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Qualitative and quantitative phenotype of Kai Tor-Kai Tang (*Gallus gallus*) in the lower-northern region of Thailand

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Abstract. *Incharoen T, Nakhen W, Yaemkong S. 2022. Qualitative and quantitative phenotype of Kai Tor-Kai Tang (*Gallus gallus*) in the lower-northern region of Thailand. Biodiversitas 23: 5387-5395.* The Kai Tor-Kai Tang (KT) chicken is a crossbreed between an indigenous domestic village breed and a local wild red junglefowl. Colorful plumage, a crowing voice, and a large single comb are specific characteristics of the phenotype. Due to their populations, there is a clear need to improve the qualitative and quantitative understanding of these chickens. A study of their phenotype variation may be an advantageous approach in the conservation and preservation of the breed, as well as social and commercial utilizations in rural communities. This study aimed to characterize the phenotypes of KT populations reared in the lower-northern region of Thailand, which includes Phetchabun, Phitsanulok, Phichit, Sukhothai, Uthai Thani, and Uttaradit provinces. A total of 100 KT chickens from 35 local farms were characterized under field conditions for 12 qualitative and 2 quantitative traits. Frequencies and means were calculated for phenotypical characteristics. Correlation coefficients and affecting factors were evaluated between qualitative traits. The results indicated that the most prominent colors of the earlobe, the colors around the eyes, beak, and shank were red (38%), orange (54%), brown (64%), and grey (56%), respectively. The main color of the neck and back plumage was brown-yellow (49% and 31%, respectively), the both long curving tail and back tail was black-green (96%), and the wing plumage color was red (79%) while 49.26%, 99% and 73% of the chickens had Jak Kod Hna comb, normal spur type, and Plod scale type, respectively. The overall mean body weight and age of the chickens were 1.07 ± 0.2 kg and 11.99 ± 7.4 months. The highest correlation (r: 1; $p<0.01$) was observed between the colors of the long curving tail and the back tail. The whole region had a significant effect on long-curving tail and back tail color ($p<0.05$), and all farm sizes had a significant effect on earlobe color ($p<0.05$).

Keywords: Diversity, native chicken, phenotypical characteristics, Phitsanulok Province, Thailand

INTRODUCTION

Native chickens appear to have originated in Southeast Asia nearly 10,000 years ago (Maw et al. 2015). They are believed to have evolved from junglefowl. There are two subspecies found in Thailand: *Gallus gallus gallus* and *Gallus gallus spadiceus* (Dorji et al. 2012). They can be found only in national parks and forested mountains (Mekchay et al. 2014; Rofii et al. 2018). Originally, Thai native chickens were found all around the local countryside; these native chickens were well-known as Kai Jae, Kai Ta Phao Thong, and Kai Oo (Tungtakanpoung 2015). They were initially used culturally as offerings in rituals and in fighting sport, and their crowing signaled the arrival of early morning. In addition, the chickens were raised by farmers not only as a food source or for household consumption but also they were sold within local communities as part of self-sufficient economies. Mekchay et al. (2014) noted that indigenous chickens appear to prevail in several breeds, and each has its own dominant gene. It seems that the genetic and phenotype diversity of Thai native chickens plays a vital role in improving the breed to meet specific purposes, such as food, cockfighting, and pets.

The Kai Tor-Kai Tang (KT) chicken is a crossbreed between an indigenous domestic village breed and a local wild red junglefowl (*Gallus gallus gallus*). It is well known that the red junglefowl has been accepted as the remaining ancestor of the present domestic chicken (Nguyen-Phuc and Berres 2018). Specifically, the KT rooster has two different types, which can be identified by the color of the ear patches, which are either red or white. Both types of these birds have been found in several provinces of northern Thailand, such as Nan, Prae, Payao, Chiang Rai, etc. KT chickens actively respond after hearing the crowing of junglefowl crowing or observing one (Charoensook et al. 2020). A male KT chicken begins to cluck at 5-6 months of age and is fully mature between 15-18 months of age. They are suitable to be raised for recreational activities, such as beauty or crowing contests, which has contributed to their increasing value. Thus, this chicken seems to be a new economic pet for rural or agricultural societies. Compared to other types of Thai native chickens, an understanding of the current state of the qualitative and quantitative phenotype of the KT chicken is very minimal due to the low impact on commercialization. There is a lot of literature reporting the diversity of the phenotypic characteristics of indigenous chicken breeds in Thailand,

