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Research Article

Characterization of Phenotypic Variation in Indigenous Chicken Populations in Lower Northern Thailand to Improve Chicken Breeding

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In Thailand, native chickens have a deep-rooted history of cultivation driven by diverse purposes, including food production, aesthetic appeal, exhibition, and cockfighting. Their remarkable adaptability, robustness, and resistance to diseases play pivotal roles in the evolution of chicken breeds. The study of morphological characteristics in native chicken breeds assumes significance for biodiversity conservation, sustainable agriculture, and cultural preservation. These traits not only unveil genetic diversity but also provide insights into adaptation that is crucial for the survival of native chicken populations in varied environmental conditions. The primary aim of this extensive research, conducted from June 2020 to May 2023, is to elucidate the morphological traits of six indigenous chicken breeds in Thailand's Uttaradit province. The research methodology involved the purposive selection of a research group from chicken farms with a minimum of 5 individuals, followed by a random selection of 20 names meeting specific criteria. The resulting group comprised 134 individuals from Khiew Phalee, Thao Thong, Lueng Hang Khao, Chee, Pra Dhu Hang Dam, and Jae species. The study's findings highlighted significant differences in eight qualitative morphological characteristics among the distinct chicken breeds, including comb type, beak color, neck plumage color, back plumage color, wing plumage color, long curved tail color, back tail color, and shank color ($p < 0.01$). Moreover, a correlation between body size and sex-specific structures across breeds was discovered, with male chickens exhibiting significantly greater body weight, size, wing length, upper and lower shank length, and toe length than females ($p < 0.0001$). Notably, the majority of native chickens displayed the walnut (Hin) beak type, except for Jae chickens, which exhibited the single (Jak) type. Beak colors ranged from blackish-green to ivory, while each breed showcased unique plumage, tail, and shank colors, coupled with varying body sizes. This comprehensive study, covering both qualitative and quantitative parameters, emphasizes the morphological diversities among the six native chicken breeds. The derived data serve as a valuable resource for refining or developing chicken breeds in alignment with the Standard of Perfection for Thai Native Chickens, catering to the evolving needs of the market.

1. Introduction

The Thai government currently prioritizes grassroots economic development by harnessing the biodiversity within communities and localities. Thailand possesses strengths that allow it to compete with other nations, notably in terms of biodiversity and local wisdom [1]. Native chickens in Thailand are acknowledged as a valuable biological diversity resource with commercial significance, reflecting trends seen in other Asian countries. Poultry enthusiasts have raised these chickens for various purposes in roles spanning from food production and aesthetic appeal to exhibition.

Especially, chickens with traits suitable for cockfighting often command higher prices compared to general chickens. Hence, concerted efforts were undertaken to conserve native chicken breeds, preserving them for use in selection processes during breed improvement and development. The conservation of native chicken breeds not only enabled local communities to achieve self-reliance but also enhanced their income, concurrently creating job opportunities for the people in the area [2].

To enhance the value of native chickens, two main avenues were explored: contests and cockfighting. Contests involved a standardized species selection process aimed at conserving native chicken breeds, with criteria contributing to a potential value addition of 40,000–100,000 Thai baht (THB average exchange rate 36 baht/1 USD). Developing breeds for cockfighting, on the other hand, required extensive knowledge of the advantageous physical characteristics of each breed. The price of a cockfighting rooster was contingent on fight outcomes, ranging from 10,000 to 100,000 baht, with more victories resulting in higher financial gains [3]. Thai wisdom defines the Standard of Perfection, detailing five crucial traits of exceptional fighting cocks. These include a distinguished, long, rounded face reminiscent of a peacock's visage, vibrant feathers enhancing brightness and fierceness, a well-proportioned body conveying balance, legs with neat scales and a strong spur, and adept posture involving standing, walking, running, wing-flapping, and fearlessness among other chickens [4, 5].

Uttaradit province in northern Thailand is well known for its crucial role in developing local chicken breeds, especially the Khiew Phalee fighting cock [6]. This region hosts five additional native chicken breeds, Thao Thong, Lueng Hang Khao, Chee, Pra Dhu Hang Dam, and Jae, serving as valuable economic assets. Each breed possesses distinctive traits: Khiew Phalee, lauded as the epitome of the Thai warrior chicken, distinguished by greenish-black feathers and unique features [7]; Thao Thong, with a tall, slender physique and white feathers, showcased captivating characteristics [4]; Lueng Hang Khao recognized for its white tail and yellow feathers, prominent in cockfighting and conservation efforts [8]; Chee, a visually striking variety with a slender physique and white plumage [4]; Pra Dhu Hang Dam, known for its parrot-like features and seamless integration of black coloring [2]; and finally, Jae or Kai Tor-Kai Tang, a product of crossbreeding, displaying a tapestry of diversity with distinct phenotypic traits [9].

Moreover, the ongoing practice of crossbreeding has resulted in the emergence of chickens intended for cockfighting in the country, leading to a continuous increase in the number of Burmese and Vietnamese chicken breeds. Consequently, the population of native chickens in Thailand has declined, as well as causing the loss of some native chicken breeds or the unique characteristics of Thailand's Lueng Hang Khao [10]. An illustrative example of the renowned Standard of Perfection for Thai fighting cocks is the white-tailed yellow chicken [4]. It is worth noting that white-tailed yellow chickens exhibited diverse comb types, sometimes even displaying signs of crossbreeding with Burmese chickens, which underscored the shifts observed in Thai native chicken breeds. Consequently, the genetic merits of native chicken populations have been diluted due to the introduction of exotic breeds, a phenomenon observed in native chicken populations in various regions [11, 12].

Previous data emphasized the morphological importance impacting the economic value and role in breed development of native chicken breeds in Thailand. However, it revealed a noticeable lack of comprehensive studies on both the qualitative and quantitative traits of these breeds. The lack of information on phenotypic diversity presented a significant obstacle to the design of appropriate breeding programs. To address this gap, the primary objective of the study was to conduct a thorough morphological analysis, encompassing both quantitative and qualitative aspects, following the guidelines of the Food and Agricultural Organization (FAO) for the genetic characterization of chicken resources. The study focused on six native chicken breeds, namely, Khiew Phalee, Thao Thong, Lueng Hang Khao, Chee, Pra Dhu Hang Dam, and Jae, all located in Uttaradit province. The information gathered from the study raised awareness about the importance of conserving biodiversity and served as valuable data for selecting characteristics to develop breeds of Thai native chicken.

2. Materials and Methods

2.1. Study Site. The study was conducted in Uttaradit province, a historical city situated in the lower northern part of Thailand at coordinates 17° 37′ 23″ north latitude and 100° 5′ 45″ east longitude. This region is home to a population of approximately 454,007 people and spans an area of 8,353 square kilometers (Figure 1). Characterized by a tropical savanna climate, Uttaradit is predominantly an agricultural province. The weather in this area exhibits an average daily temperature of around 27.5°C [13]. According to a 2023 report on livestock production in Thailand, Uttaradit province achieved the third rank in chicken production among nine provinces in the lower northern region. The province played host to around 4.36 million chickens, cared for by 27,753 farmers. Noteworthy is the cultivation of 1.09 million native chickens, involving 27,515 chicken farmers. The considerable volume of chickens, particularly the significant population of native breeds, and the participation of a substantial number of farmers highlight the economic significance of livestock production in Uttaradit [14]. Therefore, this province was selected as the study area for examining phenotypic diversity in both qualitative and quantitative traits of these breeds.

