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Research Article

Phenotypic Characterization of Malaysian Village Chicken Ecotypes in Peninsular Malaysia

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ABSTRACT

Indigenous poultry breeds are valued for their tolerance and adaptability to challenging environments, including harsh tropical climate and disease pressures. In Peninsular Malaysia, village chickens - commonly known as *Ayam Kampung* - not only play a crucial role in sustaining the livelihoods of smallholder farmers in rural areas, but also serve as a vital genetic resource for breeding and conservation efforts. This study aimed to characterize the phenotypic and morphological diversity of 15 indigenous chicken ecotypes sampled across the region. Survey and interviews with selected farmers were conducted to identify ecotypes and trace their origins using open-ended questionnaires. A total of 459 chickens were assessed for key traits, including plumage color and pattern, comb type and color, as well as beak and shank color. A non-parametric test of association was performed to examine the relationship between phenotypic traits and ecotype groupings. The results revealed significant variation among the chicken ecotypes, with five major groups identified: *Arab* chickens, cockfighting chickens, *Kurik* chickens, Naked Neck chickens, and multicolor chickens. The most prevalent traits observed were multicolor plumage (80.39%), brown-yellow beak (88.45%), and yellow shank (86.06%), with red single (70%) and pea/walnut (30%) comb types also frequently present. These variations, shaped by environmental and human influences, face threats from disease, human interference, and the introduction of other breeds. The findings provide valuable insights into the morphological characteristics of village chickens, offering a foundation for future breeding programs. Furthermore, conserving these indigenous chickens is essential to preserve their unique genetic resources, maintain biodiversity, and ensure their sustainable use in the future.

Key words: Diversity, indigenous breed, morphological trait, phenotypic variation, poultry

INTRODUCTION

Acknowledging the value of indigenous livestock populations across various geographic regions is crucial, as these animals have adapted to their local agro-climatic conditions (Rachman *et al*., 2024). Consequently, they represent vital genetic resources for conservation efforts and the sustainable development of agricultural practices. The thorough characterization of these breeds, both phenotypically and genotypically, is essential to understanding their unique traits, which is the first step toward effective conservation. This is particularly relevant for native tropical breeds, which may hold genetic solutions for climate resilience as global warming and climate change lead to tropic-like conditions in temperate regions.

Chickens *(Gallus gallus domesticus)* are the most widespread domestic animals globally, with a population exceeding 22 billion as of 2017 (FAO, 2022). Today, there are nearly 1,600 recognized chicken breeds globally. These birds trace their origins to jungle fowl found in India and Southeast Asia. Their evolutionary journey can be categorized into three phases: the evolution of the *Gallus* genus, the emergence of the domestic fowl, and the development of various breeds. Domestication likely began around 2000 BC in the Indus Valley, with red junglefowl in Southeast Asia being the primary ancestors (Eda, 2021). Four species of Gallus are red jungle fowl (*Gallus gallus*), Ceylon jungle fowl *(Gallus lafayettei*), gray jungle fowl *(Gallus Sonnerrati*), and green jungle fowl *(Gallus varius*) are recognized as the ancestors of domestic chickens (Lawal & Hanotte, 2021). Interestingly, in Europe, red junglefowl was initially valued more for cockfighting and religious rituals than for consumption (Mench, 2017).

Malaysian chicken population reached 296 million in 2022, accounting for 96% of the country's total livestock (DOSM, 2022). This includes 63% broiler chickens, 47% egg-layers, 4% village chickens, 1% quails, and a small portion of other poultry. Malaysian Village Chickens (MVC), locally known as *Ayam Kampung*, were raised in free-range environments, mostly in rural

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areas. They play a crucial role in the livelihood of smallholder farmers by providing a source of income, food security, and contributing to household nutrition (Kryger *et al*., 2010; Melesse, 2014; Wong *et al*., 2017; Marzlinda *et al*., 2025). These chickens are highly valued by consumers for their distinctive flavor and texture, which result from natural, traditional farming practices. This not only enhances their taste but also ties them deeply to local culture and cuisine, serving as a symbol of the close connection between agriculture and rural life in Malaysia. Village chickens are an alternative in the local poultry industry that serve a dual purpose by providing both meat and eggs, especially among rural communities, and they exhibit significant phenotypic diversity due to varied local breeding practices.

