EVALUATION OF PRODUCTION PERFORMANCE OF 3 GRAND PARENT STOCK STRAINS OF 24-WEEK-OLD BROILER BREEDS IN INDONESIA

Ahmad Bestari[1,a], Sri Darwati[1], Maria Ulfa[1], Muladno[1]
[1]Animal Production Science and Technology Study Program, IPB University, Bogor, West Java
[a]*email:* ahmadbstr@gmail.com

Abstract
The production performance of GPS broilers in Indonesia has not been well studied. This study aims to analyze the comparison of production performance between GPS of C-Line and D-Line at the age of 24 weeks and compared with the standards set by each principal. This research was conducted from November 2022 to March 2023. The results showed that each strain has its own characteristics and advantages in accordance with the genetic potential developed by the principal company in this case is a performance achievement at the age of 24 weeks. Comparison of actual broiler GPS production performance against the standard mostly shows a difference, so that each company must re-evaluate the achievement of production performance to match the standard target set by the principal.
Keywords: Performance, Productivity, Strain, GPS

EVALUASI PERFORMA PRODUKSI PERIODE PRE LAYING PADA 3 STRAIN GPS AYAM RAS PEDAGING DI INDONESIA

Abstrak
Performa produksi GPS pada strain Cobb, Indian River, dan Cobb belum banyak diteliti. Oleh karena itu tujuan dilakukan penelitian ini adalah untuk menganalisis perbandingan performa produksi antar strain GPS indukan betina pada umur 24 minggu dan juga dibandingkan dengan standar yang ditetapkan principal masing-masing. Penelitian ini dilakukan dari bulan Nopember 2022 sampai Maret 2023. Hasil penelitian menujukkan bahwa perbandingan performa produksi antar strain GPS pada umur 24 minggu yang dicapai oleh masing-masing strain sebagian besar terdapat perbedaan yang nyata baik pada bobot badan, konsumsi pakan, deplesi dan keseragaman. Adapun perbandingan performa produksi antara strain GPS dengan standar yang ditetapkan principal juga terdapat perbedaan yang nyata dan beberapa parameter capaian melebihi standar. Hal ini tentu dipengaruhi oleh perbedaan manajemen pola pemeliharaan yang berbeda dari masing-masing perusahaan menyesuaikan kondisi aktual dilapangan.
Keywords: Performa, Produktivitas, Strain, GPS

INTRODUCTION

Some broiler breeding company in Indonesia periodically import broiler chicken Grand Parent Stock (GPS) from various country to support the broiler chicken Parent Stock (PS) provision. Based on the Directorate General of Animal Husbandry and Animal Health's online poultry report, 22 companies have developed GPS broilers in Indonesia. In the last five years, the population of broiler GPS income has decreased by 12.79% from 743,827 birds in 2018 to 648,679 birds in 2022, with an average decrease of 3.25% per year (DPKH 2022).

GPS technical maintenance is divided into two periods: the growing period (1-24 weeks old) and the production period (25 – 65 weeks old). The main objective of rearing during the grower period is to produce chicks with ideal weight, optimum uniformity, condition and sufficient sexual maturity at 24 weeks of age (pre-laying) to produce good hatching eggs when entering the production period. Successful maintenance during the growing period will determine the success and achievement of performance during the production period (Cobb Brochure, 2021).

Practically, each breeding company strives to achieve production performance in

accordance with the standards issued by each principal company. The principal parameters include body weight, feed consumption, depletion, uniformity and sex ratio. The standard data can be used as a reference for the company to produce GPS breeds that comply with the standards after being reared in Indonesia. In addition, the government has required breeding companies to give online reports on the population and development of the GPS female (D-Line) and male (C-Line) they keep.

Under these conditions, it is necessary to evaluate the production performance of GPS broilers at the end of the rearing period of GPS D-Line and C-Line broilers, or 24 weeks of age. The evaluation results will be compared with the standards published by the principal company and compared between strains to see the performance of each strain. Evaluation of the production performance in various strains of 24-week-old GPS broilers can provide information on the best strains that can adapt well in Indonesia.