2.2. Ethics Statement. The experimental procedures undertaken in this study received approval and were conducted in accordance with the guidelines set forth by the Animal Ethics Committee of Pibulsongkram Rajabhat University (approval reference number: PSRU-(AG)-2021-007.

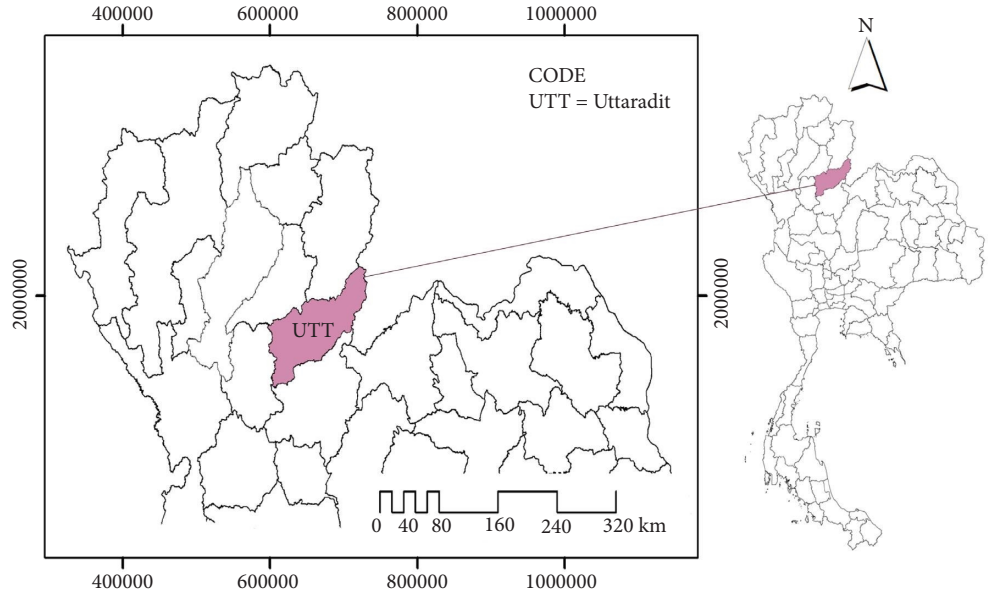


Figure 1: Illustration of a map of Thailand, generated using free and open-source software (QGIS), with a focus on highlighting the geographical positioning of Uttaradit province in the lower northern region.

2.3. Data Collection and Parameters

2.3.1. The Methodology, Population, and Sampling Procedure. This research employed a mixed-method approach, combining quantitative and qualitative methodologies. The objective was to gather data on both the quantitative and qualitative characteristics of six native chicken breeds in the study area. The data collection methods included conducting interviews to gather basic information about chickens in two aspects: the name of the breed of chicken and the age of the chicken. The collection of data was guided by the FAO [10], encompassing both qualitative and quantitative methods for chicken genetic resource characterization. Qualitative characteristics were observed and recorded by examining the unique shape and color of each external structure of the chicken. Quantitative data collection involved measuring external structures or organs. Data were collected from farms that raised native chickens throughout the period from June 2020 to May 2023. Due to the unpredictability of sample availability and the researcher's lack of knowledge about all farmers' locations, probability sampling was deemed limiting. Therefore, the sample selection in this study employed purposive sampling, a type of non-probability sampling that enables a targeted approach aligned with the research objectives. The decision-making process was grounded in the researcher's expertise and experience, with a primary focus on transparency to mitigate potential biases associated with the sample selection. The application of clear inclusion and exclusion criteria contributes to the transparency of the sampling selection process. The inclusion criteria for selecting chicken farms required each sample to include a minimum of five native chickens, specifically adult chickens aged seven months [15], with farm owners willing to cooperate in studying external morphology. The exclusion criteria included any affiliations between the sample group and the researcher, as well as individuals who were not willing to participate in the study. The exclusion criteria included any affiliations between the sample group and the researcher, as well as individuals who were not willing to participate in the study or were not domiciled in the study area. Data collection from the sample stopped after collecting twenty samples, resulting in a total study population of 134 native chickens (Table 1). The population represents both sexes and encompasses various breeds, including Khiew Phalee, Thao Thong, Lueng Hang Khao, Chee, Pra Dhu Hang Dam, and Jae.

2.3.2. Data Gathering. The data collection process entailed observing and measuring the structures or organs of chickens to delineate the morphological attributes of various native chicken breeds. Once the name of the chicken breed and the age of the chicken were identified, data were specifically collected from adult chickens. The data collection process comprised two categories: qualitative and quantitative data. Qualitative data were obtained through the observation of native chickens, aiming to understand the characteristics and distinctive colors of chickens in their natural environment. This included observing comb type, beak color, neck plumage color, back plumage color, wing plumage color, long curving tail color, back tail color, and shank color. Quantitative data were acquired by examining eight parameters, which included body weight, body height, body length, body width, wing length, upper shank length, lower shank length, and toe length. Measurements were taken from sampled native chickens of both sexes, utilizing calibrated textile measuring tapes (in cm) and hanging spring balances (in kg). The determination of both

Table 1: The number of chickens of each breed used in the quantitative and qualitative characteristics study.

Chicken breeds	Male	Female	Total
Khiew Phalee	15	11	26
Thao Thong	12	10	22
Lueng Hang Khao	14	12	26
Chee	11	10	21
Pra Dhu Hang Dam	13	9	22
Jae	10	7	17
Total	75	59	134

qualitative and quantitative parameters adhered to the descriptors outlined by the Food and Agricultural Organization (FAO) for the characterization of chicken genetic resources [10].

2.4. Data Analysis. The collected data on qualitative and quantitative parameters of native chicken populations were analysed. Qualitative parameters underwent Chi-square test analysis using Proc Freq procedures, while quantitative parameters were analysed with Proc GLM procedures. Least square means were compared using Duncan's multiple range test (DMRT). Pearson correlation coefficients for quantitative traits were explored with Proc Corr within the same software package [16]. The Chi-square test was employed for the qualitative data analysis of physical appearance, especially for characteristics not following a normal distribution. This test was applied to eight qualitative morphological characteristics observed across six distinct chicken breeds, including comb type, beak color, neck plumage color, back plumage color, wing plumage color, long curved tail color, back tail color, and shank color. In the study, eight quantitative parameters (body weight, body size and height, length, and width, wing length, upper and lower shank length, and toe length) of the six native chicken breeds were measured with p values <0.05. The results were analysed using the least square means of DMRT and Pearson correlation coefficient at p values <0.05. The DMRT statistic was used for comparing differences in means, chosen due to equal variances but variations in sample sizes among the groups. When using the Pearson correlation coefficient (r) test statistic to indicate the relationship between two variables, the coefficient ranged from −1.0 to +1.0. A close-to-1.0 value suggested a positive relationship, while a close-to-(−1.0) value indicated an inverse relationship. A coefficient equal to 0 meant the two variables were not related.

3. Results

The principal objective of this study is to expound upon the morphological traits of diverse native chicken breeds. This entails the characterization of both qualitative and quantitative parameters across six native chicken breeds in the Uttaradit province of Thailand, aligning with the descriptors outlined by the FAO for the genetic characterization of chicken resources [10]. The study involved the examination of the qualitative and quantitative external structure of native chickens, with a sample of 134 individuals from 6 breeds. This sample included 31 individuals of Khiew Phalee, 18 individuals of Thao Thong, 26 individuals of Lueng Hang Khao, 26 individuals of Chee, 21 individuals of Pra Dhu Hang Dam, and 23 individuals of Jae.