Despite their importance, there is a lack of comprehensive studies on the phenotypic and genetic diversity of village chickens in Malaysia. Understanding variation in phenotypic traits is essential for recognizing and classifying MVC ecotypes, which remain underexplored compared to commercial breeds. Hence, this study aims to characterize the phenotypic diversity of village chicken ecotypes in Peninsular Malaysia. The findings will support the development of targeted breeding programs, genetic improvement strategies, and conservation efforts to preserve these unique genetic resources.

MATERIALS AND METHODS

Study location and experimental animals

This study was conducted through a collaboration effort between the Malaysian Agricultural Research and Development Institute (MARDI) and the federal Department of Veterinary Services Malaysia (DVS). The research focused on the characterization of village chicken ecotypes across selected regions in Peninsular Malaysia. Initial data were obtained from DVS poultry farming records, which were then followed by structured field surveys and in-depth interviews with selected smallholder farmers using open-ended questionnaires. The purpose was to identify and classify existing village chicken ecotypes and to trace their potential origins based on phenotypic and morphological traits, as well as management practices.

This study identified several distinct ecotypes of village chicken across various states, including Kelantan (D), Kedah (K), Pahang (C), Perak (A), Selangor, N. Sembilan (NS), Malacca (M), and Johore (J) (Figure 1). Farmers were first screened for eligibility, with a requirement of maintaining at least 250 chickens in their flock. For sampling, no more than 10% of the total flock size was collected from each farm, in accordance with FAO (2021) guidelines, resulting in a minimum of 25 samples per ecotype. Within each location, chickens were randomly sampled from flocks showing uniform physical appearance – specifically in plumage color, pattern, and body size. Phenotypic traits were documented following the FAO standard descriptors and systematically compiled into a master spreadsheet for further analysis. Figure 1 presents the sampling distribution and population sizes at each study location.

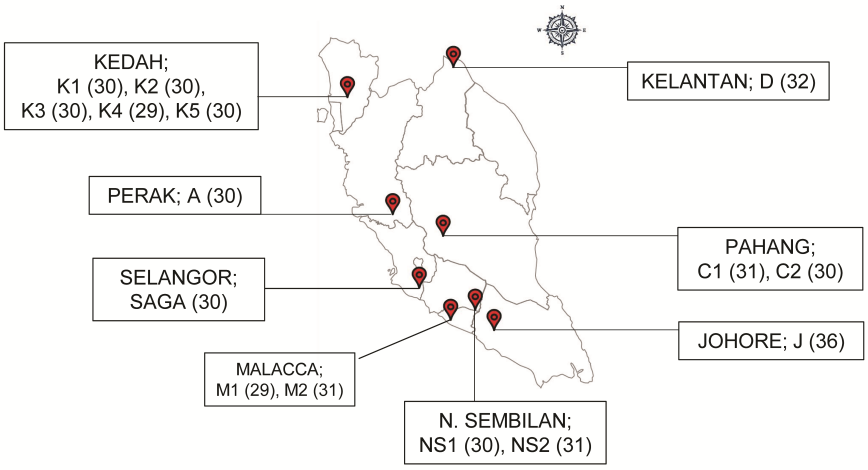

Fig. 1. Map of sampling location of village chickens in Peninsular Malaysia. The number in the bracket denotes the sample size from each location.

Assessment of phenotypic and morphological traits

A total of 459 adult village chickens, comprising 142 males and 317 females, were sampled from 15 distinct indigenous chicken ecotypes across Peninsular Malaysia. To ensure comprehensive analysis, both sexes - cockerels and hens - were included in the assessment, enabling the observation of potential phenotypic differences between sexes. Each bird was assessed for a range of qualitative morphological characteristics, including plumage color and pattern, comb types and color, as well as beak and shank coloration (Table 1). These qualitative traits were recorded through direct visual assessment and categorized based on the phenotypic descriptors outlined by the FAO (2012) for chickens. To ensure consistency and accuracy in documentation, each chicken was photographed individually from three angles: front, right lateral, and left lateral. Birds were positioned on a flat surface and photographed while standing naturally on both legs to standardize posture and facilitate reliable morphological comparison.