MATERIALS AND METHODS

The study was conducted by evaluating GPS production performance data of female broilers (D-Line) and male (C-Line) using secondary data sourced from the Directorate General of Livestock and Animal Health. The data focused on production performance for the final rearing period of 24 weeks, derived from 46 flocks spread across 8 breeding companies in East Java, Central Java, West Java, Lampung, South Sumatra, North Sumatra, and West Kalimantan from 2019 to 2021, with observed variables including body weight, cumulative feed consumption, cumulative mortality/depletion, uniformity and sex ratio. The data from recapitulation and normality testing were further tested with the following procedures:

1) Analysis of the comparison of production performance achievements between strains, regions and companies was tested as follows:
   a. In normal distributed data, using the ANOVA test, if the significant variable was within the level of 5%, then Duncan's further test would be carried out.

   b. Data that are not normally distributed would be analyzed with the Kruskal-Wallis H non-parametric test;
   c. Performance comparison can only be done between S2 and S3 strains that have fast feather growth properties using an independent T-test.
   d. The S1 strain had slow feather growth, therefore, the date only analyzed with descriptive tests.
2) Comparative analysis of actual and standard production performance achievements was tested as follows:
   a. If the data was normally distributed, then t-test testing would be performed;
   b. If the data was not normally distributed, then Wilcoxon non-parametric testing as an alternative to the paired two-sample t test would be performed (Uyanto, 2006).

RESULTS AND DISCUSSION

GPS broilers breeding companies are very limited in Indonesia. These companies focus on producing broiler GPS, which in turn produces parent stock (PS). PS will produce final stock sold to and reared by companies or farmers (Wahyuni and Lestari 2022). Broiler GPS parent selection is crucial. Therefore, each company must establish a strict system for their broiler GPS management (John 2009). The price per GPS bird of imported broilers is also very expensive, hence the requirement for companies to follow the manual or guidelines issued by their breeding company (principal) (Aviagen 2019; Cobb 2021; Hubbard 2021). The results of the GPS productivity evaluation study of female broilers (D-Line) and male (C-Line) from strains S1, S2 and S3 were divided into two comparative discussions: performance comparisons between strains, and comparison with each strain's principal standards.

Comparison of Production Performance Between Strains

Performance comparisons between strains are needed to assess the characteristics of each broiler GPS strain developing in Indonesia. Broilers are categorized into fast feathering (FF) types, represented by strains S2 and S3, and slow feathering (SF) types, represented by S1 strains, based on differences in GPS feather growth speed. The comparison tests between strains are conducted on S2 and S3 strains, as outlined in Table 1 below.

Table 1. Comparison of production performance achievements between S2 and S3 strains aged 24 weeks

Sex	Variables		Strains		Sig.
			S2	S3	
Female (D-Line)	BB	(g)	$3{,}062.00 \pm 84.46$	$3{,}195.78 \pm 147.37$	0.01
	KP	(g)	$11{,}026.20 \pm 257.71$	$11{,}143.11 \pm 410.55$	0.20
	DP	(%)	9.26 ± 1.96	8.00 ± 3.08	0.26
	UNF	(%)	83.50 ± 1.58	84.72 ± 5.95	0.53
Male (C-Line)	BB	(g)	$3{,}645.40 \pm 196.15$	$3{,}461.11 \pm 278.94$	0.09
	KP	(g)	$13{,}018{,}20 \pm 230.18$	$12{,}288.50 \pm 846.45$	0.01
	DP	(%)	41.39 ± 10.41	50.72 ± 25.97	0.16
	UNF	(%)	82.00 ± 4.64	86.96 ± 5.55	0.02
	SXR	(%)	15.74 ± 2.18	15.17 ± 5.91	0.81

Description: BB = Body weight; KP = feed consumption; DPL = Depletion; UNIF = uniformity, SXR = sex ratio.