3.1. Description of the Morphological Characteristics. The study results involved the observation and measurement of chicken structures or organs to delineate the morphological attributes of various native chicken breeds. It was discovered that native chickens exhibit physical characteristics, distinguishing them from other poultry breeds. They typically display a sturdy and compact build, featuring a well-proportioned body. Their feathers showcase a variety of colors and patterns, highlighting the breed's rich diversity. The head of native chickens is often adorned with a distinctive comb, varying in both shape and size. Additionally, they possess expressive eyes that reflect their alert and active nature. The beak is typically strong and adapted to their foraging habits. A notable feature of native chickens is the diversity of their plumage colors and patterns. The size and shape of their wings may vary, providing them with agility in movement. Native chickens exhibit a diverse array of physical characteristics, setting them apart from other poultry breeds. They typically possess a robust and compact build, featuring a well-proportioned body. The diversity of plumage colors and patterns is a notable characteristic of native chickens. The size and shape of their wings may vary, providing them with agility in movement. Native chickens commonly possess strong and sturdy legs, well-adapted to a free-range lifestyle, possibly in combination with chicken cages. The color of their legs may vary, and they often have robust claws suitable for scratching the ground in search of food or for defensive purposes.

In this study, each chicken breed examined showcases specific characteristics, especially in male chickens. These specific traits significantly influence the value of the chickens. The details of the characteristics and body structure size of each chicken breed can be observed in Figure 2 and are summarized in Table 2. This section summarizes the characteristics and the size of the body structure in male chickens for each breed. In the first breed, Khiew Phalee chickens observed in this study share common features. They possess a crest known as a walnut-type comb, locally referred to as "Hin" in Thai. The beak, neck plumage, back plumage, wing plumage, long curving tail, and back tail in these chickens all exhibit a blackish-green color, while the shanks are black. This gives rise to the name of this chicken breed, also known as "Khiew Hang Dam." This is because chickens of this breed have feathers that are blackish-green, covering the entire body, and a dark green tail that resembles black. "Khiew" means green in Thai, "Hang" means tail, and "Dam" means black. The average measurements for body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are as follows: 2.87 ± 0.09 kilograms, 54.76 ± 0.77 cm, 22.22 ± 0.38 cm, 17.98 ± 0.34 cm, 18.27 ± 0.37 cm, 14.36 ± 0.28 cm, 11.37 ± 0.21 cm, and 8.75 ± 0.18 cm, respectively. In the second breed, Thao Thong chickens exhibit shared features across all

Figure 2: Six chicken breeds depicted as follows: (a) Khiew Phalee, (b) Thao Thong, (c) Lueng Hang Khao, (d) Chee, (e) Pra Dhu Hang Dam, and (f) Jae.

individuals, including a walnut-type comb, ivory beak, neck plumage in brown or orange, back plumage in orange or grey, wing plumage in brown or grey, a long curving tail in white or grey, a grey back tail, and shanks in white-yellow. The mean values of body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are 2.65 ± 0.12 kg, 54.17 ± 1.02 cm, 21.33 ± 0.51 cm, 19.46 ± 0.45 cm, 17.57 ± 0.49 cm, 15.06 ± 0.38 cm, 11.65 ± 0.27 cm, and 9.57 ± 0.24 cm, respectively. The overall appearance of this breed of chicken features a grey base with highlights of golden yellow feathers. This characteristic gives rise to the name "Thao Thong," where "Thao" in Thai means grey, and "Thong" in Thai means golden yellow.

Lueng Hang Khao is the third chicken whose external morphology had been studied in detail. It was found that this breed of chicken has a walnut-type comb, similar to the preceding two breeds. Other noteworthy features include an ivory beak, golden yellow neck plumage, and golden yellow or black back and wing plumage. The long curving tail can be either white or black, with a black back tail and white-yellow shanks. The average measurements for body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are 2.83 ± 0.10 kg, 54.43 ± 0.83 cm, 22.86 ± 0.41 cm, 19.85 ± 0.36 cm, 17.56 ± 0.41 cm, 15.70 ± 0.31 cm, 12.44 ± 0.22 cm, and 9.48 ± 0.19 cm, respectively. The fourth species, the Chee, exhibits a walnut-

Table 2: Data and information about the qualitative variables used in Chi-square analysis for the six native chicken breeds under study.

Qualitative variables	*Chicken breeds*					
	Khiew Phalee	Thao Thong	Lueng Hang Khao	Chee	Pra Dhu Hang Dam	Jae
Comb						
Single (Jak)	0.00	0.00	0.00	0.00	0.00	100.00
Walnut (Hin)	100.00	100.00	100.00	100.00	100.00	0.00
Beak						
Blackish-green	100.00	0.00	0.00	0.00	100.00	100.00
Ivory	0.00	100.00	100.00	100.00	0.00	0.00
Neck plumage						
Blackish-green	100.00	0.00	0.00	0.00	0.00	0.00
Brown	0.00	41.18	0.00	0.00	0.00	0.00
Grey	0.00	58.82	0.00	0.00	0.00	0.00
Orange	0.00	0.00	0.00	0.00	0.00	95.45
Pra Dhu	0.00	0.00	0.00	0.00	100.00	0.00
White	0.00	0.00	0.00	100.00	0.00	0.00
Yellow-gold	0.00	0.00	100.00	0.00	0.00	4.55
Back plumage						
Black	0.00	0.00	46.15	0.00	0.00	0.00
Blackish-green	100.00	0.00	0.00	0.00	0.00	0.00
Brown	0.00	41.18	0.00	0.00	0.00	0.00
Grey	0.00	58.82	0.00	0.00	0.00	0.00
Orange	0.00	0.00	0.00	0.00	0.00	100.00
Pra Dhu	0.00	0.00	0.00	0.00	100.00	0.00
White	0.00	0.00	0.00	100.00	0.00	0.00
Yellow-gold	0.00	0.00	53.85	0.00	0.00	0.00
Wing plumage						
Black	0.00	0.00	46.15	0.00	0.00	0.00
Blackish-green	100.00	0.00	0.00	0.00	0.00	0.00
Grey	0.00	58.82	0.00	0.00	0.00	0.00
Orange	0.00	41.18	0.00	0.00	0.00	0.00
Pra Dhu	0.00	0.00	0.00	0.00	100.00	0.00
White	0.00	0.00	0.00	100.00	0.00	0.00
Yellow-gold	0.00	0.00	53.85	0.00	0.00	100.00
Long curving tail						
Black	0.00	0.00	46.15	0.00	100.00	100.00
Blackish-green	100.00	0.00	0.00	0.00	0.00	0.00
Grey	0.00	58.82	0.00	0.00	0.00	0.00
White	0.00	41.18	53.85	100.00	0.00	0.00
Back tail						
Black	0.00	0.00	100.00	0.00	100.00	100.00
Blackish-green	100.00	0.00	0.00	0.00	0.00	0.00
Grey	0.00	100.00	0.00	0.00	0.00	0.00
White	0.00	0.00	0.00	100.00	0.00	0.00
Shank						
Black	100.00	0.00	0.00	0.00	33.33	0.00
Blackish-green	0.00	0.00	0.00	0.00	66.67	0.00
Grey	0.00	0.00	0.00	0.00	0.00	100.00
White-yellow	0.00	100.00	100.00	100.00	0.00	0.00

Note. The Chi-square test indicated a statistically significant difference with a p value <0.001 for all the data.

type comb and ivory beak. The neck plumage, back plumage, wing plumage, long curving tail, and back tail are white, while the shanks are white-yellow. Chee is a white chicken breed raised for both egg production and meat consumption. The name of the Chee chicken is inspired by the white-robed female priestess of Thailand. The average measurements for body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are 2.97 ± 0.14 kg, 54.85 ± 1.15 cm, 22.15 ± 0.58 cm, 20.35 ± 0.51 cm, 17.80 ± 0.55 cm, 15.50 ± 0.43 cm, 12.20 ± 0.31 cm, and 9.30 ± 0.27 cm, respectively. From the yellow color of the neck plumage, back plumage, and upper wing plumage (referred to as "Lueng" in Thai), and the white fur on the tail (referred to as "Khao" in Thai), the name of this chicken breed originates.