such as the White Tailed-Yellow chicken (Yaemkong and Ngoc 2016; Yaemkong and Ngoc 2019), the Khiew-Phalee chicken (Phromnoi et al. 2022), the Black-bone chicken (Buranawit et al. 2016), and other breeds of native chicken in Thailand (Akaboot et al. 2012; Laenoi et al. 2015; Maw et al. 2015). However, chicken identification has been done mainly on the phenotype, both qualitatively and quantitatively (Ismoyowati and Susanto 2012). Descriptive phenotype identification is needed to understand how the specific characteristics of the KT chicken can be visually differentiated from other kinds of local chicken. Thus, the objective of this study was to describe the qualitative and quantitative phenotypical characteristics of the male KT chicken in the lower-northern region of Thailand. The current investigation may be one effective approach to conserving and increasing the commercial value of KT chickens in Thailand.

MATERIALS AND METHODS

Study area, population, and sampling

The study was conducted in the lower-northern region of Thailand, between 18º36´north latitude and 99º72´ east longitude (Figure 1) in six provinces: Phetchabun, Phitsanulok, Phichit, Sukhothai, Uthai Thani, and Uttaradit. The climate of Thailand is tropical, with three seasons as follows: winter (November to February: warm [21°C to 32°C] and dry [70% RH, precipitation 124 mm/year]); summer (March to June: hot [25°C to 36°C] and dry [69% RH, precipitation 187 mm/year]); and the rainy season (July to October: hot [24°C to 33°C] and humid [79% RH, precipitation 903 mm/year]) as described by Koonawootrittriron et al. (2012). A total of 100 adult male KT chickens were selected from 35 small households in the lower-northern region, according to the randomly purposive sampling method of Workneh and Rowland (2004). All birds were raised semi-free range and vaccinated for endemic poultry viruses, such as Newcastle disease, Marek's disease, infectious bronchitis, and fowl pox.

Description of farmers and farms

Most farmers were male (89%). The farmers' average age was 38.38 ± 11.4 years old, with 43% having a high-school education, followed by a bachelor's degree (40%), a primary school education (14%), and a master's or higher degree (3%). Their main occupations were working for the government (29%), followed by farming (26%), business owners (21%), other self-employed (18%), working for a private organization (3%), and other (3%). The majority raised KT chickens on own land (97%), while the minority rented from other people (3%). More farmers did not keep the rearing records (74%) than kept records (26%). The majority of farmers raised chickens for sale and contests (74%) rather than only for contests (26%).

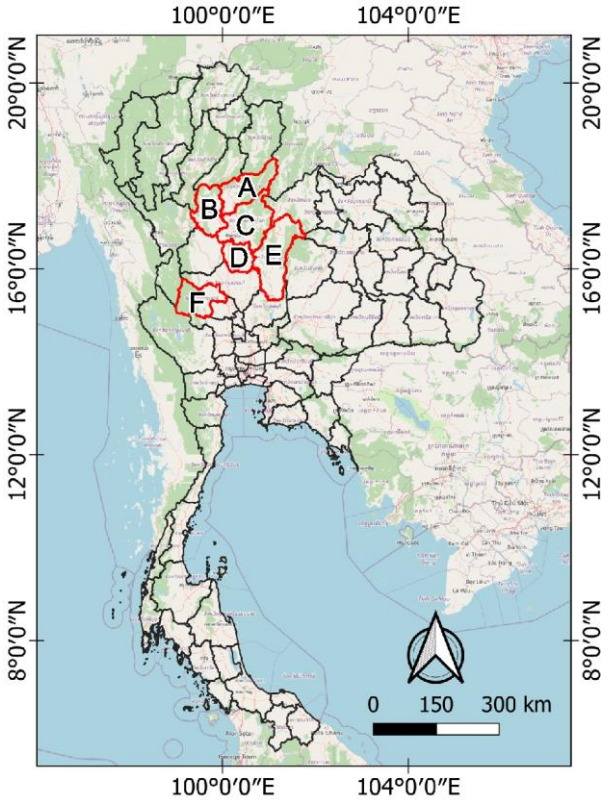

Figure 1. Map of Thailand, showing the location of A: Uttaradit, B: Sukhothai, C: Phitsanulok, D: Phichit, E: Phetchabun and F: Uthai Thani located in the lower-northern region of Thailand.