The GPS body weight on S2 and S3 D-Line broilers are different from every strains. The D-Line from S3 strain on average weighted 3,195.78 g at 24 weeks, heavier than the weight from the S2 strain with 3,062.00 g. This difference implies that the body weight growth of the S2 strain was slower than the S3 strains. The C-Line from S2 strain has a body weight of 3,645.40 g at 24 weeks of age, higher than the body weight observed in the S3 strain, with 3,461.11 g. The body weight on GPS broilers C-Line showed no significant difference between each strain.

Differences in production performance, particularly body weight, can be attributed to several factors, including feed consumption, environment, seeds, and feed quality (Siagian 2021). This aligns with Zainal's (2012) research, which equates that variations in chickens body weight are influenced by distinct genetic potential and adaptability among each individual chickens. Furthermore, according to the principal's guide for each strain at the age of 24 weeks, the body weight of D-Line in S3 strain is 3,120.00 g, which is greater than the weight in S2 (2,935.00 g). Conversely, in males, the target body weight for S3 strain is 3,220.00 g, which is smaller than the standard weight in strain S2 (3,600.00 g).

Body weight is one of the factors that affect mating activities, therefore, it indirectly affects fertility and hatchability. Body weight is closely related to the feeding pattern, which requires adherence to the appropriate quantity and nutritional content. This ensures that the response in male and female chickens aligns with the recommended body weight curve set by each principal. Overweight roosters often encounter mating problems, while underweight males often experience stress that decreases its semen quality. In other cases, a high difference in male and female body weight, reaching 40%, can result in to decreased responsiveness in females and, consequently, a decline in fertility rates. Referring to Mejia (2020), it is recommended to maintain an optimal fertility rate by keeping the differences between male and female weights within the range of 15% to 20%. Therefore, implementing careful selection in both male and female chickens is important to achieve optimal body weight.

There was no notable difference on cumulative feed consumption among 24 weeks-old GPS of D-Line broilers between the two strains. The S3 strain consumed a total of 11,143.11 g feed, higher than the S2 strain, which consumed 11,026.20 g. When associated with its body weight, the S2 strain had a lower relative efficiency based on its Feed Conversion Ratio (FCR) than the S3 strain (FCR value of 3.60, compared to an FCR of 3.49). A noticeable difference in feed consumption was also observed on the C-Line GPS broilers. S2 strain had an average of 13,018.20 g feed consumption, higher than the S3 strain with 12,288.50 g. The higher consumption rate in the S2 strain did not go hand in hand with the increase in body weight. This was evident from a better Feed Conversion Ratio (FCR) value in the S3 strain, with 3.55 compared to the S2 strain with 3.57.

The difference in feed consumption is closely related to the implemented management practices. Feeding should always be adjusted to the recommended feed levels provided by each principal, while taking into account the chickens's body weight in a given week, which consequently affects the daily feed consumption per bird. Several factors affect the level of feed consumption, including

environmental temperature, chicken health, ration energy content, feeding system, sex, and chicken genetics (Fahrudin *et al.* 2016).

The cumulative mortality rate up to 24 weeks of age showed no significant differences between strains, both in the GPS of C-Line and D-Line broilers. however, the mortality rate on the GPS of D-Line broilers from the S3 strain was 8.00%, lower than the S2 strain with 9.26% mortality rate (Table 2). The mortality rate on C-Line broiler GPS in both strains was higher than on the D-Line broiler GPS, possibly due to the strict selection process in the C-Line aimed to obtain superior male genetics. Mortality in the S3 strain reached 50.72%, higher than the S2 strain at 41.39%.

The death rate is greatly influenced by the management system, if the management is done well, the death rate can be eliminated. Even in FS-level broilers, the mortality rate of up to 5% is tolerated (Purwanti 2006), indicating good overall performance by the breeding company. Some factors causes death in chickens, including poultry house and equipment sanitation, environmental hygiene, disease, and cage density. High-density poultry house can lead to increased aggression in the competition for feed, with smaller chickens will not be able to compete against larger chickens, which results in higher mortality rates (Permana 2020).

