscripts with different lowercase letters (a, b) within the same row indicate significant differences at P < 0.05, while uppercase letters (A, B) indicate significant differences at P < 0.01.

Feed intake during the grower phase did not differ significantly across strains (P > 0.05), with all values remaining within the recommended range of 70–80 g/bird/week (Leeson and Summers, 2005). Cobb consumed 74.27 g/bird/week, closely aligning with optimal intake for efficient growth. Ross showed slightly lower intake (72.75 g), which, while still adequate, may be influenced by high ambient temperatures typical of tropical climates conditions known to suppress feed intake without necessarily compromising performance (Amrullah et al., 2024). Hubbard recorded the highest average intake (78.94 g), which corresponds with its larger body frame and greater energy requirements. These findings indicate that all three strains adapted well to the feeding regime, although strain-specific energy metabolism likely influenced minor variations in intake.

Although the differences in actual body weight were not statistically significant, Cobb achieved the highest average final body weight (1,833.2 g), followed by Hubbard (1,799.9 g) and Ross (1,742.4 g). These values were slightly below the respective strain standards (Cobb: ~1850 g; Hubbard: ~1900 g; Ross: ~1800 g), likely due to environmental factors such as heat stress, stocking density, or nutrient partitioning efficiency under tropical management systems (Masir et al., 2024). Despite these slightly lower values, Cobb's performance reflects stable growth potential, indicating its suitability for tropical broiler breeding operations. Conversely, the lower body weight observed in Ross may reflect its reproductive-oriented selection profile, which often involves a trade-off between body mass and reproductive efficiency (Aviagen, 2022).

Among the traits analyzed, body weight uniformity exhibited significant variation (P < 0.05), with Cobb achieving the highest uniformity score (80.71%), outperforming both Ross (78.44%) and Hubbard (78.38%). Uniformity in body weight is a critical parameter in broiler breeding, as it supports consistent responses to nutrition, synchronized growth, and optimized flock management practices such as vaccination and grading (Roscha et al., 2022). Cobb's high uniformity suggests a strong genetic predisposition for homogeneous growth, enhancing predictability and operational efficiency throughout the production cycle. In contrast, the slightly lower uniformity observed in Hubbard and Ross indicates greater individual variation, potentially requiring more targeted management strategies—such as precision feeding, lighting synchronization, and weight-based flock stratification—to maintain consistent performance.

Laying Phase Performance

During the reproductive phase, significant differences were observed in depletion, egg production, body weight, and egg weight among strains, whereas feed intake and hatchability showed no significant variation (Table 2).

Table 2. Performance of broiler Grandparent Stock (GPS) strains during the laying phase

Parameter	Cobb (n = 368)	Hubbard (n = 574)	Ross (n = 256)
Depletion (%)	0.629 ± 0.546^{b}	0.870 ± 0.818^{a}	0.479 ± 0.430^{c}
Feed intake (kg/bird/phase)	132.7 ± 71.86^{A}	134.8 ± 77.81^{A}	134.8 ± 77.81^{A}
Hen-day egg production (%EGG)	38.17 ± 16.81^{b}	49.31 ± 18.33^{a}	49.13 ± 21.33^{a}
Hatchability (%HE actual)	95.30 ± 8.210^{A}	95.01 ± 4.170^{A}	94.79 ± 9.740^{A}
Body weight (kg)	4.193 ± 0.249^{b}	4.727 ± 0.528^{a}	4.165 ± 0.434^{b}
Egg weight (g)	64.85 ± 6.100^{A}	63.82 ± 8.800^{AB}	62.65 ± 5.180^{B}

Note: Values are expressed as mean ± standard deviation. Superscripts with different lowercase letters (a, b, c) within the same row indicate significant differences at P < 0.05. Superscripts with different uppercase letters (A, B) within the same row indicate significant differences at P < 0.01. Feed intake represents total cumulative intake per bird during the laying phase.

During the laying phase (26–69 weeks), significant differences were observed among strains in mortality, egg production, body weight, and egg weight, while feed intake and hatchability remained statistically similar. Among the evaluated strains, Ross exhibited the lowest mortality rate at 0.479%, significantly lower than Cobb (0.629%) and Hubbard (0.870%) ($P < 0.05$). These values are well within the standard commercial limit of <5% annual depletion, as outlined in the strain manuals and supported by (Rasyaf, 2012). The superior survival rate of Ross throughout the laying phase suggests greater physiological resilience and adaptability under prolonged production conditions. This observation is consistent with the genetic profile of Ross, which emphasizes reproductive efficiency and metabolic balance (Aviagen, 2022). In contrast, the relatively higher mortality in Hubbard, although still acceptable, may be attributed to its larger body size and higher metabolic demand, which can increase vulnerability to heat stress and production-related pathologies in tropical environments.

