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Correlation Analysis of Broiler Production Traits: A Case Study in Humid Tropical East Kalimantan

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Abstract
Broiler production in humid tropical regions such as East Kalimantan faces challenges from persistently high temperatures and humidity, which can affect feed intake, growth rate, and feed conversion efficiency. This study aimed to examine the correlation among key production parameters feed intake, daily weight gain, feed conversion ratio (FCR), and mortality across commercial broiler farms with different housing systems in East Kalimantan. An observational field study was conducted on four broiler farms rearing Ross, Lohmann, and Cobb strains under both closed-house and open-house environments. Data were analyzed using Pearson correlation after normality testing, with a significance level of $\alpha = 0.05$. The average feed intake was 3.70 ± 0.64 kg/bird, final body weight 2.08 ± 0.13 kg, total body weight gain 2.04 ± 0.13 kg, FCR 1.81 ± 0.23, and mortality 3.92 ± 0.74%. A significant positive correlation was found between feed intake and FCR ($r = 0.961$; $p < 0.05$), and a very strong correlation between body weight gain and final body weight ($r = 1.000$; $p < 0.01$). Broilers raised in closed-house systems showed lower FCR and more stable growth compared to those in open-house systems. These findings highlight the crucial role of microclimatic control in improving feed efficiency and growth performance of broilers in humid tropical environments. Optimizing housing design and environmental management is therefore recommended to enhance the productivity and economic efficiency of broiler farming in tropical regions.

Keywords: *broiler chicken; correlation; feed conversion ratio; body weight gain; humid tropics.*

1. Introduction

Broiler production in humid tropical regions such as East Kalimantan faces distinctive environmental challenges characterized by persistently high temperature and humidity, which can adversely affect growth rate, feed intake, and feed conversion efficiency [1;2]. Ideally, commercial broiler operations are expected to achieve rapid growth, low feed conversion ratio (FCR), and minimal mortality through optimal nutritional, environmental, and biosecurity management. Under standard industry conditions, the target for average daily gain (ADG) typically exceeds 55–60 g/bird/day with an FCR below 1.6 to ensure high economic efficiency. However, in actual tropical field conditions, particularly in East Kalimantan, heat and humidity often induce chronic heat stress, reducing feed intake and growth rate, which in turn compromises feed efficiency and productivity. Variations in management practices, housing design (closed versus open house), and the genetic strain of broilers further contribute to performance differences among farms [3]. Therefore, field-based investigations using real commercial data are essential to understand how production parameters interact under humid tropical environments [4].

High ambient temperature and humidity are known to trigger heat stress in broilers, leading to reduced feed intake, slower growth, and poorer feed efficiency (FCR). These conditions disrupt physiological balance and upregulate the expression of heat shock proteins, particularly HSP70, as a cellular adaptive response [5]. Chronic heat exposure also alters energy metabolism, suppresses immune function, and modifies feeding and drinking behavior, ultimately affecting performance and carcass quality [6]. The gap between ideal production standards and on-farm realities in humid tropical regions such as East Kalimantan often results in lower feed efficiency

and inconsistent market weights, which directly influence farm profitability. Previous studies have highlighted that housing design, microclimate regulation, and feeding management strongly influence FCR and ADG [3]. However, systematic empirical data from small- and medium-scale commercial farms in East Kalimantan remain limited.

Recent experimental and modeling studies have revealed dynamic patterns between feed intake and broiler growth performance. Variations in feeding behavior during the production cycle may lead to differences in growth rate and feed efficiency, suggesting that feed intake can serve as an important predictive indicator of growth response under varying environmental conditions [7;8]. Research on housing systems has shown that closed-house facilities generally provide better microclimate control, maintaining stable temperature and humidity levels that help reduce mortality and improve FCR compared with open-house systems, although final performance outcomes still depend heavily on management practices and stocking density [9]. Nevertheless, most of these studies were experimental or conducted at large-scale industrial operations, while on-farm data from small and medium commercial producers in humid tropical regions remain scarce.