Figure 2. Showing the location of phenotypical characteristics of KT chicken in the lower-northern region of Thailand

Regarding the chicken's diets, most farmers chose paddy rice (57%), followed by corn (21%), commercial feeds (19%), and broken rice (3%); the majority added local herbs (86%), while 14% did not. *Tinospora crispa* (40%) was the main herb used, followed by commercial herbal products (37%), Kaempferia (13%), and chili (10%). The majority of farmers in this study used a semi-free-range rearing system (72%), followed by indoor only (17%) and free range (11%), and also gave vaccinations to their chicken (68.57%). The income compensation of farmers selling KT chickens was an average of 1407.14 ± 1278.8 Thai baht per head when the chickens were 7.56 ± 3.26 months old and had an average weight of 1.08 ± 0.25 kg.

Data collection

Data were collected for a total of 100 adult male KT chickens from 35 farmers. The data for the phenotypical characteristics of KT chickens in the lower-northern region were described through field observations, direct measurements, and photography (Yaemkong and Ngoc 2019), and animal genetic resources under field conditions for qualitative and quantitative traits following FAO standard descriptors (FAO 2012). The qualitative phenotypical characteristics included the comb type, earlobe color, color around the eyes, beak color, neck plumage color, back plumage color, wing plumage color, long curving tail color, back tail color, shank color, spur type, and scale type (Figure 2). The quantitative phenotypical characteristics were the body weight (kg) and age (month).

The location of individual farms was used to assign farms to one of six provinces: Phetchabun, Phitsanulok, Phichit, Sukhothai, Uhai Thai, and Uittaradit. The average number of KT chickens for the duration of this study was used to classify farms into three farm sizes: small (less than 10 chickens per farm), medium (between 10 and 20 chickens per farm), and large (more than 20 chickens per farm). The experiment procedures were approved by the Pibulsongkram Rajabhat University Animal Ethics Committee (Approval number: PSRU-(AG)-2020-007).

Statistical analysis

Analyses were performed for phenotypical characteristics using the Proc freq (qualitative traits) and Proc means (quantitative traits) procedures (Yaemkong and Ngoc 2019). The qualitative correlation coefficients were estimated using the Proc corr procedure (SAS 2004). The bivariate correlation produces a sample correlation coefficient (r), which measures the strength and direction of linear relationships between pairs of continuous qualitative traits and factors affecting them using the same program by the General Linear Model (GLM). Significant levels for the effects test were measured as α: 0.05.

RESULTS AND DISCUSSION

Qualitative phenotypical characteristics

Male KT chickens in the lower-northern region of Thailand were evaluated for qualitative phenotypical characteristics, including the type of comb, spur, and scale, as well as the color of the earlobe, the area around the eyes, the beak, the shank, and the plumage of the neck, back, wing, long curving tail, and back tail (Figures 3-14). The results indicated that the single comp was classified into four types: Jak Kod Hna (49%), Jak Kod Hlang (39%), Jak Bae Sai (7%), and Jak Bae Khwa (5%). The maximum proportion of the earlobe color was red (38%) and red-white (38%), followed by white-red (19%) and white (5%). The color around the eyes varied from orange (54%) to yellow (34%) to red (12%), and the beak color varied from brown (64%) to black (28%) to yellow (8%).

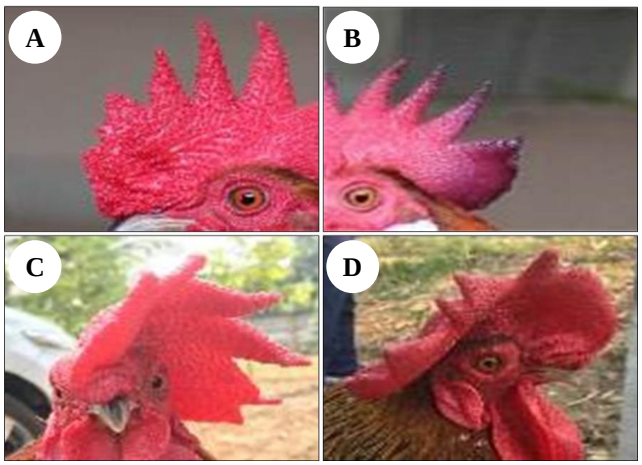

Figure 3. The phenotypical characteristics of the different single comp type such as Jak Kod Hna (A), Jak Kod Hlang (B), Jak Bae Sai (C) and Jak Bae Khwa (D)