Hen-day egg production (HDEP) differed significantly among strains ($P < 0.05$). Cobb recorded the lowest HDEP (38.17%), whereas Ross (49.13%) and Hubbard (49.31%) achieved significantly higher values. Although these figures fall below ideal standards (Ross: 55–65%; Hubbard: 50–60%), they still indicate acceptable productivity under tropical conditions. The lower performance of Cobb may reflect its genetic predisposition toward growth rather than reproductive traits. Furthermore, suboptimal management factors—such as inadequate lighting regimes, imbalanced breeder nutrition, or poor body weight control—may further limit reproductive efficiency (Ferreira et al., 2019). Previous studies have highlighted that synchronizing light stimulation with nutritional planning is critical for optimizing reproductive performance in broiler breeders (North & Bell, 1990; Leeson & Summers, 2005).

Despite the differences in egg production, total cumulative feed intake across strains did not vary significantly, averaging between 132,749.8 and 134,785.8 g/bird for the entire laying period. This suggests that basic nutritional requirements during the reproductive phase are similar across strains. However, when feed intake is interpreted alongside egg production, Cobb appears to have the least efficient feed-to-egg conversion, highlighting the need for strain-specific dietary strategies. Precision feeding based on reproductive phase dynamics could improve Cobb's laying efficiency by ensuring energy and protein intake are aligned with ovulatory cycles and egg formation demands (Cobb-Vantress, 2021).

All strains maintained excellent hatchability rates exceeding industry standards (Cobb: 95.30 ± 8.2%; Hubbard: 95.01 ± 4.2%; Ross: 94.79 ± 9.7%; overall mean: 95.03 ± 7.4%), with no significant between-strain variation ($P = 0.083$, one-way ANOVA). These values substantially surpassed the 90% minimum threshold for commercial viability (Decuypere and Bruggeman, 2007). High hatchability indicates strong fertility, viable embryos, and effective incubation management. The consistency across strains also suggests optimal male-to-female ratios, semen quality, and breeder flock health. These findings underscore that, when genetic potential is complemented by optimal environmental and technical management, reproductive performance can be maintained at consistently high levels, regardless of strain.

Body weight during the laying phase differed significantly among strains ($P < 0.01$), with Hubbard achieving the highest average (4,727 g), followed by Cobb (4,193 g) and Ross (4,165 g). The heavier mass of Hubbard corresponds with its genetic design focused on larger body frames (Masir et al, 2024). While increased body weight often correlates with larger eggs and potentially stronger chicks, it can also reduce mating efficiency and increase health risks due to excessive fat deposition and skeletal stress.

Cobb and Ross maintained weights closer to their ideal range (Cobb: 4,200–4,400 g; Ross: 4,100–4,200 g), suggesting a more favorable balance between reproductive performance and metabolic load. These results emphasize the importance of tailored weight control programs particularly for heavier strains—to sustain optimal fertility and reduce production-related complications.

Egg weight exhibited significant differences ($P < 0.05$), with Cobb producing the heaviest eggs (64.85 g), followed by Hubbard (63.82 g) and Ross (62.65 g). These values fall within the standard egg weight range for commercial GPS strains and align with previous findings linking larger egg size to higher chick quality and early broiler performance (Iqbal et al., 2016). However, excessive egg weight can increase the risk of shell fragility, delayed pipping, or malposition during hatching, potentially negatively impacting hatchability and chick viability. Therefore, achieving a balance between optimal egg mass and structural integrity is essential for maximizing both fertility and hatch success. Targeted feeding strategies that incorporate essential micronutrients for shell quality (e.g., calcium, vitamin D3, zinc) should be employed to support the production of high-quality hatching eggs.

Integrated Strain Performance and Implications

The integrated evaluation of growth and reproductive performances of three commercial Grandparent Stock (GPS) strains Cobb, Ross, and Hubbard highlights distinctive genetic and physiological traits that cater to specific production priorities. Each strain demonstrated unique advantages across the production cycle, underlining the importance of strain-specific management strategies, especially in tropical environments such as Indonesia. The comparative analysis conducted in this study provides critical insight into how each strain performs under real-world commercial conditions, offering a basis for rational strain selection and national poultry breeding strategy development.