Addressing this gap, the present study provides field-based empirical evidence of the correlations among production parameters in commercial broiler farms under humid tropical conditions in East Kalimantan. Specifically, it investigates the relationships among feed intake, ADG, FCR, and mortality across farms employing different housing systems. The outcomes are expected to contribute both theoretically by enriching the understanding of performance interactions under humid tropical stress and practically by offering management insights for improving feed efficiency and productivity in local broiler operations. Furthermore, these findings may serve as a reference for policy and technical recommendations for broiler production systems in similar tropical regions [10].

2. Materials and Methods

2.1. Study Location and Subjects

This study was conducted on four commercial broiler farms located in East Kalimantan, Indonesia, specifically in Penajam Paser Utara and Kutai Kartanegara Regencies. The observation period extended from January to August 2025. The region is characterized by a humid tropical climate with an average daily temperature ranging from 27°C to 33°C and relative humidity between 70% and 90%. These environmental conditions were considered an essential factor in evaluating broiler performance and production efficiency.

The research employed an on-farm observational approach with a descriptive correlational design. The study subjects consisted of commercial broiler flocks from four different farms using Ross, Lohmann, and Cobb strains, with an initial population ranging from 4,000 to 5,500 birds per farm. Three farms operated under a closed-house system, while one farm used an open-house system. The grow-out period varied from 28 to 37 days, and feeding and watering management followed each farmer's operational standards.

2.2. Observed Variables

The main performance parameters observed in this study included:

1) Feed intake (kg/bird) – calculated as the total feed supplied minus feed residuals, divided by the number of birds.
2) Initial and final body weight (kg/bird) – determined by weighing representative bird samples from each flock.
3) Body weight gain (kg/bird) – calculated as the difference between the mean final and initial body weight.
4) Feed Conversion Ratio (FCR) – obtained from the ratio between total feed intake and body weight gain.

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5) Mortality rate (%) – determined by dividing the number of dead birds by the initial population and multiplying by 100.

The mean and standard deviation for each parameter were computed from the combined data of the four farms to represent the general production condition of broilers raised under humid tropical environments in East Kalimantan.

2.3. Data Analysis

All data collected from the four farms were analyzed using SPSS software version 16.0. The analysis began with the Shapiro–Wilk normality test to determine the distribution pattern of each variable. Variables with normal distribution were analyzed using Pearson's correlation, while non-normally distributed data were analyzed using Spearman's rank correlation.

The parameters analyzed included feed intake, average daily gain (ADG), feed conversion ratio (FCR), final body weight, and mortality rate. The statistical significance level was set at $\alpha = 0.05$. Correlation analysis was performed to evaluate the strength and direction of the relationships among production parameters, either positive or negative, allowing for a functional interpretation of interrelationships among broiler performance variables. Additionally, descriptive statistics were used to compare performance differences among farms based on housing system (closed vs. open house) and strain type. Correlation results were visualized using scatter plots to illustrate the interaction patterns between key production variables.

The analytical procedure followed the approaches of [4], who utilized correlation tests to evaluate the relationship between dietary energy and broiler performance, and [11], who examined growth uniformity in relation to feed homogeneity and final body weight. The use of Pearson's correlation in poultry performance studies is widely recommended, as it effectively identifies the strength and direction of associations among productivity parameters across different management systems [12].

Table 1. Interpretation of Correlation Coefficient Strength

Interval Koefisien	Tingkat Hubungan
0.00 – 0.199	Very weak
0.20 – 0.399	Weak
0.40 – 0.599	Moderate
0.60 – 0.799	Strong
0.80 – 1.000	Very strong

(Source: [7])

3. Results and Discussion

The analysis was conducted to evaluate the relationships among feed intake, body weight gain, and feed conversion ratio (FCR) across four commercial broiler farms in East Kalimantan. Descriptive results indicated that the average feed intake was 3.70 ± 0.64 kg/bird, the average body weight gain was 2.04 ± 0.13 kg/bird, and the mean FCR was 1.81 ± 0.23. Mortality ranged from 3.43% to 5.00%, while the rearing period varied between 28 and 37 days (Table 2).