Table 1. Description of the phenotypic characteristics of Malaysian Village Chicken (MVC)

Traits	Descriptions
Plumage color/pattern	White / Multi-colored
Beak color	Brown-yellow / Brown-gray/ Black
Shank color	Yellow / Black / Yellow-black / Yellow-gray
Comb color	Red / Red-gray
Comb type	Single / Pea @ Walnut

Data and statistical analysis

The phenotypic data were compiled into structured tables for clarification and organization. Description statistics, including percentages, were employed to explore and interpret qualitative morphological traits. All phenotypic traits were coded as categorical variables and analyzed using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). The association between chicken ecotypes and qualitative traits (plumage color, beak color, shank color, comb color, and comb type) was evaluated using Pearson's Chi-square (χ^2) test of independence via the PROC FREQ procedure. For tables with expected cell frequencies less than five, Fisher's Exact Test was applied automatically to provide a more reliable p-value. Statistical significance was set at $p<0.05$. This approach allowed for a comprehensive evaluation of patterns and variations within the dataset.

RESULTS

Ecotype Identification

In this study, Malaysian Village Chickens (MVC) sampled across Peninsular Malaysia were categorized into five distinct groups, each with unique characteristics, namely *Arab*, cockfighting, *Kurik*, Naked Neck, and multicolored. Group of *Arab* chickens made of chicken ecotypes M1, M2, cockfighting chickens (D, K1, K2, K3), *Kurik* chickens (C1, C2), Naked Neck chickens (NS1, NS2), and multicolor chickens (A, SAGA, K4, K5, J) (Table 2).

The *Arab* chicken group stands out with ring-shaped black circles around their eyes. The cockfighting group is known for its tall body, tapered chest, and fierce attitude, traits that align with the nature of cockfighting. The *Kurik* group is recognized for its pretty stunning laced plumage patterns, while the Naked Neck group is characterized by its bald neck. The multicolor group is dominant, featuring yellow, red, white, and black (black plumage). This group also includes a unique dull colored variety, entirely black beak, shank, and even its meat, known locally as *Selasih* chickens.

The classification into five distinct ecotype groupings based on qualitative traits allows for a deeper understanding of how physical characteristics vary across local chicken populations. These differences highlight the practical realities and diversity within small-scale poultry farming.

Qualitative traits variation

The percentages for these village chickens' qualitative morphological traits are summarized in Table 3. Four main criteria were observed, focusing on plumage pattern and color, beak color, comb type and color, and shank color (Figure 2). Plumage color varied significantly among the village chickens, with multicolor plumage being the most prevalent, observed in 80.39% of the studied chickens. In contrast, white plumage was much less common. Among those with colored plumage, 85.92% were male, and 86.75% were female. White plumage was found in three chicken ecotypes of N. Sembilan1 (NS1), Malacca2 (M2), and Kedah4 (K4), including both males and females.

Focusing on beak color, the most common variation observed was brown-yellow, found in 88.45% of the chickens. This was followed by black beaks at 6.54% and brown-gray beaks at 5.01%. As for comb types, Malaysian village chickens predominantly have single or pea/walnut combs, both of which are typically red. Single combs are the most common, present in 70% of village chicken ecotypes. Pea/walnut combs make up the remaining 30% and are primarily found in specific ecotypes, such as N. Sembilan1 (females), Kedah1, Kedah2 (females), Kedah4 (females), Johore, and Kelantan. Comb color is mostly red (87.15%), with a smaller proportion (12.85%) displaying a red-gray hue, notably in Kedah4 and Kedah5.

For shank color, yellow is the most common (86.06%), followed by yellow-gray and black, both at 6.97%, and yellow/black at 3.49%. Black shanks were specifically found in both male and female chickens of the Kedah5 ecotype, which is known for being part of a multicolored group of black chickens.