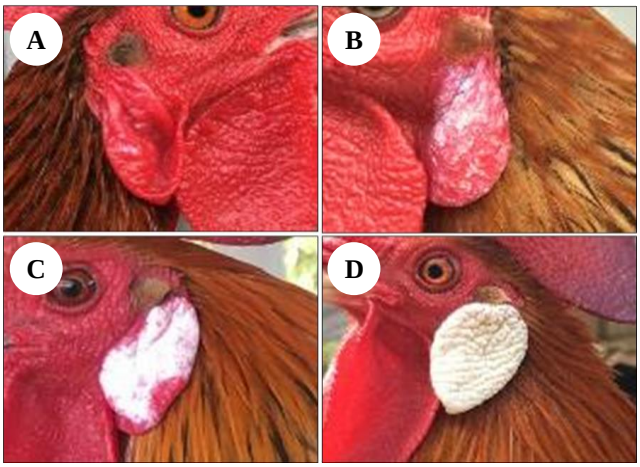

Figure 4. The phenotypical characteristics of the earlobe color such as red (A), red-white (B), white-red (C) and white (D)

Figure 5. The phenotypical characteristics of color around the eyes such as orange (A), yellow (B) and red (C)

Figure 6. The phenotypical characteristics of beak color such as brown (A), black (B) and yellow (C)

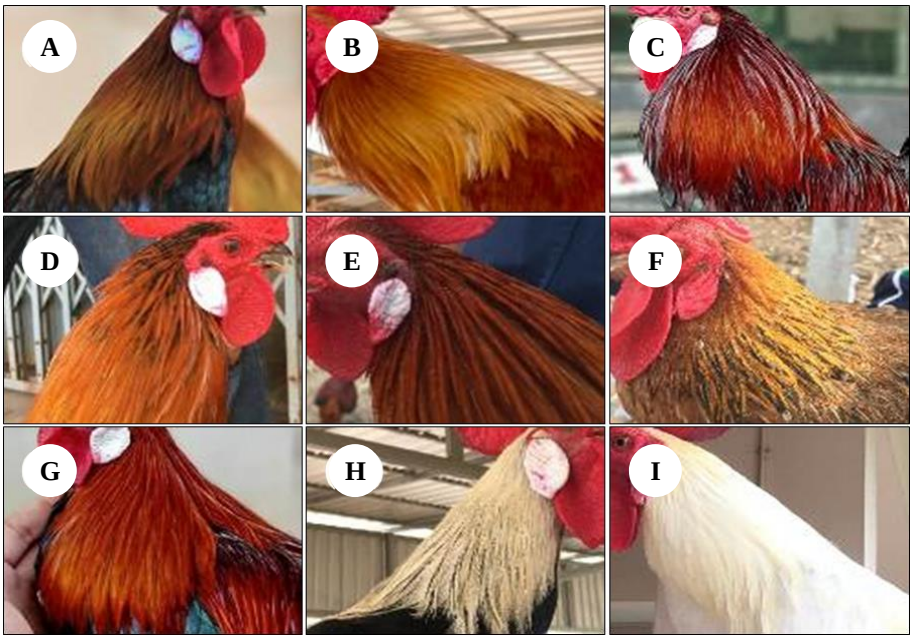

Figure 7. The phenotypical characteristics of neck plumage color such as brown-yellow (A), yellow (B), red (C), orange (D), brown (E), brown barred (F), red-yellow (G), pale yellow laced with black (H), and white (I)

The predominant colors of the neck plumage and back plumage were brown-yellow (49% and 31%, respectively), followed by yellow (18% and 18%, respectively), red (10% and 16%, respectively), orange (7% and 13%, respectively), brown (6% and 12%, respectively), brown barred (4% for neck plumage) and brown-white (4% for back plumage), red-yellow (3% and 3%, respectively), pale yellow laced with black (2% and 2%, respectively) and white (1% and 1%, respectively). The wing plumage color was red (79%), followed by orange (29%), brown (10%), brown-white (4%), pale yellow laced with black (2%), yellow (1%), and white (1%). Variations in the color of the long curving tail and back tail in the KT chicken, where black-green (96%) was prominent, followed by brown-white (3%) and white (1%). Most KT chickens had grey shanks (56%), with fewer having black (44%). The normal spur type (99%) was predominant in this study, with a small number having the twin type (1%). The Plod scale type (73%) was prominent over Jorakhe Khob Fan (27%).