Uniformity production performance parameters in GPS of D-Line broilers indicate no significant differences between strains. The level of uniformity in the S3 strain was 84.72%, slightly higher than the the S2 strain with 83.50%. A noticeable difference in C-Line was observed between the two strains, where the S3 strain showed 86.96% uniformity, greater than the S2 strain of 82.00%. Uniformity in body weight becomes a measure of the chicken variability within a population, as the physically the body weight of chickens should be uniform. Good uniformity indicate small variation among chicken body weights in one population, an important condition to reach optimal egg production or hen day production (Sahlan 2022). A good degree of uniformity should reach at least 80%, as $\geq$ 80% uniformity reflects good body weight uniformity. Conversely, $\leq$ 80% uniformity level indicates poor body uniformity (Fadilah and Fatkhuroji, 2013).

In addition to weighing, maintaining uniformity also involves grading, culling, and selection of chickens according to their sizes, accompanied by special treatment. It is recommended to sort chickens into 3 groups based on their body weight: heavy, average, and light (Cobb 2020). The chickens were graded into certain groups to ensuring that the overall flock/group of chickens has the same average weight, and help the farm to achieve the targeted body weight.

The sex ratio up to 24 weeks of age did not show significant difference between strains. The sex ratio in strain S2 was 15.74%, slightly higher than strain S3 at 15.17%. The sex ratio value represents the proportion of males to females, with the observed sex ratio being 12.78%. Sex ratio plays an important role in optimizing fertility and hatchability, and it needs to be considered to each specific strain, as each strain will respond differently to hatchability (Haghighi 2016).

Most companies often focus on female rearing management, however, fertility rate in hatching eggs is greatly influenced by the number of males during the mating process. Balancing the male and female ratio is very important to maintain optimal fertility levels. Flock with too many males can lead to heightened aggression towards females. Conversely, if the number of males is too small, some females might remain unmated (Mejia 2020).

The observed differences in production performance between each strain cannot be separated from various internal and external factors. These factors include employee expertise, extreme weather, feed quality and breed quality. Although technological advancement in closed house systems should have mitigated the weather factors and micro conditions (temperature, humidity and wind speed), differences among production performance among each breeding company remain plausible.

Table 2 presents production performance data on the slow feathering (SF) S1 strain. Based on Table 3, the average body weight gain on the D-Line of GPS broilers amounted to 2,967.72 g with an average cumulative consumption rate up to 24 weeks of age of 10,423.94 g. The C-Line GPS broilers average body weight reached 3,770.44 g, with an average cumulative consumption rate of 13,016.94 g.

Table 2. GPS production performance of broiler strain S1 aged 24 weeks

Sex	Variable		N	Minimum	Maximum	Mean
Female (D-Line)	BB	(g)	18	2.886,00	3.067,00	2,967.72 ± 47.93
	KP	(g)	18	10.075,00	10.924,00	10,423.94 ± 218.61
	DEP	(%)	18	5,00	21,00	9.28 ± 4.23
	UNIF	(%)	18	85,63	96,30	90.27 ± 3.06
Male (C-Line)	BB	(g)	18	3.606,00	3.909,00	3,770.44 ± 88.82
	KP	(g)	18	12.595,00	13.387,00	13,016.94 ± 210.80
	DEP	(%)	18	33,77	71,01	57.24 ± 7.69
	UNIF	(%)	18	91,45	98,84	94.85 ± 2.42
	SXR	(%)	18	11,42	14,9	12.18 ± 0.77

Description: BB = Body weight; KP = feed consumption; DEP = Depletion; UNIF = uniformity, SXR = sex ratio.