The farms employed two different housing systems, closed house and open house, which exhibited notable variation in environmental conditions, feed management, mortality, and production performance. In general, birds reared in closed-house systems experienced a more stable microclimate in terms of temperature and humidity, whereas open-house systems were highly influenced by fluctuating tropical ambient conditions. Such environmental stability positively affected feed intake, body weight gain, and FCR. This finding aligns with [13], who reported that effective ventilation and temperature control reduce heat stress and maintain physiological balance in broilers raised under hot climates. Similarly, [6] noted that closed-house systems typically maintain temperatures of 27–30 °C and relative humidity of 60–70%, significantly improving growth rate and FCR compared to open-house systems during the dry season in tropical regions. [1] also demonstrated that housing design and environmental management efficiency largely determine production outcomes, with closed houses producing

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higher final weights and lower FCR values than open houses. Collectively, these findings emphasize the critical role of microclimate management and housing design in sustaining broiler performance in humid tropical environments.

Table 2. Performance indicators of broiler chickens reared under humid tropical conditions.

Parameter	Farm Arif	Farm Herry	Farm Hamid	Farm Aqwil	Mean ± SD
Location	Penajam Paser Utara	Kutai Kartanegara	Penajam Paser Utara	Penajam Paser Utara	–
Housing type	Closed house	Closed house	Open house	Closed house	–
Growing period (days)	37	28	35	34	33.50 ± 3.87
Strain	Ross	Lohmann	Cobb	Lohmann	–
Initial population (birds)	5,000	4,000	4,000	5,500	4,625 ± 750
Final population (birds)	4,810	3,800	3,863	5,310	4,446 ± 738.51
Mortality (%)	3.80	5.00	3.43	3.45	3.92 ± 0.74
Total feed intake (kg)	17,250	12,150	18,250	20,600	17,062.5 ± 3,563.33
Feed intake per bird (kg)	3.45	3.04	4.56	3.75	3.70 ± 0.64
Initial body weight (kg/bird)	0.038	0.042	0.039	0.043	0.041 ± 0.002
Final body weight (kg/bird)	2.151	1.910	2.204	2.061	2.08 ± 0.13
Total body weight gain (kg/bird)	2.113	1.868	2.165	2.018	2.04 ± 0.13
Feed Conversion Ratio (FCR)	1.63	1.63	2.11	1.86	1.81 ± 0.23

Average mortality across farms remained within the acceptable commercial range (< 5%) but fluctuated depending on housing system and heat-stress level. This agrees with [14], who reported that heat stress and stocking density are the main drivers of mortality in tropical broiler production. Feed intake showed a positive correlation with final body weight, though the relationship was not strictly linear, reflecting the influence of metabolic efficiency and physiological status. Elevated feed intake that does not correspond to improved growth may indicate nutrient imbalance, particularly disproportionate energy-to-protein ratios or physiological disturbances associated with environmental stress. Recent studies suggest that low-nutrient-density diets (e.g., reduced energy or protein levels) may trigger compensatory feeding behavior, whereby birds increase feed intake but fail to achieve higher weight gain due to inadequate essential nutrient supply [5;15]. Therefore, higher feed intake alone cannot be interpreted as improved performance; it must be analyzed alongside ration quality and environmental conditions to accurately assess production efficiency.

Variation in FCR values among the farms further supports the influence of housing and management. Broilers raised in closed-house systems exhibited lower FCRs, reflecting higher feed efficiency compared with those in open houses. This is consistent with the results of [16], who found that temperature-controlled housing systems minimize excessive energy expenditure from heat stress, thereby enhancing feed utilization efficiency. Collectively, these findings suggest that environmental control remains a key determinant of broiler growth and feed efficiency under modern tropical production systems.