Statistical observation

Descriptive statistics summarizing the qualitative morphological traits of the village chicken ecotypes are presented in Table 4. Chi-square tests of independence revealed statistically significant associations between chicken ecotypes and all qualitative traits assessed in the study population ($p<0.001$), indicating that these traits were not uniformly distributed across ecotypes. Due to the presence of expected cell frequencies below five in some contingency tables, Fisher's Exact Test was also applied to confirm the results. Consistent significance patterns were observed for beak, shank, and comb color ($p<0.001$), further supporting the presence of phenotypic differentiation among ecotypes.

Table 2. Morphological characteristics of five Malaysian village chicken groups for males and females

Ecotype groups	Ecotypes (location)	Phenotypic description
Arab	M1, M2	 Unique characteristic: ring-shaped black circles around their eyes. Plumage: multicolor (golden red, gold-silver), silver white with black speckled, Beak: brown-yellow; Comb type/ color: single/ red; Shank: yellow
Cockfighting	D, K1, K2, K3	 Unique characteristic: tall body, tapered chest and fierce attitude. Plumage: multicolor, Beak: brown-yellow, brown-gray; Comb type/ color: single, pea/ red; Shank: yellow
Kurik	C1, C2	 Unique characteristic: stunning laced plumage, speckled plumage pattern. Plumage: multicolor; Beak: brown-yellow; Comb type/ color: single/ red; Shank: yellow
Naked Neck	NS1, NS2	 Unique characteristic: Bald neck Plumage: multicolor, white; Beak: brown-yellow; Comb type/ color: single, pea/ red; Shank: yellow
Multicolor	A, J, K4, K5, Saga	 Plumage: multicolor dominant, featuring yellow, red, black (black plumage), white; Beak: brown-yellow; Comb type/ color: single, pea/ red, red-gray; Shank: yellow, black

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Table 3. Percentages for morphological traits detected among the village chicken ecotypes

Trait/ Location	Plumage color/ pattern		Beak color			Shank color				Comb color		Comb type	
	White variation	Colored variation	Brown-yellow	Brown-gray	Black	Yellow	Black	Yellow / Black	Yellow-gray	Red	Red-gray	Single	Pea/ walnut
N. Sembilan1, NS1													
Male (*n*=16)	100	0	100	0	0	0	0	100	0	100	0	100	0
Female (*n*=14)	100	0	100	0	0	100	0	0	0	100	0	0	100
N. Sembilan2, NS2													
Male (*n*=10)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=21)	0	100	100	0	0	100	0	0	0	100	0	100	0
Malacca1, M1													
Male (*n*=8)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=21)	0	100	100	0	0	100	0	0	0	100	0	100	0
Malacca2, M2													
Male (*n*=14)	100	0	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=17)	100	0	100	0	0	100	0	0	0	100	0	100	0
Kedah1, K1													
Male (*n*=2)	0	100	100	0	0	100	0	0	0	100	0	0	100
Female (*n*=28)	0	100	100	0	0	100	0	0	0	100	0	0	100
Kedah2, K2													
Male (*n*=0)	0	0	0	0	0	0	0	0	0	0	0	0	0
Female (*n*=30)	0	100	100	0	0	100	0	0	0	100	0	0	100
Kedah3, K3													
Male (*n*=0)	0	0	0	0	0	0	0	0	0	0	0	0	0
Female (*n*=30)	0	100	100	0	0	100	0	0	0	100	0	100	0
Kedah4, K4													
Male (*n*=4)	100	0	100	0	0	100	0	0	0	0	100	100	0
Female (*n*=25)	100	0	100	0	0	100	0	0	0	0	100	0	100
Kedah5, K5													
Male (*n*=5)	0	100	0	0	100	0	100	0	0	0	100	100	0
Female (*n*=25)	0	100	0	0	100	0	100	0	0	0	100	100	0

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Table 3. Continued

Pahang1, C1													
Male (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=16)	0	100	100	0	0	100	0	0	0	100	0	100	0
Pahang2, C2													
Male (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Perak, A													
Male (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Johore, J													
Male (*n*=5)	0	100	100	0	0	94.44	5.56	0	0	100	0	0	100
Female (*n*=31)	0	100	96.77	3.23	0	100	0	0	0	100	0	0	100
Kelantan, D													
Male (*n*=18)	0	100	50	50	0	94.44	5.56	0	0	100	0	0	100
Female (*n*=14)	0	100	3.23	96.7	0	0	0	0	100	100	0	0	100
SAGA													
Male (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0
Female (*n*=15)	0	100	100	0	0	100	0	0	0	100	0	100	0