Pra Dhu Hang Dam is the fifth breed of chicken that had been studied. This chicken breed features a walnut-type comb crest. The beak is blackish-green, while the neck

plumage, back plumage, and wing plumage are distinctively colored in a shade of olive green, but with a brighter appearance. In Thai folk wisdom, this color is referred to as "Pra Dhu," and it is said to resemble the color of old leaves from the *Pterocarpus* tree. This color is distinctive and is used to name this particular chicken breed. The name of the tail, called "Hang Dam," comes from the color of the long curving tail and back tail, which is black. The word "tail" means "Hang" in Thai, and the word "black" means "Dam" in Thai. The shanks are black and blackish-green. The average measurements for body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are 2.93 ± 0.12 kg, 53.47 ± 0.95 cm, 22.32 ± 0.49 cm, 19.95 ± 0.41 cm, 17.34 ± 0.45 cm, 15.35 ± 0.35 cm, 12.13 ± 0.25 cm, and 9.52 ± 0.22 cm, respectively.

The last breed examined in this study is identified as Jae or bantam breeds. This chicken breed is classified as an ornamental or beautiful breed. This chicken breed, known as Jae, boasts a distinctive machine-shaped crest, a greenish-black beak, prominent orange neck plumage, matching back plumage, yellow-gold wing plumage, a black long curving tail, and a black back tail, with grey shanks. The average measurements for body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length are 1.12 ± 0.19 kg, 32.64 ± 0.97 cm, 13.58 ± 0.51 cm, 12.77 ± 0.42 cm, 11.05 ± 0.48 cm, 8.93 ± 0.36 cm, 6.98 ± 0.26 cm, and 5.81 ± 0.23 cm, respectively.

3.2. Qualitative Variables. Phenotypic characteristics, encompassing comb type (Figures 3(a) and 3(b)), beak color (Figures 3(c) and 3(d)), neck plumage color (Figure 4), back plumage color (Figure 5), wing plumage color (Figure 6), long curved tail color (Figure 7), back tail color (Figure 8), and shank color (Figure 9), were meticulously documented across the native chicken population in this area. Significantly, there were statistically significant differences observed among the breeds for all qualitative variables ($p < 0.01$). Variations were evident across all variables within the six distinct breeds based on a Chi-square test with a p value less than 0.001 (Table 2).

This comprehensive examination of the six chicken breeds reveals the variations in their crest types, beak colors, neck plumage colors, back plumage colors, wing plumage colors, long curving tail colors, back tail colors, and shank colors. Specifically, two types of crests, the walnut comb and the single crest, were observed, with the walnut comb found in Khiew Phalee, Thao Thong, Lueng Hang Khao, Chee, and Pra Dhu Hang Dam, while Jae chickens exhibit the single comb type. The beak color varies between blackish-green and ivory, with Khiew Phalee, Pra Dhu Hang Dam, and Jae displaying a blackish-green beak, and Thao Thong, Lueng Hang Khao, and Chee showcasing an ivory beak.

In neck plumage color, seven variations were identified, including blackish-green, brown, grey, orange, Pra Dhu, white, and yellow-gold. Each breed displays unique neck colors, with some maintaining color stability, while others exhibit more than one color. Khiew Phalee has blackish-green neck plumage, Lueng Hang Khao features yellow-gold, Chee displays white, and Pra Dhu Hang Dam exhibits Pra Dhu. Thao Thong shows variations with brown and grey, and Jae showcases orange and yellow-gold neck plumage.

Back plumage color differs among the breeds, with Thao Thong having both brown and grey, Lueng Hang Khao featuring black and yellow-gold, and the remaining four breeds each showing a single back plumage color: blackish-green (Khiew Phalee), white (Chee), Pra Dhu (Pra Dhu Hang Dam), and orange (Jae). Wing plumage color varies, with Khiew Phalee featuring black, Thao Thong displaying blackish-green, Lueng Hang Khao showcasing grey and orange, Chee presenting white, and Jae exhibiting yellow-gold.

The long curving tail color differs across breeds: blackish-green (Khiew Phalee), grey and white (Thao Thong), black and white (Lueng Hang Khao), white (Chee), and black (Pra Dhu Hang Dam and Jae). Back tail color is black for Lueng Hang Khao, Pra Dhu Hang Dam, and Jae, blackish-green for Khiew Phalee, grey for Thao Thong, and white for Chee. Shanks exhibit white-yellow for Thao Thong, Lueng Hang Khao, and Chee, black for Khiew Phalee, and grey for Jae. Pra Dhu Hang Dam chickens display both blackish-green and black shanks, with blackish-green being the dominant color.

This detailed examination provides a thorough understanding of the unique characteristics of each breed, contributing valuable insights into the diversity of indigenous chicken populations.

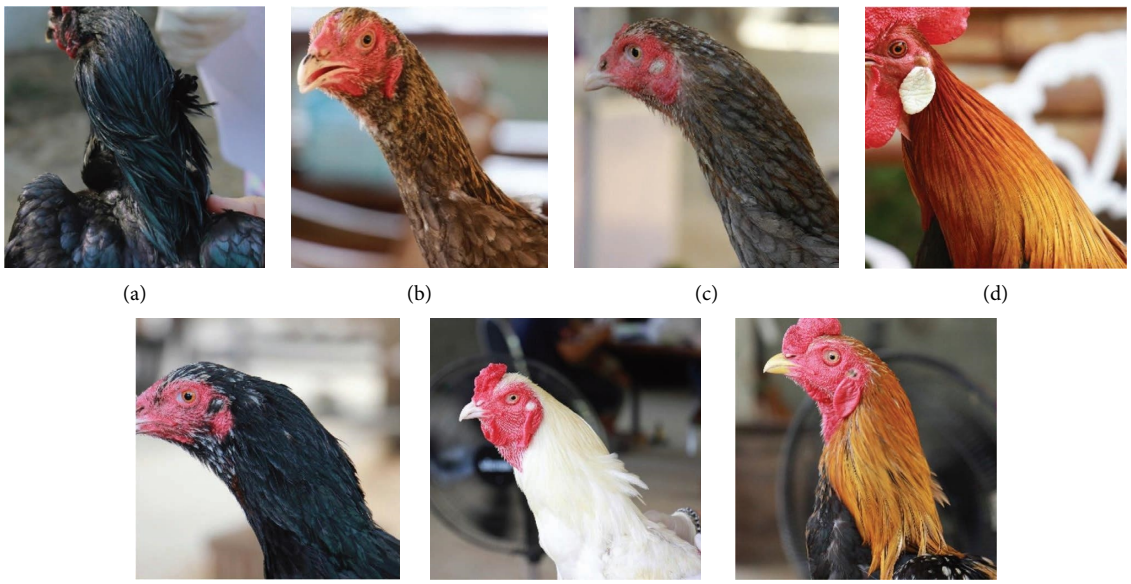
3.3. Quantitative Variables. The study examined eight quantitative variables, encompassing body weight, body height, body length, body width, wing length, upper and lower shank length, and toe length, across six native chicken breeds. The analysis revealed significant differences in the averages for these variables among different chicken breeds and between male and female chickens. Notably, these differences were statistically significant ($p < 0.01$), with the exception of the variable of sex within each breed ($p > 0.05$).