3.1. Normality Test

The normality test was conducted before performing correlation analysis on each key variable (mortality, feed intake, final body weight, total weight gain, and FCR). Data normality was assessed using the Shapiro–Wilk test to determine the appropriateness of the parametric Pearson correlation. The results are presented in Table 3.

All key variables showed significance values greater than 0.05, indicating that the data were normally distributed and met the assumptions for using the Pearson correlation test. The choice of the Shapiro–Wilk method is supported by statistical literature due to its high detection power for small to medium sample sizes before applying parametric tests [17]. Moreover, [18] emphasized that Pearson correlation is valid when the data distribution is normal, and

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relationships among variables are linear. Similarly, [19] applied the Shapiro–Wilk test in broiler performance studies to ensure valid interpretation of inter-variable correlations. Hence, the normal distribution of data in this study suggests that farm-to-farm variations remain within the natural range, allowing the use of Pearson correlation analysis with valid statistical assumptions.

Table 3. Results of Normality Test

Variable	Shapiro–Wilk Statistic	Significance	Interpretation
Mortality (%)	0.788	0.082	Normal
Feed intake (kg/bird)	0.966	0.817	Normal
Final body weight (kg/bird)	0.948	0.705	Normal
Total weight gain (kg/bird)	0.948	0.704	Normal
FCR	0.862	0.266	Normal

3.2. Correlation Analysis

The correlation analysis was conducted to examine the relationships among broiler production performance parameters, including mortality, feed intake, final body weight, total body weight gain (BWG), and feed conversion ratio (FCR). The Pearson correlation test was performed using SPSS version 16.0, and the results are presented in Table 4.

Table 4. Pearson correlation coefficients among broiler performance parameters

Variable Relationship	r (Pearson)	Sig. (p)	Interpretation
Mortality – Feed intake	–0.790	0.210	Not significant, strong negative correlation
Mortality – Final body weight	–0.854	0.146	Not significant, strong negative correlation
Mortality – BWG	–0.848	0.152	Not significant, strong negative correlation
Mortality – FCR	–0.676	0.324	Not significant, moderate negative correlation
Feed intake – Final body weight	0.806	0.194	Not significant, strong positive correlation
Feed intake – BWG	0.802	0.198	Not significant, strong positive correlation
Feed intake – FCR	0.961	0.039	Significant positive correlation
Final body weight – BWG	1.000	0.000	Highly significant positive correlation

Figure 1 shows the relationship among key parameters (feed intake, FCR, BWG, and final body weight) in four commercial broiler farms. The scatter plot reveals a linear trend between feed intake and FCR, as well as a strong positive relationship between BWG and final body weight.

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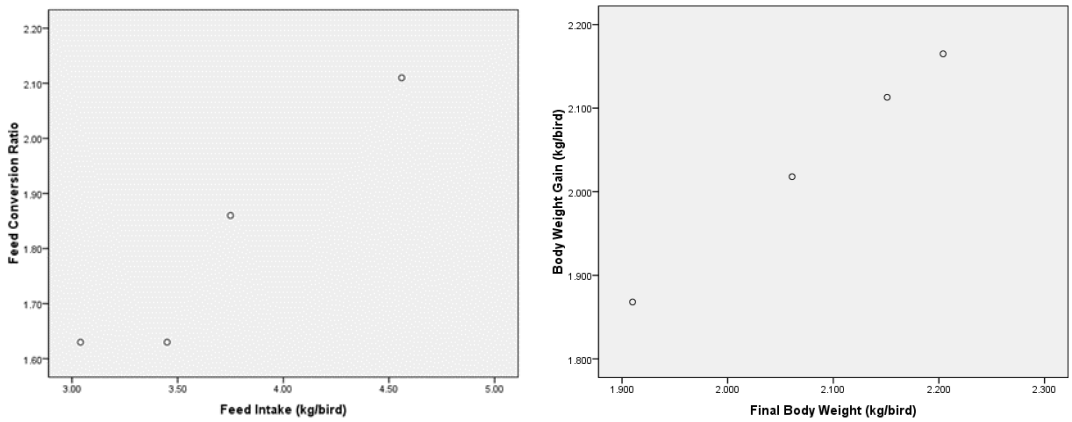

Figure 1. Scatter plot showing the correlation between feed intake and feed conversion ratio (FCR) (a) and final body weight and body weight gain (b) of broiler chickens.