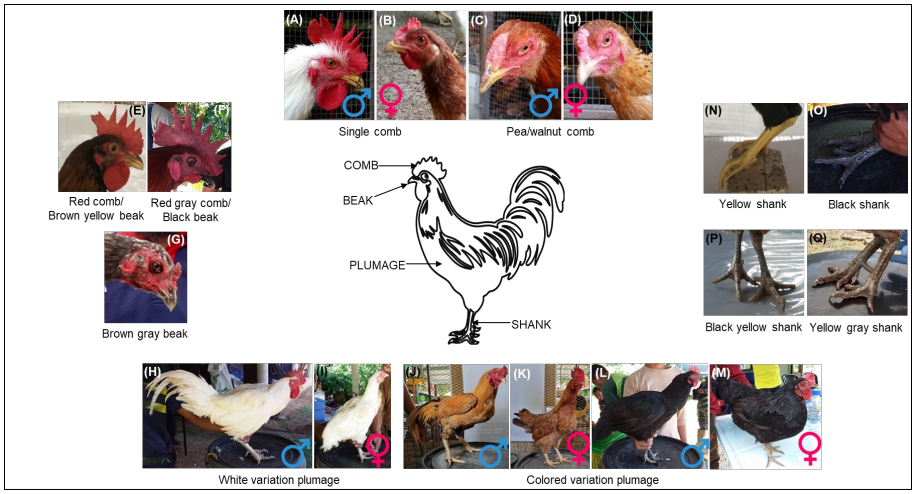

Fig. 2. Four main morphological criteria of Malaysian village chickens: single comb for male (A) and female (B); pea/walnut comb for male (C) and female (D); variation color for comb and beak (E, F, G); variation plumage color for male and female (H, I, J, K, L, M); and variation for shank color (N, O, P, Q).

The same hypothesis testing procedures, using both the Chi-square and Fisher's exact test, were applied to assess the association between phenotypic traits and five predefined chicken groups (Arab, Cockfighting, Kurik, Naked Neck & Multicolored). Once again, all p-values were statistically significant, leading to rejection of the null hypothesis. These results indicate that the distribution of each observed trait (plumage pattern, beak, shank, comb color, and comb type) is not independent across groups.

DISCUSSION

Phenotypic groupings of Malaysian Village Chickens

Village chickens - often referred to as 'indigenous', 'native', 'local' or 'traditional' poultry - are readily distinguishable from standardized commercial or heritage breeds. In this study, phenotypic grouping of Malaysian Village Chickens (MVC) revealed distinct categories based on plumage, beak, shank, and comb characteristics, with additional striking morphological features observed in certain birds. Notable types include Arab, Cockfighting, Kurik, Naked Neck, and Multicolor chickens. Together, these contribute to the rich diversity of 15 unique village chicken ecotypes found across Peninsular Malaysia.

Arab chickens typically occur in two common plumage variants: silver Arab, characterized by white feathers patterned with black spots across the body, and gold Arab, displaying golden-red barred plumage with reddish-yellow neck, black eye ring, black skin, shank, and beak. An additional gold-silver variant of Arab chicken was also observed in the present study (Table 2), likely resulting from the mixed rearing of silver and gold birds in the same flock, enabling random mating. Similar mixed patterns were reported by Tamzil *et al*. (2020). Although the origins of Arab chicken in Malaysia remain unclear, their presence is notable given their role in egg production and their meat quality and growth rate, which are comparable to other village chicken types.

The Cockfighting group – locally associated with traditional competitive fighting – was also recorded. These birds are generally larger in size and often exhibit a pea comb, a trait observed in three of the four ecotypes (D, K1, K2) classified within this group. This comb type is also found in China's Anjian cockgame chicken, valued for its unique crowing sounds, whereas the Pelung chicken of Indonesia, a likely ancestral type, has a single comb type, which is a common comb feature in chicken in other tropical countries (Yang *et al*., 2022). Comb type has functional and selective implications; for example, single and rose combs are often associated with fertility and production traits favoured by farmers (Chebo *et al*., 2023). In this study, comb type distribution was significantly associated with group χ^2 = 276.043, p<0.001), suggesting structured phenotypic differentiation rather than random variation.