Cobb exhibited consistent superiority during the grower phase, with the lowest depletion rate (0.30%) and the highest body weight uniformity (80.71%). These indicators suggest that Cobb possesses excellent early-life viability and growth synchrony, both of which are pivotal for achieving efficient and cost-effective management in large-scale breeding operations (Roscha et al., 2022; Bell and Weaver, 2012). Uniformity enhances flock handling, vaccination efficiency, and feed distribution precision critical aspects in automated or semi-automated systems (Kiani, 2022). While Cobb's body weight was only marginally higher than Hubbard, its combination of low mortality and tight uniformity positions it as a genetically stable and management-friendly strain for early growth phases in hot, humid conditions.

In contrast, Ross emerged as the most robust strain during the reproductive phase. It recorded the lowest laying-phase mortality (0.479%) and a high Hen-Day Egg Production (49.13%), which was significantly better than Cobb. Although its egg weight was slightly lower than Cobb's, the overall reproductive efficiency of Ross coupled with moderate body weight suggests a strain optimized for sustained performance and metabolic stability. This aligns with previous reports noting Ross's advantage in reproductive longevity and adaptability to varied management systems (Aviagen, 2022). The relatively lean body frame of Ross breeders may contribute to reduced metabolic burden during laying, enhancing survivability and fertility under prolonged production cycles (Masir et al, 2024).

The Hubbard strain, despite showing the highest mortality rates across both production phases (grower: 0.56%; laying: 0.87%), exhibited superior performance in key output metrics. It attained the greatest mature body weight (4,727 ± 528 g) and maintained competitive egg production (49.3% hen-day production), with mean egg weight (63.8 ± 8.8 g) approaching

Cobb's benchmark (64.9 ± 6.1 g). This phenotypic profile reflects intentional genetic selection for growth potential and yield. However, the strain's elevated depletion rates suggest particular vulnerability to tropical stress factors, necessitating enhanced environmental control, tiered biosecurity protocols, and phase-specific nutritional adjustments - particularly during the critical grower-to-lay transition period (Rasyaf, 2012; Iqbal et al., 2016).

These results collectively underscore that GPS strain selection should not rely solely on general productivity metrics but must also consider the compatibility between genetic potential and local environmental constraints. In tropical settings, where heat stress, disease pressure, and feed variability are persistent challenges, strains like Cobb and Ross—both demonstrating resilience and biological efficiency offer strategic value for sustainable GPS multiplication. Conversely, Hubbard's potential for high output can still be leveraged through investment in climate-controlled housing, precision feeding, and advanced reproductive management, particularly where economies of scale justify such inputs.

Importantly, the current study introduces novel insights by integrating full-cycle, population-level data from over 100,000 birds across two major Indonesian breeding companies. Unlike previous studies that focused primarily on Parent Stock or commercial broilers (Singh and Yadav, 2020), this research provides one of the first comprehensive comparisons of GPS strain performance under tropical commercial field conditions, using retrospective operational records spanning multiple years. This context-specific evaluation fills a critical gap in the literature and offers valuable direction for designing locally adapted GPS development programs, which could eventually reduce dependence on imported genetics and enhance national breeding sovereignty.

The optimal strain choice should be tailored to the specific goals of a given operation. Cobb is best suited for operations that prioritize early growth uniformity and low mortality; Ross excels in reproductive efficiency and long-term viability; and Hubbard, while requiring intensive care, offers high biological output that can be valuable in high-input systems. The findings support the development of decision-support frameworks for GPS strain selection in Indonesia and other tropical countries, integrating performance data with cost-efficiency modeling, environmental adaptability, and genetic sustainability considerations.

Conclusions

Each broiler Grand Parent Stock strain evaluated in this study exhibited unique biological advantages, reflecting their genetic makeup and adaptability to tropical production environments. The Cobb strain demonstrated excellent early survivability and flock uniformity, making it ideal for operations focused on consistent growth and streamlined management. The Ross strain stood out for its superior reproductive performance and longevity, highlighting its suitability for prolonged egg production and breeder durability. In contrast, the Hubbard strain showed strong potential in terms of body weight and total egg mass, though it demanded more intensive management to address related health and environmental challenges. These results emphasize the importance of selecting strains based on specific production goals, environmental conditions, and management capabilities to optimize performance and ensure sustainability in poultry breeding programs.

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