The results indicate a significant positive correlation between feed intake and FCR ($r = 0.961$; $p < 0.05$), implying that higher feed intake does not necessarily reflect improved feed efficiency; in fact, it may indicate reduced efficiency. This finding aligns with the report of [8], who observed that excessive feed consumption without proportional growth led to higher FCR values. Similarly, [18] found a positive association between daily feed intake and FCR in broilers, while [10] confirmed that feed efficiency (FCR) is consistently correlated with both feed intake and metabolic efficiency traits. These results highlight that feed quantity alone is insufficient; feed management and environmental conditions play pivotal roles in optimizing efficiency.

A highly significant correlation between final body weight and BWG ($r = 1.000$; $p < 0.01$) indicates that cumulative growth directly determines market body weight. [17] reported that growth uniformity and consistent feed intake were positively correlated with final weight, while [18] found that greater BWG significantly enhanced both carcass yield and overall production quality. [19] further emphasized that stable environmental and nutritional conditions promote flock uniformity, which ultimately improves final body weight and reduces individual variability. Hence, achieving optimal slaughter weight depends not only on daily growth rates but also on consistent management and environmental stability throughout the rearing period.

The relationship between feed intake and BWG followed a consistent pattern, where higher intake per bird was associated with greater growth potential. [20] reported a positive correlation between individual feed consumption and final body weight, while observing that greater variation in feed intake within flocks led to increased overall growth performance. [21] also demonstrated that higher dietary energy levels increased both feed intake and BWG, though FCR improvement was not always proportional. Thus, feed intake remains a crucial indicator of growth capacity, provided that nutrient utilization and management practices are optimized.

Mortality was found to negatively affect total feed intake and production efficiency. [22] noted that high mortality rates reduce the effective flock size, contributing to total feed intake and live weight production. Similarly, [23] reported that suboptimal environmental conditions, such as high temperature and poor ventilation, can increase mortality and decrease feed efficiency. Therefore, even though the correlations between mortality and individual performance traits were not statistically significant, they remain relevant indicators of management quality, particularly under humid tropical conditions.

Overall, the correlation results confirm that feed intake, BWG, and FCR are closely interrelated in determining broiler performance. Increased feed intake tends to promote growth, but its efficiency depends largely on proper management and microclimatic control. These findings emphasize the importance of optimizing housing systems and environmental conditions

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to sustain production efficiency, especially in humid tropical regions such as East Kalimantan [1;9].

4. Conclusion

This study demonstrates that the humid tropical environment of East Kalimantan markedly influences the production performance of commercial broiler chickens. The correlation analysis revealed a significant positive relationship between feed intake and feed conversion ratio (FCR) ($r = 0.961$; $p < 0.05$), indicating that higher feed consumption does not necessarily result in improved feed efficiency. In contrast, the very strong correlation between body weight gain and final body weight ($r = 1.000$; $p < 0.01$) confirms that cumulative growth is the primary determinant of market weight. Broilers raised under closed-house systems consistently exhibited better performance than those reared in open-house systems, characterized by lower FCR values and reduced mortality rates (<5%). These findings underscore the critical role of housing design and environmental management in improving feed efficiency and overall broiler performance under humid tropical conditions. Furthermore, the correlation among performance parameters suggests that production outcomes are not solely influenced by feed intake but also by growth stability, nutritional balance, and managerial factors. Therefore, the adoption of microclimate control technologies and optimized nutritional strategies should be prioritized to enhance production efficiency and flock health in broiler operations across East Kalimantan and similar tropical regions.

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