An assessment of the variation in the qualitative phenotypical characteristics found that KT chickens in the regions of the study predominantly had Jak Kod Hna comb, red earlobes, orange around the eyes, brown beak, brown-yellow neck and back plumage, red wing plumage, black-green long curving and back tails, grey shanks, normal spur type, and Plod scale type. These results were similar to those reported by Dorji et al. (2012) and Setianto et al. (2019).

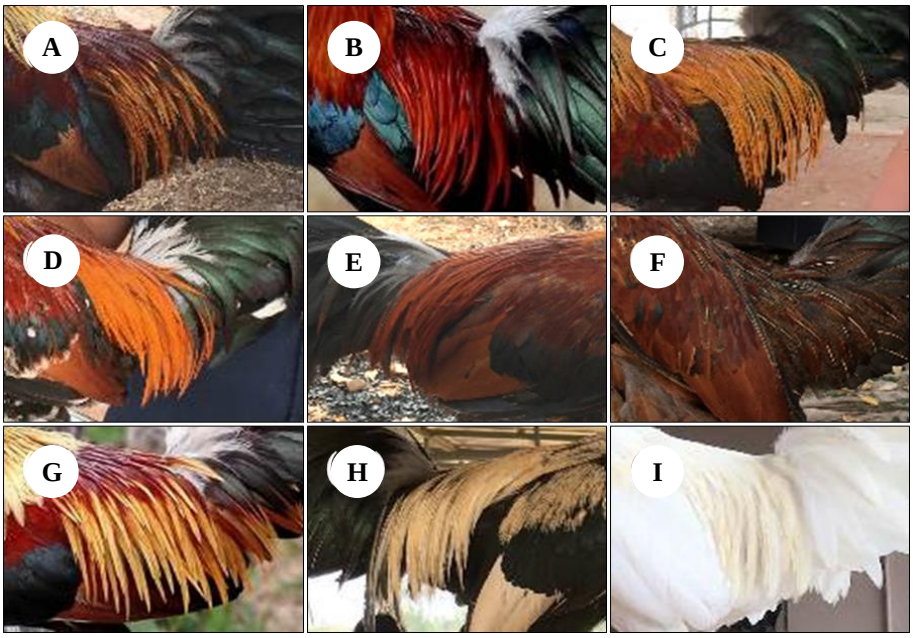

Figure 8. The phenotypical characteristics of back plumage color such as brown-yellow (A), yellow (B), red (C), orange (D), brown (E), brown-white (F), red-yellow (G), pale yellow laced with black (H) and white (I)

Figure 9. The phenotypical characteristics of wing plumage color such as red (A), orange (B), brown (C), brown-white (D), pale yellow laced with black (E), yellow (F) and white (G)

Figure 10. The phenotypical characteristics of long curving tail color such as black-green (A), brown-white (B) and white (C)

Figure 11. The phenotypical characteristics of back tails color such as black-green (A), brown-white (B) and white (C)

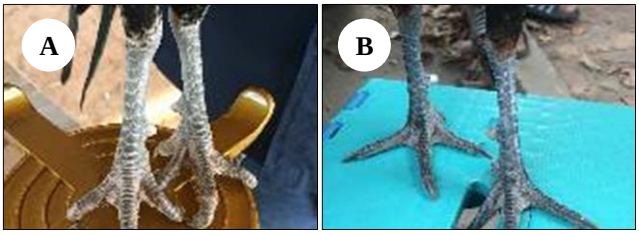

Figure 12. The phenotypical characteristics of shank color such as grey (A) and black (B)