The higher consumption on broiler GPS C-Line was possible due to the effect of sex factors on feed consumption rate, as male consumes more feed than females (Lantowa 2021). The cumulative mortality rate up to 24 weeks of age on the GPS of D-Line broilers was 9.28%, much lower than the 57.24% mortality rate observed on S1 strain's C-Line. This higher mortality rate on the C-Line was possible due to the selection / culling process aimed at obtaining the best males and achieving a high level of uniformity. In this data demonstration, the GPS uniformity of C-Line broilers was 91.45%, higher than the uniformity of S1 broiler GPS at 85.63%. Culling was carried out not only to obtain the best males but also to maintain the male and female ratio. The evaluation results indicate that the male and female sex ratio in the S1 strain averaged 12.18%, closely aligning with the standard set at 12%.

Comparison of Actual Production Performance and Principal Standards

In an effort to achieve optimal production performance, each broiler GPS breeding company makes every effort to reach the production performance targets from the guidelines/standards published by each principal. A comparison of the production of GPS strains of actual broilers with the standards set by the principal reveals the extent of the company's ability to match the maintenance system set by the principal. Comparison of production performance between S1, S2, S3 strains for actual performance with the

standards of each strain in this study is presented in Table 3.

The production performance of all D-Line GPS broilers strains had marked differences with the principal standards at 24 weeks of age. In these three strains, the actual body weight of D-Line GPS broilers exceeds the body weight set by the principal standard. For example, the average actual weight of D-Line from S3 strain was 3,461.11 g, 75.78 g ± 147.37 heavier than the the principal-set standard of 3,120.00 g. The body weight of GPS C-Line broilers in S1 and S3 strains at the age of 24 weeks were significantly different from the principal standards of each strain. The average actual body weight of male broiler GPS in strain S3 was 3,461.11 g, 241.11 g heavier than the weight determined by the principal (3,220.00 g ± 278.94). However, the S2 strain showed no difference with the body weight standard set by the principal, achieving 3,645.40 g, a slight excess of 45.40 g from the principal's standard of 3,600.00 g ± 196.15.

Chicken's body weight is closely related to its fertility. Chickens with standard body weight within exhibit higher fertility than those with excessive or insufficient body weight. Overweight conditions hinder hens' ability to complete mating, as it is more difficult for sperm cells to reach the top of the oviduct for oocytes fertilization before albumen begins to be stored. Additionally, overweight chickens often have legs problems , further interfering with normal mating (Daskalopoulou 2012).

Table 3. Comparison of production performance between strains (actual) and principal standards at 24-weeks

Strain	Sex	Variable		Mean	Standard	Sig (2 Tailed)
S1	Female (D-Line)	BB	(g)	2,967.72±47.93	2.800,00	0,00
		KP	(g)	10,423.94±218.61	9.919,00	0,00
		DPL	(%)	9.28±4.23	5,00	0,00
		UNIF	(%)	90.27±3.06	80,00	0,00
	Male (C-Line)	BB	(g)	3,770.44±88.82	3.700,00	0,00
		KP	(g)	13,016.94±210.80	11.739,00	0,00
		DPL	(%)	57.24±7.69	5,00	0,00
		UNIF	(%)	94.85±2.42	80,00	0,00
		SXR	(%)	12.18±0.77	12,00	0,34
S2	Female (D-Line)	BB	(g)	3,062.00±84.46	2.935,00	0,00
		KP	(g)	11,026.20±257.71	11.214,00	0,05
		DPL	(%)	9.26±1.96	5,00	0,00
		UNIF	(%)	83.50±1.58	80,00	0,00
	Male (C-Line)	BB	(g)	3,645.40±196.15	3.600,00	0,48
		KP	(g)	13,018,20±230.18	12.894,00	0,12
		DPL	(%)	41.39±10.41	5,00	0,00
		UNIF	(%)	82.00±4.64	80,00	0,21
		SXR	(%)	15.74±2.18	12,00	0,00
S3	Female (D-Line)	BB	(g)	3,195.78±147.37	3.120,00	0,04
		KP	(g)	11,143.11±410.55	10.634,40	0,00
		DPL	(%)	8.00±3.08	5,00	0,00
		UNIF	(%)	84.72±5.95	80,00	0,00
	Male (C-Line)	BB	(g)	3,461.11±278.94	3.220,00	0,00
		KP	(g)	12,288.50±846.45	11.289,60	0,00
		DPL	(%)	50.72±25.97	5,00	0,00
		UNIF	(%)	86.96±5.55	80,00	0,00
		SXR	(%)	15.17±5.91	12,00	0,04

Description: BB = Body weight; KP = feed consumption; DPL = Depletion; UNIF = uniformity, SXR = sex ratio.