Kurik-type MVCs are characterized by their mottled or "speckled" plumage patterns, typically a mix of black, white, and brown feathers. This mottling often extends across the entire body, creating a camouflage-like appearance that differentiates them from solid-colored types. Meanwhile, Naked Neck MVCs are easily recognized by their reduced feather coverage on the neck, distinctively exposing bare skin. This trait is associated with greater heat tolerance, making them well-suited for Malaysia's tropical climate. While plumage colors are diverse, the bare neck remains the defining characteristic. Phenotypically, naked-necked individuals are heterozygous, hence the appearance of a small tuft of feathers on the ventral side of the neck, which is almost absent in the homozygote, due to a 40% reduction in feather coverage compared to normal plumage (Fathi, 1987).

Across Southeast and South Asia, native chickens display varying degrees of color diversity. In Indonesia, for example, 31 local breeds have been identified, ranging from the uniformly colored Bangkok and Merawang chickens to the more varied (Irmaya, 2022) but still regionally consistent Kampung chickens (Ulfah *et al*., 2015), which differ from Malaysian Village Chickens (MVC) despite sharing a name. Native populations in Bangladesh, Sri Lanka, Vietnam, and Pakistan typically show modest variation in plumage, comb, and earlobe colors (Bett *et al*., 2014), often within a limited palette, while Ethiopian ecotypes exhibit broader variation in body and appendage colors (Musa *et al*., 2023). In contrast, the original red junglefowl (RJF) maintains a consistent, striking pattern—males with colorful but fixed plumage, white or red earlobes, and grayish-blue shanks. This makes the Multicolor MVC, with its highly variable and irregular mix of colors across the entire body, distinctly different from both RJF and many other regional breeds.

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Table 4. Non-parametric analyses on qualitative traits of village chicken-based ecotypes and groups

Ecotype Group	A		C				K		MC					N		Chi-square / Fisher's Exact	*P*-value
Ecotype/ Trait	M1	M2	D	K1	K2	K3	C1	C2	A	J	K4	K5	Saga	NS1	NS2		
Plumage																$\chi^2_{ecotype}$: 459.000, df = 14	<.0001
White	0	31	0	0	0	0	0	0	0	0	29	0	0	30	0	χ^2_{group}: 117.676, df = 4	
Colored	29	0	32	30	30	30	31	30	30	36	0	30	30	0	31		
Beak																Fisher's Exact Test	<.0001
Yellow	29	31	10	30	30	30	31	30	30	35	29	0	30	30	31		
Black-gray	0	0	22	0	0	0	0	0	0	1	0	0	0	0	0		
Black	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0		
Shank																Fisher's Exact Test	<.0001
Yellow	29	31	17	30	30	30	31	30	30	35	29	0	30	14	31		
Black	0	0	1	0	0	0	0	0	0	1	0	30	0	0	0		
Yellow-black	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0		
Yellow-gray	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0		
Comb color																Fisher's Exact Test	<.0001
Red	29	31	32	30	30	30	31	30	30	36	0	0	30	30	31		
Red-gray	0	0	0	0	0	0	0	0	0	0	29	30	0	0	0		
Comb type																$\chi^2_{ecotype}$: 411.843, df = 14	<.0001
Single	29	31	0	0	0	30	31	30	30	0	4	30	30	16	31	χ^2_{group}: 276.043, df = 4	
Pea	0	0	32	30	30	0	0	0	0	36	29	0	0	12	0		

A = *Arab* chicken; C = cockfighting chicken; K = *Kurik* chicken; MC = multicolor chicken; N = Naked Neck chicken; NS1 = N. Sembilan1; NS2 = N. Sembilan2; M1 = Malacca1; M2 = Malacca2; K1 = Kedah1;
K2 = Kedah2; K3 = Kedah3; K4 = Kedah4; K5 = Kedah5; C1 = Pahang1; C2 = Pahang2; A = Perak; J = Johore; D = Kelantan; χ^2= Chi-square test