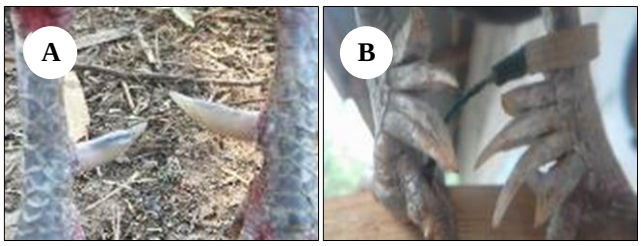

Figure 13. The phenotypical characteristics of spur type such as normal (A) and twin (B)

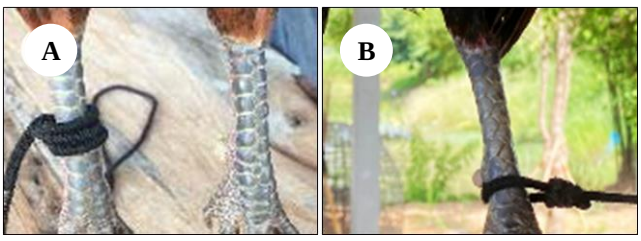

Figure 14. The phenotypical characteristics of scale type such as Plod (A) and Jorakhe Khob Fun (B)

However, Charoensook et al. (2020) showed that Kai Tang's beautiful neck feature was golden or red color and the ear patches on the sides of the head were red or white. Moreover, the Department of Livestock Development (2021) reported that some breeds of Kai Tang had red earlobes and the same color of beak, eyes and shank. Additionally, Setianto et al. (2019) revealed that in the wild, the red color of red junglefowl helped chickens to disguise their body color with dry leaves when threatened with predators. The current genetic purity of red junglefowl ranges from 92% to 93.75% (Brisbin et al. 2005). However, Rotimi et al. (2016) state that the diversity of phenotypes was caused by genetics and the environment.

Quantitative phenotypical characteristics

Analysis of the quantitative phenotypical characteristics showed an average age (11.99 ± 7.4 months old) and body weight (1.07 ± 0.2 kg) in Table 1. The body weight was in agreement with that reported by Arsirapoj (2008), who found that male red junglefowls in Uthai Thani province, Thailand weighed 800-1000 g. Similarly, Choicharoen (2009) studied the characteristics related to the growing stages of chicks, which were arbitrarily separated into three age periods using the definition of Knizetova et al. (1995): the first period was defined as 1 to 7 days old (inclusive), and the birds were studied every two days to evaluate their descriptive and morphometric characteristics. The second period was defined as 2 weeks to 20 weeks old (inclusive), and the birds were evaluated once a week for both descriptive and morphometric characteristics. The third period was defined as 6 months to 1 year old (inclusive), and the birds were evaluated once a month for both descriptive and morphometric characteristics.

Correlation between qualitative traits

The highest correlation (r: 1; $p<0.01$) was between the color of the long curving tail and the back tail, followed by the correlation (r: 0.7; $p<0.01$) between the color of the neck plumage and the back plumage; the correlation (r: 0.59; $p<0.01$) between the color of the wing plumage and the long curving tail and back tail; the correlation (r: 0.42; $p<0.01$) between the color of the back plumage and the long curving tail and back tail; the correlation (r: 0.41; $p<0.01$) between the color of the neck plumage and the long curving tail and back tail; the correlation (r: 0.33; $p<0.01$) between the color of the back plumage and the shank; the correlation (r: 0.31; $p<0.01$) between the color of the back plumage and the wing plumage; the correlation (r: 0.27; $p<0.01$) between the color of the neck plumage and the wing plumage; the correlation (r: 0.25; $p<0.05$) between the comb type and the color of the long curving tail and the back tail; the correlation (r: 0.24; $p<0.05$) between the color around the eyes and the scale type; the correlation (r: 0.22; $p<0.05$) between the color of the neck plumage and the shank; and the correlation (r: 0.2; $p<0.05$) between the color of the neck plumage and the scale type, and between the color of the wing plumage and the shank (Table 2).