Feed consumption is an important production parameter for a breeding company. Table 3 shows that the GPS feed consumption of D-Line broilers for S1, S2, and S3 strains has a marked difference from the standards set by each principal. Feed consumption on S2 strains was less than the established standards, while feed consumption on S1 and S3 strains exceeded the standards. The feed consumption on S1 and S3 strains GPS of C-Line broilers was higher than their respective standards, while S2 strains was 13,018.20 g±230.18, showing no difference with the feed standards of 12,894.00 g. In addition to being influenced by the nutritional content, variation in feed consumption is also influenced by housing comfort factors, such as temperature, humidity, and stocking density (Umam 2014). Housing factors had been mitigated by adapting the closed house technology, hence the observed high feed consumption for almost all strains in this study.

Based on these data, the company still has to re-evaluate the feeding pattern to be in accordance with the set standards. Specifically, C-Line GPS from S2 strain showed good feed consumption, which is also reflected by the body weight aligning with the principal's standards. The difference between actual and standard feed consumption was possible because feed consumption is influenced by several factors, namely energy content in feed, body weight, strain, production rate, stress level, livestock activity, feed management, and environmental temperature (Sitompul 2016).

Table 3 presents cumulative mortality data at 1 – 24 weeks of age with marked differences between actual and standard in each strain. In this case, the mortality rate was higher than the established standard of 5.00%. The mortality rate on GPS broiler D-Line in strain S3 was 8.00%, lower than strain S1 at 9.28% and strain S2 at 9.26%. Meanwhile, the mortality rate in GPS broilers C-Line strain S2 was 41.39%

lower than strain S3 by 50.72% and strain S1 by 57.24%. The large mortality rate on the GPS of C-Line broilers was most likely due to the very strict culling and selection.

Production performance in uniformity both on GPS broilers D-Line and C-Line showed significant difference when compared to the standards in each strain. In this case, the uniformity of all strains at the age of 24 weeks was above 80%, above the standard set by the principal. As stated by Fadilah and Fatkhuroji (2013), the ≥ 80% level of uniformity indicates good uniformity of body weight produced. The high level of uniformity in the Indian River strain of 90.27% ± 3.06 in the GPS of female broilers and 94.85% ± 2.42 GPS of male broilers was very possible, because the S1 strain was only managed by one company with the same management standards.

Table 3 presents sex ratio performance data, taking into account the adequacy of males and females at 24 weeks of age. It indicates a marked difference between actual and standard achievement. The sex ratio in all strains was above the standard set at 12%, which means that the number of males is sufficient for the mating process of females available in each flock, and even more.

CONCLUSION

Based on the results of the description and discussion above, it can be concluded:

1. Each strain has its own characteristics and advantages in accordance with the genetic potential developed by the principal company, particularly the performance at the age of 24 weeks; and
2. A comparison of actual GPS broiler production performance against standards shows a significant difference. Each breeding company must re-evaluate production performance achievements to achieve the standard targets set by the principal.
3. Further research needs to be done by measuring the relationship between rearing period production performance achievements and success in the broiler GPS production period in Indonesia.

REFERENCES

Agon. 2022. Modern Chickens Are Getting Bigger, Harvesting Faster. *Agon*. [accessed on June 17, 2023]. http://www.agrina-online.com/data/27/index-agrinaLiputanSpecial.

Cobb. 2020. Cobb Breeder Management Guide. Cobb-vantress. [accessed on 15 April 2020]. http:// www.cobb-vantress.com.