Detailed data in Table 3 present the least square means of the quantitative variables for each of the six native chicken breeds. Chee chickens distinguished themselves by having the highest average body weight (2.97 ± 0.14 kg), body height (54.85 ± 1.15 cm), and body width (20.35 ± 0.51 cm). On the other hand, Lueng Hang Khao chickens displayed the longest body length (22.86 ± 0.41 cm), upper shank length (15.70 ± 0.31 cm), and lower shank length (12.44 ± 0.22 cm). Khiew Phalee and Thao Thong chickens showcased unique features, with the former having the longest wing length (18.27 ± 0.37 cm) and the latter possessing the longest toe length (9.57 ± 0.24 cm).

Jae chickens, in contrast, demonstrated relatively lower average values for all variables when compared to the other breeds. Furthermore, across all breeds, male chickens consistently exhibited superior performance in all variables compared to females, although these differences were not statistically significant ($p > 0.05$). Male chickens were observed to exhibit a larger body size compared to females. This difference in size encompasses body weight, width, length,

(a) (b) (c) (d)

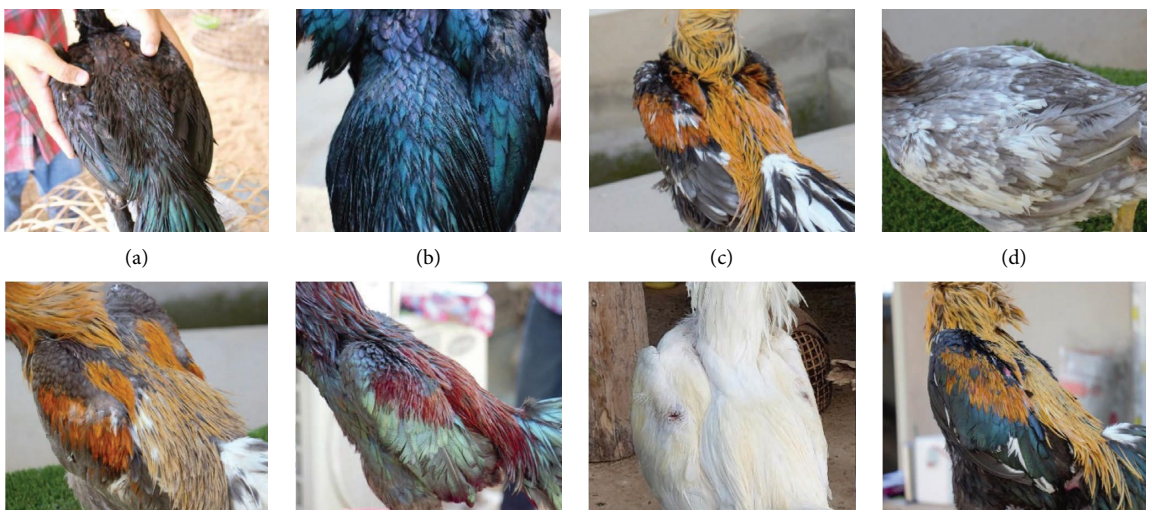
Figure 3: Variation in qualitative traits of comb type and beak color in the native chicken breeds. *Note*. (a) Single comb, (b) walnut comb, (c) blackish-green beak, and (d) ivory beak.



(a) (b) (c) (d)

(e) (f) (g)

Figure 4: Variation in qualitative traits of neck plumage color in native chicken breeds. *Note*. (a) Blackish-green, (b) brown, (c) grey, (d) orange, (e) Pra Dhu, (f) white, and (g) yellow-gold.



(a) (b) (c) (d)

(e) (f) (g) (h)

Figure 5: Variation in qualitative traits of back plumage color in native chicken breeds. *Note*. (a) Black, (b) blackish-green, (c) brown, (d) grey, (e) orange, (f) Pra Dhu, (g) white, and (h) yellow-gold.

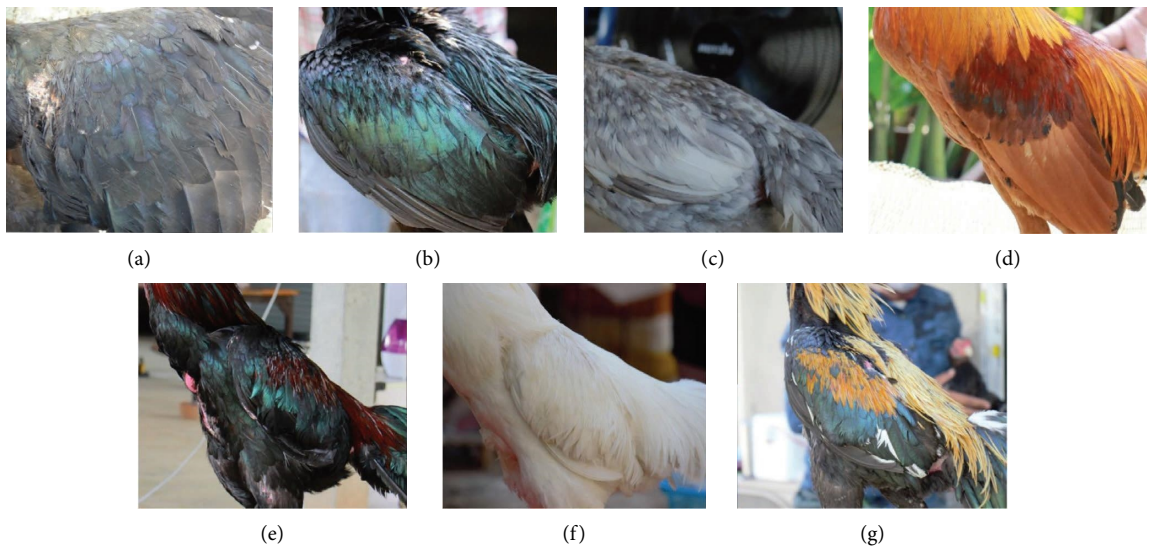


Figure 6: Variation in qualitative traits of wing plumage color in native chicken breeds. *Note*. (a) Black, (b) blackish-green, (c) grey, (d) orange, (e) Pra Dhu, (f) white, and (g) yellow-gold.

Figure 7: Variation in qualitative traits of long curved tail color in native chicken breeds. *Note*. (a) Black, (b) blackish-green, (c) grey, and (d) white.

Figure 8: Variation in qualitative traits of back tail color in native chicken breeds. *Note*. (a) Black, (b) blackish-green, (c) grey, and (d) white.

Figure 9: Variation in qualitative traits of shank color in native chicken breed. *Note*. (a) Black, (b) blackish-green, (c) grey, and (d) white-yellow.

Table 3: Data and information about the least square means of quantitative variables for the six native chicken breeds under study.