Table 1. Least square means and standard errors of age and body weight of KT chicken in the lower-northern region of Thailand

Quantitative traits	Least square means ± standard errors
Age (month)	11.99 ± 7.4
Body weight (kg)	1.07 ± 0.2

Table 2. The correlation between comb type (CT), earlobe color (EC), color around the eyes (CE), beak color (BC), neck (NP), back (BP) and wing plumage color (WP), long curving tail color (LC), back tail color (BT), shank color (SC), spur type (SPT) and scale type (SCT) of KT chicken in the lower-northern region of Thailand

Qualitative traits	CT	EC	CE	BC	NP	BP	WP	LC	BT	SC	SPT	SCT
Comb type	1	0.07	-0.1	-0.07	0.09	0.09	0.15	0.25*	0.25*	0.37	0.03	-0.19
Earlobe color	0.07	1	-0.04	-0.14	0.01	-0.03	0.08	0.01	0.01	-0.13	0.05	0.01
Color around the eyes	-0.1	-0.04	1	0.06	0.07	0.09	-0.15	0.04	0.04	-0.04	-0.06	0.24*
Beak color	-0.07	-0.14	0.06	1	0.18	0.2	-0.12	-0.04	-0.04	0.04	-0.09	0.04
Neck plumage color	0.09	0.01	0.07	0.18	1	0.7**	0.27**	0.41**	0.41**	0.22*	0.06	0.2*
Back plumage color	0.09	-0.03	0.09	0.2	0.7**	1	0.31**	0.42**	0.42**	0.33**	-0.15	0.14
Wing plumage color	0.15	0.08	-0.15	-0.12	0.27*	0.31*	1	0.59**	0.59**	0.2*	0.05	-0.02
Long curving tail color	0.25*	0.01	0.04	-0.04	0.41**	0.42**	0.59**	1	1**	0.18	-0.02	-0.07
Back tail color	0.25*	0.01	0.04	-0.04	0.41**	0.42**	0.59**	1**	1	0.18	-0.02	-0.07
Shank color	0.37	-0.13	-0.04	0.04	0.22*	0.33*	0.2*	0.18	0.18	1	-0.11	0.14
Spur type	0.03	0.05	-0.06	-0.09	0.06	-0.15	0.05	-0.02	-0.02	-0.11	1	-0.16
Scale type	-0.19	0.01	0.24*	0.04	0.2*	0.14	-0.02	-0.07	-0.07	0.14	-0.16	1

Note: **Correlation is significant at 0.01% level and *Correlation is significant at 0.05% level

The correlation between the color of the tail and the plumage in this study was significantly positive and high. The results agreed with findings presented in many studies that revealed significant correlations of those features in other Thai native chickens (Yaemkong and Ngoc 2019; Department of Livestock Development 2021).

Moreover, the shank color was associated with the plumage color. Similarly, Guni and Katule (2013) found that plumage color was closely associated with shank and earlobe color; shank color was associated with skin and earlobe color; and earlobe color was associated with comb-type in Tanzanian chickens. However, Tabassum et al. (2014) noted that the type of bird and the color of the plumage, shank, or eggshell did not significantly affect each other in indigenous chickens in Bangladesh. The current results indicate that the color of the long curving tail could be used as an indicator of the color of the back tail and plumage and that also the color of the shank could be used as an indicator of the plumage color in KT chicken in the lower-northern region of Thailand. In addition, these correlations could be used as an aid in selection programs (Buranawit et al. 2016).

Effects of farm location and farm size

The location of the farm was an important factor affecting the color of the long curving tail and the back tail ($p<0.05$), while all other characteristics were not different ($p>0.05$). The black-green long curving tail and back tail was the highest in all farm locations (Table 5). The earlobe color varied significantly ($p<0.05$) depending on the farm size, except for other factors. In all farms, red was the earlobe color with the highest percentage (Table 5). In the current study, color variations of the earlobe, the long curving tail and the back tail were observed between farm location and farm size, which may be the result of their geographical isolation as well as periods of natural and artificial selection by the owner. Similar results were also reported in previous studies (Halima et al. 2007; Tadele et al. 2018; Department of Livestock Development 2021). Moreover, Emebet et al. (2014) reported that almost all chickens (81.50%) in the study area had an earlobe and that the dominant earlobe colors were red (30.60%) and red and white (30.60%), followed by white (26.70%). This was consistent with the study by Kumpala et al. (2016), who reported that Thai native chickens reared by ethnic groups in Nan province had red earlobes (54.50%). Similarly, Rotimi et al. (2016) studied the phenotypic characterization of indigenous chicken populations in Gwer-West, Benue State, Nigeria. The results showed that two earlobe colors (red and white) were identified among native chickens. Red was much more common (79.37%) than white (20.63%). This result agreed with that obtained by Egahi et al. (2010), who reported 20.63% and 73.02% white and red earlobes, respectively. Additionally, Duguma (2006) found a diversity of phenotypic characteristics between the farm location and the farm size. It is, therefore, more suitable and meaningful to describe indigenous chickens based not only on their location but also on a classification of observable phenotypic traits within locations. Finally, it would be possible to standardize these phenotypic characters across the country and establish some criteria to characterize the features of separate indigenous chicken breeds.