Cobb. 2021. Cobb500 Grandparent Management Supplement. Cobb-vantress. [accessed on May 132022]. http://www.cobb-vantress.com.

Daskalopoulou, I. 2012. Effect of body weight at maturity on fertility and hatchability traits of broiler parent stock. *Int J Bus Econ Sci Appl*. 1 I:79–86. doi:10.5281/zenodo.4063702.

Dawami A. 2022. Business process of breeding chickens. *Poultry Breeding Company Association*. Jakarta

[DBPP] Directorate General of Livestock Production Development. 2001. Development of Purebred Chicken Breeding in Indonesia. Jakarta: DBPP.

[DPKH] Directorate General of Livestock and Animal Health. 2011. Guidelines for breeding good breed chickens. Jakarta: DPKH.

[DPKH] Directorate General of Livestock and Animal Health. 2022. Livestock and Animal Health Statistics 2022. Jakarta: DPKH.

Elfick D. 2006. How Chicken Became a Global Food Phenomenon in 50 Years Dominic. In: *A Brief History of Broiler Selection*. Aviagen International.

Fahrudin, A., W. Tanwiriah, and H. Indrijani. 2016. Ration consumption, weight gain and conversion of local chicken rations at Jimmy Farm's Farm Cipanas Cianjur Consumption. *Artik Fak Breeder Univ Padjadjaran*.

Haghigi, M., M. Irani, M. Jafari, S. Firouzi, and H. Habibi. 2016. Effect of sex ratio on the production and hatchability of broiler breeder flock. *J World Poult Res*. 6(1):14–17.

Hubbard. 2019. Efficiency Plus, Performance objectives. [diakses 2022 Mei 13]. https://www.hubbardbreeders.com/media/broiler_performance_objectives_efficiency_plus_enptes_20190717__026422600_1023_23082019.pdf.

Mejia, D. L. 2020. Better Male Management Increases Flock Fertility. [diakses 2023 Jun 13]. https://www.cobb-vantress.com/en_US/articles/better-male-manage-ment-increases-flock-fertility.

Permana, A. D. 2020. Impact of cage density on depletion rate in broiler parent stock grower phase. *J Anim Res Appl Sci*. 2(2):7–12. DOI:10.22219/aras.v2i2.12824.

Purwanti M, Ace IS, Rizal K, Wahyuningsih. 2006. Quality performance of free-range chickens traders resulting from crossing male scavenger chickens with local female chickens. *Match Refiner*. 1(1):11–17.

Sahlan A. 2022. The level of uniformity of body weight of laying hens of Lohmann Brown strain Layer period in Global Buwana Farm Bogor Arridho Sahlan Veterinary Paramedic Study Program. [accessed 2023 May 20]. https://ereport.ipb.ac.id/id/eprint/10774/1/J3P219074-01-Arridho-cover.pdf.

Siagian, T. B., and N. K. Nugraheni. 2021. Broiler breeder performance in the final phase of grower. *J Ternak*. 12(2):36. doi:10.30736/jt.v12i2.115.

Sitompul, S. A., O. Sjofjan, and I. H. Djunaidi. 2016. The effect of several types of commercial feed on quantitative and qualitative production performance of broilers. *Bul Farmer*. 40(3):187. DOI:10.21059/BuletinPeternak.v40i3.11622.

Umam, M. K., H. S. Prayogi, and V. M. A. Nurgiartiningsih. 2014. The performance of broiler rearing in system stage floor and double floor. *J Ilmu-ilmu Peternak*. 24(3):79–87. http://jiip.ub.ac.id/.

Uyanto, S. S. 2006. *Pedoman Analisis Data dengan SPSS*. Jogjakarta: Graha.

Wahyuni, W., and A. Lestari. 2022. The prevalence of illness and mortality of laying hens (case study on a farm of hens of laying breeds). *Tarjih Trop Livest J*. 2(2):68–75. [accessed 30 Jun 2023]. DOI:10.47030/trolija.v2i2.440.