Variation in qualitative traits

Plumage color and pattern

In the present study, Malaysian Village Chickens (MVC) predominantly exhibited multicolored plumage, with feather colors ranging from red, brown, yellow, buff, and gray to, less commonly, black and white. White plumage occurred but was far less frequent than the vibrant multicolor combinations. Plumage color is an important phenotypic trait that can reflect breed identity and, in some cases, gender. The diverse plumage patterns observed in MVC contrast sharply with the uniform appearance of commercial broilers and may provide ecological advantages, such as camouflage against predators (Bibi *et al*., 2021).

Plumage diversity in MVC contrasts with that of indigenous chickens in nearby regions. In Medan, Indonesia, over half of village chickens are black (Sitanggang & Hasnudi, 2016), and female Pelung in West Java are predominantly black (Asmara *et al*., 2019). In contrast, chickens in Bangladesh, Sri Lanka, Vietnam, and Pakistan exhibit a broader range, including grayish (19%), black (17%), multicolor (16%), and other shades (Bett *et al*., 2014). African breeds also vary, with Ethiopian chickens typically brown or white, while white is more common in Ghana (Moreda *et al*., 2014; Asmamaw, 2016; Tolasa, 2021). In MVC, a distinctive all-black subgroup locally known as *Selasih* chicken was recorded. This uniform pigmentation, caused by the MC1R gene promoting eumelanin synthesis (Feng *et al*., 2017), extends beyond feathers to skin and internal organs due to a genetic condition called fibromelanosis – giving the breed its characteristic black meat (Saxena, 2019). Although resembling India's Kadaknath, China's Black Silkie, and Indonesia's Cemani (Prakash *et al*., 2023), *Selasih* exhibit slightly duller plumage but, like other black-meet breeds worldwide, they are valued for their lean meat and perceived medicinal benefits.

Although some commercial broilers, such as Sasso and brown egg-laying hens like Hy-Line, share certain plumage similarities with MVC, they differ in body conformation and production traits (Department of Animal & Food Sciences, 2024). The Red Jungle fowl (RJF), considered the wild ancestor of domestic chickens, displayed the classic reddish and gold feathering pattern typical of the species (Syahar *et al*., 2014). Compared to MVCs, their plumage was more uniform and less variable in color, suggesting that selective breeding and local adaptation have increased phenotypic diversity in village populations. This variation represents valuable genetic resources for future breeding programs aimed at improving ecological resilience, consumer appeal, and conservation of indigenous poultry.

Beak color

Malaysian village chickens predominantly exhibit brown-yellow beaks. This contrasts with patterns in some neighboring countries, such as Indonesia, where black beaks are more common in several breeds, such as KUB (Irmaya, 2022). Within Indonesian breeds, sexual dimorphism is apparent: in male Bangkok chickens, most frequently have black beaks (61%), whereas (85%) of females display yellow beaks, while Sentul chickens exhibit a distinct sex-linked pattern – yellow in males and black in females. Study in Ethiopian indigenous chicken population (Chebo *et al*., 2023) also indicates apparent sexual dimorphism with predominance of black beak in males, while varied beak colors in females.

Beak pigmentation is influenced primarily by skin pigments such as lipochrome, which also affects the shank coloration (Gwaza *et al*., 2018). The significant association between ecotype and beak color in the present study (Fisher's Exact Test, $p<0.001$) supports the hypothesis that pigmentation traits are not randomly distributed, but instead shaped by both genetic and environmental factors.

Comb type and color

In Malaysia, fighting chickens ("Sabung") typically display pea or walnut-shaped combs, locally referred to as "kacang" (peanuts). Single combs are also observed in village chickens, consistent with the pattern reported across Southeast Asian countries like Indonesia (Arlina *et al*., 2015; Rafian *et al*., 2017; Asmara *et al*., 2019; Maharani *et al*., 2019; 2021), Thailand (Buranawit *et al*., 2016), Pakistan (Bibi *et al*., 2021), and India (Lalhlimpuia *et al*., 2021). This single comb recessive genotype (*rrpp)* is considered the wild type of native chicken genetics and may have been favored through genetic selection influenced by cultural and religious practices (Winaya *et al*., 2023) due to its link to heat-dissipation advantages in a tropical climate. Comb type distribution in the present study was significantly associated with ecotype ($p<0.001$), indicating a structured phenotypic pattern rather than random variation.