Quantitative variables	*Chicken breeds*						Averages	p value
	Khiew Phalee	Thao Thong	Lueng Hang Khao	Chee	Pra Dhu Hang Dam	Jae		
Body weight							**<0.0001**	
Male	3.44 ± 0.13	3.09 ± 0.19	3.26 ± 0.14	3.42 ± 0.23	3.40 ± 0.18	1.19 ± 0.13	2.96 ± 0.07^{a}	0.3333
Female	2.29 ± 0.14	2.21 ± 0.15	2.41 ± 0.15	2.52 ± 0.16	2.47 ± 0.14	1.05 ± 0.36	2.15 ± 0.08^{b}	
Average	2.87 ± 0.09^{a}	2.65 ± 0.12^{a}	2.83 ± 0.10^{a}	2.97 ± 0.14^{a}	2.93 ± 0.12^{a}	1.12 ± 0.19^{b}	2.59 ± 0.87	<0.0001
Body height							**<0.0001**	
Male	61.75 ± 1.05	58.43 ± 1.59	59.86 ± 1.12	60.40 ± 1.88	58.25 ± 1.49	36.00 ± 1.12	55.78 ± 0.58^{a}	0.0793
Female	47.79 ± 1.12	49.91 ± 1.27	49.00 ± 1.21	49.30 ± 1.33	48.69 ± 1.17	29.29 ± 1.59	45.66 ± 0.53^{b}	
Average	54.76 ± 0.77^{a}	54.17 ± 1.02^{ab}	54.43 ± 0.83^{ab}	54.85 ± 1.15^{ab}	53.47 ± 0.95^{b}	32.64 ± 0.97^{c}	50.72 ± 10.02	<0.0001
Body length							**<0.0001**	
Male	23.38 ± 0.53	22.57 ± 0.79	23.64 ± 0.56	23.80 ± 0.94	24.71 ± 0.79	14.00 ± 0.54	22.02 ± 0.29^{a}	0.0862
Female	21.07 ± 0.56	20.09 ± 0.63	22.08 ± 0.61	20.50 ± 0.67	19.92 ± 0.58	13.17 ± 0.86	19.47 ± 0.27^{b}	
Average	22.22 ± 0.38^{ab}	21.33 ± 0.51^{b}	22.86 ± 0.41^{a}	22.15 ± 0.58^{ab}	22.32 ± 0.49^{ab}	13.58 ± 0.51^{c}	20.68 ± 3.93	<0.0001
Body width							**<0.0001**	
Male	19.25 ± 0.25	20.71 ± 0.70	21.29 ± 0.49	22.20 ± 0.83	21.75 ± 0.65	13.40 ± 0.48	19.77 ± 0.25^{a}	0.3958
Female	16.71 ± 0.49	18.20 ± 0.58	18.42 ± 0.53	18.50 ± 0.58	18.15 ± 0.51	12.41 ± 0.70	17.02 ± 0.23^{b}	
Average	17.98 ± 0.34^{b}	19.46 ± 0.45^{a}	19.85 ± 0.36^{a}	20.35 ± 0.51^{a}	19.95 ± 0.41^{a}	12.77 ± 0.42^{c}	18.17 ± 3.30	<0.0001
Wing length							**<0.0001**	
Male	20.19 ± 0.51	19.14 ± 0.76	18.93 ± 0.54	19.40 ± 0.90	19.38 ± 0.56	11.27 ± 0.52	18.05 ± 0.28^{a}	0.0928
Female	16.36 ± 0.54	16.00 ± 0.61	16.18 ± 0.61	16.20 ± 0.64	15.31 ± 0.56	10.83 ± 0.83	15.15 ± 0.26^{b}	
Average	18.27 ± 0.37^{a}	17.57 ± 0.49^{ab}	17.56 ± 0.41^{ab}	17.80 ± 0.55^{ab}	17.34 ± 0.45^{b}	11.05 ± 0.48^{c}	16.55 ± 3.48	<0.0001
Upper shank length							**<0.0001**	
Male	16.00 ± 0.39	16.86 ± 0.59	17.57 ± 0.42	16.80 ± 0.70	17.00 ± 0.55	10.00 ± 0.40	15.70 ± 0.21^{a}	0.5855
Female	12.71 ± 0.42	13.27 ± 0.47	13.83 ± 0.45	14.20 ± 0.49	13.69 ± 0.43	7.86 ± 0.59	12.59 ± 0.19^{b}	
Average	14.36 ± 0.28^{b}	15.06 ± 0.38^{b}	15.70 ± 0.31^{a}	15.50 ± 0.43^{ab}	15.35 ± 0.35^{ab}	8.93 ± 0.36^{c}	14.05 ± 3.07	<0.0001
Lower shank length							**<0.0001**	
Male	12.38 ± 0.28	12.57 ± 0.42	13.71 ± 0.30	13.20 ± 0.51	13.50 ± 0.40	7.53 ± 0.29	12.15 ± 0.15^{a}	0.2672
Female	10.36 ± 0.30	10.73 ± 0.34	11.17 ± 0.33	11.20 ± 0.36	10.77 ± 0.31	6.43 ± 0.43	10.11 ± 0.14^{b}	
Average	11.37 ± 0.21^{b}	11.65 ± 0.27^{b}	12.44 ± 0.22^{a}	12.20 ± 0.31^{ab}	12.13 ± 0.25^{ab}	6.98 ± 0.26^{c}	11.05 ± 2.33	<0.0001
Toe length							**<0.0001**	
Male	9.50 ± 0.25	10.14 ± 0.37	10.21 ± 0.26	10.20 ± 0.44	10.50 ± 0.35	6.33 ± 0.25	9.48 ± 0.13^{a}	0.7068
Female	8.00 ± 0.26	9.00 ± 0.29	8.75 ± 0.28	8.40 ± 0.31	8.54 ± 0.27	5.29 ± 0.37	7.99 ± 0.12^{b}	
Average	8.75 ± 0.18^{b}	9.57 ± 0.24^{ab}	9.48 ± 0.19^{a}	9.30 ± 0.27^{ab}	9.52 ± 0.22^{ab}	5.81 ± 0.23^{c}	8.67 ± 1.72	<0.0001

Note. The values presented in the context are represented as means with standard deviation, and these values have been compared using Duncan's new multiple range test, with the differentiation represented by different letters. The study investigated eight quantitative variables, including body weight (in kg), body height, body length, body width, wing length, upper and lower shank length, and toe length (all in cm), across six native chicken breeds.

and height, as well as the length of the wing, upper shank, lower shank, and toe, with males consistently found to be longer than females in these aspects.

3.4. Correlation between Quantitative Variables. The findings from the study on the correlation between quantitative characteristics of native chickens reveal a high and statistically significant correlation ($p < 0.05$), all pointing in the same direction. This correlation serves as an indicator that improvement in one characteristic within these six native chicken breeds is likely to result in an improvement in another characteristic (Table 4). The observed correlation underscores the interconnected nature of these quantitative traits and suggests that efforts to enhance any one trait will result in desirable effects on chicken traits.

Concerning chicken body weight, the study observed positive correlations with body height, body length, body width, wing length, upper shank length, lower shank length, and feet length across all breeds. Exceptions included the absence of correlation between body weight and body length for Khiew Phalee and Kai Lueng Hang Khao chickens, as well as between body weight and body width for Thao Thong chickens. Additionally, the body height of the chickens exhibited positive relationships with body length, body width, wing length, upper shank length, lower shank length, and feet length across all breeds. Notably, exceptions encompassed the lack of correlation between body height and body length for Lueng Hang Khao chickens, between body height and body width for Thao Thong chickens, and between body height and feet length for Jae chickens. Significant positive correlations between body length and all other variables were solely discerned in Pra Dhu Hang Dam chickens (Table 4).