Shank color

Malaysian village chickens most often have yellow shank, a trait also common in other Southeast Asian indigenous chickens, like in Indonesia (Arlina *et al*., 2015; Maharani *et al*., 2019; Tamzil *et al*., 2020), the Philippines (Godinez *et al*., 2020), also in Bangladesh (Sarker *et al*., 2014), South-Western Ethiopia (Bayou *et al*., 2022), and the transboundary region of Jammu and Kashmir in India (Singh *et al*., 2022). In Nigeria, chickens display a wider variety of shank colors, with pink being the most common (39%), followed by colors such as milky, dark ash, ash, red, light pink, light yellow, ash, and yellow (Shuaibu *et al*., 2020).

Shank and skin color play an important economic role due to the different consumer preferences in various regions. Yellow pigmentation is produced by carotenoids as a result of a homozygous recessive allele, whereas melanin generates darker tones, and a dominant allele produces white color (Lalhlimpuia *et al*., 2021). The scarcity of white shanks in our dataset suggests a low prevalence of the dominant allele in the Malaysian population. Skin color is also influenced by genetics, nutrition, environmental adaptability, and health conditions. A significant association between ecotype and shank color further supports the role of both genetic inheritance and environmental adaptation in shaping pigmentation traits.

Association of ecotype with qualitative morphological traits

Analysis of qualitative traits revealed that chicken ecotype and grouping significantly influenced all qualitative morphological traits assessed, including plumage, beak, shank, comb coloration, and comb type. Chi-square tests showed highly significant associations ($p<0.001$), and the application of Fisher's Exact Test to account for low expected frequencies confirmed the

robustness of these findings. The marked variation in coloration traits among group ecotypes reflects visible phenotypic divergence, likely driven by environmental adaptation, geographic separation, and farmer-driven selection. These results underscore the phenotypic distinctiveness of village chicken ecotypes and suggest a strong genetic basis for their diversity. Collectively, the findings provide evidence of differentiation among village chicken ecotypes, supporting their potential value as a reservoir of adaptive traits. Preserving these populations is essential for maintaining genetic diversity and ensuring their continued contribution to sustainable breeding and conservation strategies.

Future studies should include village chickens from the Bornean archipelago (Sabah & Sarawak) to determine whether they can be grouped into one of the five existing categories or show greater resemblance to Indonesian chickens, perhaps reflecting geographical isolation over thousands of years. Considering the vital role MVCs play in Malaysian households and globally, evaluating their genetic makeup and documenting their morphological traits remains a priority for advancing understanding and guiding conservation efforts.

CONCLUSION

Five distinct groupings of Malaysian Village Chicken (MVC) were identified from fifteen ecotypes sampled across Peninsular Malaysia, each exhibiting notable differences in appearance and size. These variations have been shaped by factors such as geographical isolation, transportation, and limited artificial breeding. However, their unique traits are at risk of being lost due to disease, human intervention, and the introduction of other commercial breeds. Morphological characterization provides a critical first step in genetic conservation by identifying and documenting phenotypic diversity that reflects underlying genetic variation. This information directly informs targeted conservation strategies, such as selective breeding and *in situ* flock management, to maintain rare or adaptive traits. Integrating morphological data with complementary tools - including microsatellite marker analysis, SNP genotyping, and phenotypic mapping - will enable more precise assessment of genetic diversity and accelerate conservation planning. Such integrated approaches can form the basis of sustainable improvement programs that enhance productivity while safeguarding biodiversity. Preserving MVC's traits through a coordinated conservation and breeding program will help secure their role as a resilient genetic resource for climate-resilient agriculture, biodiversity protection, and long-term food security.

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ETHICAL STATEMENT

This study was approved by the Malaysian Agricultural Research and Development Institute (MARDI) Animal Ethics Committee, approval number: 20200630/R/MAEC00077.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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