Regarding body width, the study found significant correlations with wing length, upper shank length, lower shank length, and feet length for Lueng Hang Khao, Chee, and Pra Dhu Hang Dam chickens. Correlations were also

Table 4: Data and information on the correlation between quantitative variables for the six native chicken breeds studied.

Quantitative variables	*Chicken breeds*						Total
	Khiew Phalee	Thao Thong	Lueng Hang Khao	Chee	Pra Dhu Hang Dam	Jae	
Body weight							
Body height	0.83**	0.78**	0.76**	0.75**	0.69**	0.67**	0.85**
Body length	0.33	0.49*	0.30	0.60*	0.65**	0.67**	0.70**
Body width	0.59**	0.41	0.70**	0.55*	0.77**	0.82**	0.76**
Wing length	0.52**	0.65**	0.79**	0.59*	0.58**	0.79**	0.78**
Upper shank length	0.49**	0.60**	0.54**	0.59*	0.63**	0.55**	0.71**
Lower shank length	0.44*	0.62**	0.60**	0.54*	0.73**	0.67**	0.75**
Feet length	0.52**	0.58*	0.54**	0.58*	0.51*	0.58**	0.69**
Body height							
Body length	0.52**	0.65**	0.28	0.60*	0.73**	0.55**	0.79**
Body width	0.45*	0.25	0.67**	0.55*	0.84**	0.55**	0.78**
Wing length	0.71**	0.67**	0.66**	0.59*	0.69**	0.52*	0.83**
Upper shank length	0.66**	0.78**	0.67**	0.67**	0.79**	0.70**	0.84**
Lower shank length	0.63**	0.71**	0.59**	0.69**	0.78**	0.53*	0.83**
Feet length	0.55**	0.60**	0.52**	0.69**	0.69**	0.41	0.78**
Body length							
Body width	0.31	0.37	0.31	0.73**	0.86**	0.79**	0.76**
Wing length	0.45*	0.41	0.31	0.78**	0.61**	0.63**	0.75**
Upper shank length	0.56**	0.47*	0.42*	0.47	0.74**	0.19	0.78**
Lower shank length	0.42*	0.42	0.28	0.50	0.73**	0.43	0.77**
Feet length	0.52**	0.40	0.24	0.42	0.62**	0.27	0.72**
Body width							
Wing length	0.12	0.34	0.56**	0.61*	0.77**	0.69**	0.68**
Upper shank length	0.29	0.08	0.52**	0.70**	0.81**	0.32	0.75**
Lower shank length	0.38*	0.16	0.57**	0.71**	0.81**	0.55**	0.80**
Feet length	0.57**	0.12	0.58**	0.70**	0.66**	0.46*	0.79**
Wing length							
Upper shank length	0.70**	0.62**	0.52**	0.48	0.63**	0.49*	0.76**
Lower shank length	0.44*	0.47*	0.47*	0.36	0.62**	0.80**	0.73**
Feet length	0.28	0.30	0.40*	0.22	0.42	0.49*	0.61**
Upper shank length							
Lower shank length	0.71**	0.59*	0.87**	0.82**	0.82**	0.66**	0.89**
Feet length	0.69**	0.40	0.73*	0.86**	0.76**	0.58**	0.83**
Lower shank length							
Feet length	0.74**	0.65**	0.79**	0.86**	0.77**	0.49*	0.87**

Note. * and ** exhibited statistically significant differences in Pearson correlation, with p values of less than 0.05 and 0.01, respectively. The study investigated even quantitative variables, including body weight (in kg), body height, body length, body width, wing length, upper and lower shank length, and toe length (all in cm), across six native chicken breeds.

established with lower shank length and feet length for Khiew Phalee chickens and Jae chickens, as well as with wing length for Jae chickens. Conversely, no significant associations were identified between wing length and upper shank length, wing length and lower shank length, and wing length and feet length in Chee chickens. Furthermore, relationships between wing length and feet length in Khiew Phalee chickens, Thao Thong chickens, and Pra Dhu Hang Dam chickens were not observed. The upper shank length of chickens displayed positive relationships with lower shank length and feet length across all breeds, except for the feet length of Thao Thong chickens. Additionally, lower shank length significantly correlated with feet length in all breeds (Table 4).

4. Discussion

Based on the investigation into the diversity of phenotypic characteristics of Thai native chickens within lower northern Thailand, the outcomes of the study can be elucidated as follows.

This study classifies two native chicken comb types: the walnut comb and the single comb. The walnut comb proves to be the dominant type across six breed species, namely, Khiew Phalee, Thao Thong, Lueng Hang Khao, Chee, and Pra Dhu Hang Dam chickens. Notably, only the single comb type is observed in Jae chickens. These findings are consistent with previous studies that investigated the characteristics of cockscombs in five chicken breeds (Pra Dhu

Hang Dam, Khiew Phalee, Thao Thong, Chee, and Lueng Hang Khao) within the study area and in the neighboring Phitsanulok Province. These studies revealed that Pra Dhu Hang Dam, Khiew Phalee, and Lueng Hang Khao chickens displayed the walnut comb type [4, 17, 18]. According to earlier reports from studies on the comb of Jae chickens across six provinces in the lower northern region of Thailand: Phetchabun, Phitsanulok, Phichit, Sukhothai, Uthai Thani, and Uttaradit, it was noted that Jae chickens showed the single comb type [9]. No diversity in comb types was noted in each chicken breed. This uniformity is maintained by each studied chicken breed possessing only one comb phenotypic trait. This contrasts with previous research, where Pea-type combs were observed in the Lueng Hang Khao population in Northeast Thailand, the Chee population in the East and Central regions of Thailand, and the Pra Dhu Hang Dam population in the Central regions of Thailand [19]. These chickens, therefore, display a genetic trait of a comparatively consistent comb, which varies uniquely across distinct regions.

Regarding beak color, Thao Thong, Lueng Hang Khao, and Chee chickens exhibited only ivory beak color and white-yellow shank color. This is consistent with the previous findings [17, 20], which noted that Thao Thong and Lueng Hang Khao chickens displayed white-yellow beak and shank colors. On the other hand, the predominant beak and shank color for Khiew Phalee, Pra Dhu Hang Dam, and Jae chickens was blackish-green. Several researchers [4, 8, 9, 17] have previously reported similar beak and shank coloration in various Thai native chicken breeds. Additionally, only blackish-green plumage and white tail colors were observed in Khiew Phalee and Chee chickens, respectively. These results align with previous findings, providing descriptive information about the colors of the beak, plumage, and tail in Khiew Phalee chickens, which exhibited blackish-green tones [21]. In contrast, observations indicated that Jae chickens had a grey shank but a brown beak color [9]. However, the plumage color of the six breeds did not correspond with the results of other studies that reported black as the predominant plumage color in Thai native chickens [22–24]. This discrepancy may have been because the studied samples had their coat color controlled by genes that mainly utilized black color. Previous studies have described the regulation of fur color by three genes: melanocortin 1 receptor (*MC1R*), tyrosinase (*TYR*), and agouti signaling protein (*ASIP*) genes. Each gene gives a different coat color. Three SNPs in the *MC1R* gene resulted in six haplotypes, notably H5 and H6 associated with white and grey feathers. *TYR* gene variations yielded six haplotypes, excluding P2, P3, and P6 in black chicken plumage. The single SNP (*T168C*) in the ASIP gene favored the homozygous dominant genotype across various plumage color groups [25].

Furthermore, evidence from several studies had explained that significant variations in the color of all characters observed in native chickens could primarily be attributed to the geographic situation, encompassing factors such as isolation, natural selection, and artificial selection. Consequently, distinct characteristics emerged in various native chicken groups, and their names were often designated based on their niche areas [26, 27]. The study examined the impact of geographic factors on village chickens in Jordan's Karak Governorate, covering six regions in Karak, Tafilah, Madaba, Aqaba, and Al-Mafraq. Findings revealed disparities in phenotypic features between sexes and regions. Traditional rearing practices without genetic improvement or gene flow from distant regions maintained a resemblance to ancestral traits. Predominant traits included pink color, a single comb, a beige beak, orange eyes, and red earlobes with white speckling. Regional differences and elevation significantly influenced trait variations in both sexes [26].

Hence, the varied physical characteristics observed in local chickens suggested substantial genetic potential as a genetic resource for use in future breeding. These results increased knowledge and could have helped in the development of conservation plans for chicken breeds. Safeguarding this extensive gene pool from genetic erosion was crucial [28].

The results indicated that female chickens exhibited lower quantitative values for all variables compared to male chickens' counterparts. Our findings align with previous studies that investigated the weight and structural size of other native chicken breeds in the upper northern and lower northern regions of the country, where males tended to exhibit greater weight or larger size compared to females [22, 24]. The difference in size could be attributed to sexual dimorphism, where males and females displayed differential growth rates. Previous research explained this difference as a result of the actions of hormones [29]. This aligns with the research on sexual dimorphism in terms of quantitative variables, which is expected due to differing growth rates between males and females. This phenomenon is explained by variations in the levels of male sex hormones, responsible for greater muscle development in males compared to females [30, 31]. Various investigations of Thai native chickens have reported body weight ranges from 1.25 to 2.42 kg [22, 24, 28], which were lower than the average body weight of the six breeds (2.59 ± 0.87 kg) observed in the present study. The average body weight of Jae chickens in this study closely matched the previous findings, which reported an average body weight of 1.07 ± 0.20 kg for Jae in the lower northern region of Thailand [9]. These variations in quantitative variables could be attributed to differing genetic backgrounds, chicken maturity (including animal age), agroclimatic conditions, or environmental factors, including farm management and the nutritional status of the chickens [24]. Therefore, genetic factors and environmental conditions of different breeds and rearing environments could have caused variations in body size in native chickens. Nafiu et al. explained that the quantitative properties of native Indonesian chickens, including head length, chest length, wings length, shank length, back length, neck circumference, and chest circumference, indicated that the observed differences were influenced by a combination of genetic factors and environmental conditions [25].

In examining relationships among different chicken breeds, positive correlations were observed among various physical characteristics. They identified relationships

between body weight and body measurements, including the length of wings, shanks, and feet, both within and between species of chickens ($p < 0.05$). For instance, Chee's findings indicated within-species correlations (r) between body weight and body measurements ranging from 0.54 to 0.75. Additionally, interspecies correlations varied from 0.69 to 0.85. These results align with prior research, confirming the existence of noteworthy correlations in these traits both within chickens of the same breed and across diverse chicken species [8, 24, 32–35]. These correlations imply the potential for estimating a chicken's body weight based on its linear body measurements. While other correlations generally showed positivity, their strengths exhibited variations ($p < 0.05$). The phenotypic correlation between body weight and various linear body parameters was not only positive but also statistically significant, suggesting that alterations in one body trait are likely to be associated with changes in others.

From this study, a database on the diversity of external structural characteristics has been established for all six native chicken breeds in Uttaradit province. This was carried out in accordance with the study guidelines of the FAO for the genetic characterization of chicken resources [10] and the Standard of Perfection, outlining the five characteristics of exceptional fighting cocks. This database serves as a guide for conservation and improvement planning, facilitating the selection of appropriate characteristics within each breed. Ultimately, this contributes to fostering a sustainable and efficient career in raising native chickens. The conclusion drawn was that existing variations in size and aesthetic characteristics of indigenous chickens can be improved through selective breeding tailored to the specific needs of farmers. This aligns with several previous reports, which have explained that existing variations in size and aesthetic characteristics of indigenous chickens can be improved through selective breeding customized to the specific needs of farmers. Furthermore, it was highlighted that farmers would benefit economically from support in the husbandry and management of indigenous chickens [35–37]. For example, the potential development of broiler chicken breeds utilizing Pelung chickens highlighted the local chicken's capability to evolve into a broiler chicken. A study conducted in Indonesia investigated the crossbreeding of Pelung and broiler chickens, revealing distinct characteristics in the second generation. Although the average body weight of the second-generation chickens surpassed that of Pelung, it did not exceed the average weight of broilers. These chickens exhibited a variety of coat colors, including white, black, brown, and black with white patterns (dotted). In addition, the second generation exhibited a distinctive inheritance pattern of foot colors, encompassing black, white, and yellow, while maintaining a notable level of phenotypic uniformity amid considerable variation [38].

5. Conclusions

In conclusion, this study contributes to a comprehensive database on the external structural characteristics of six native chicken breeds in Uttaradit province, aligning with FAO guidelines and the Standard of Perfection for the genetic characterization of chicken resources. This database serves as a valuable resource for conservation and improvement planning, aiding in the selection of desirable characteristics within each breed. Importantly, the conclusion drawn emphasizes the potential for improving existing variations in size and aesthetic characteristics through selective breeding tailored to the specific needs of farmers, aligning with previous reports advocating for economic support in the husbandry and management of indigenous chickens. The study's insights into the potential development of broiler chicken breeds utilizing local chickens, as demonstrated in the Pelung breed in Indonesia, further highlighting the adaptability and potential economic benefits of indigenous chicken breeds.

Our discoveries ease concerns of invasion from non-native chickens, directly threatening Thailand's standard of perfection for native breeds. This intrusion jeopardizes the preservation of unique traits, casting doubt on the long-term viability of conserving the distinctive features defining Thai native poultry. By seamlessly integrating our findings into the broader context of past research, this study enriches our comprehension of phenotypic diversity in Thai native chickens. In the future, research should delve into the complexities of native chicken breeds. Molecular genetic techniques should be employed to examine genetic diversity, identifying pure and hybrid chicken lines. This enhanced understanding will significantly contribute to the conservation and sustainable development of native chicken populations, aligning with the evolving needs of the market. This holistic approach ensures the preservation of valuable genetic resources and upholds the cultural and historical significance of the country.

Data Availability

The data supporting the current study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

S.Y., S.P., C.M., and T.J. conceptualized the study; S.Y., S.P., C.M., and T.J. proposed the methodology; S.Y., S.P., C.M., and T.J. validated the study, formally analysed the study, and investigated the study; S.Y., S.P., C.M., and T.J. gathered the resources; S.Y., S.P., C.M., and T.J. curated the data; S.Y. and T.J. wrote and prepared the original draft; S.Y. and T.J. edited and reviewed the manuscript; S.Y., S.P., and T.J. visualized the study, supervised the study, and administered the project; S.Y., S.P., and T.J. acquired the funding. All authors have read and agreed to the published version of the manuscript.

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