The findings of this study show that KT chickens in the lower-northern region of Thailand represent distinct phenotypic variations in both qualitative and quantitative characteristics in different geographical areas and/or farms. In order to promote the utilization, conservation and preservation of KT chickens, data should be collected and characterized toward improving the breed.

In conclusion, the present study reveals that the qualitative phenotypical characteristics include the predominant Jak Kod Hna comb, red earlobes, orange color around the eyes, brown beak, brown-yellow neck and back plumage, red wing plumage, black-green long curving and back tails, grey shanks, normal spur type, and Plod scale type. The quantitative traits of KT chickens in the current study were 1.07 ± 0.2 kg of body weight and 11.99 ± 7.4 months of age. Qualitative traits showed a significant positive correlation between long curving tail and back tail color ($r: 1$; $p<0.01$). The colors of the long curving tail and back tail varied significantly ($p<0.05$) depending on the farm location, and the earlobe color was significantly ($p<0.05$) different depending on the farm size.

Table 5. Percentage of qualitative traits of KT chicken in the lower-northern region of Thailand by provinces and farm size

Traits	Provinces						Farm size		
	Phetchabun	Phitsanulok	Phichit	Sukhothai	Uhai Thai	Uttaradit	Small	Medium	Large
Jak comb type			0.2944					0.4876	
Kod hna	60	63.45	40	37.5	55.56	33.33	37.5	55.26	60.53
Kod hlang	40	23.08	0	50	11.11	42.86	37.5	23.68	26.32
Bae say	0	9.62	40	12.5	22.22	14.29	12.5	15.79	10.53
Bae khwa	0	3.85	20	0	11.11	9.52	12.5	5.26	2.63
Earlobe color			0.5418					0.0196	
Red	60	38.46	40	37.5	44.44	28.57	25	44.74	39.47
White	0	3.86	0	0	11.11	9.52	0	5.26	7.89
Red-white	0	42.31	60	37.5	44.44	28.57	33.33	31.58	47.37
White-red	40	15.38	0	25	0.00	33.33	41.67	18.42	5.26
Color around the eyes			0.4844					0.5395	
Red	20	7.69	0	25	22.22	14.29	12.5	13.66	10.53
Yellow	0	36.54	60	12.5	44.44	33.33	20.83	34.21	42.11
Orange	80	55.67	40	62.5	33.37	52.38	66.67	52.63	47.37
Beak color			0.7261					0.5721	
Yellow	0	9.62	20	12.5	0	4.76	8.33	7.89	7.89
Black	40	23.08	0	25	44.44	38.1	33.33	34.21	18.42
Brown	60	67.31	80	62.5	55.56	57.14	58.33	57.89	73.68
Neck plumage color			0.2542					0.8647	
Red	20	7.69	20	12.5	11.11	9.52	8.33	13.16	7.89
Pale yellow laced with black	0	0	0	12.5	0	4.76	0	0	5.26
Yellow	20	11.54	20	12.5	33.33	33.33	20.83	18.42	15.79
Orange	0	5.77	0	0	11.11	14.29	4.17	7.89	7.89
Brown	0	9.62	0	0	0	9.52	12.5	5.26	5.26
Brown-yellow	60	57.69	40	62.5	33.33	28.57	50	47.37	50
Red-yellow	0	3.85	0	0	0	0	0	5.26	0
White	0	1.92	0	0	0	0	0	0	2.63
Brown-barred	0	1.92	40	0	11.11	0	4.17	2.63	5.26
Back plumage color			0.5701					0.6765	
Red	20.00	19.23	20.00	25.00	11.11	9.52	16.67	23.68	15.79
Pale yellow laced with black	0.00	0.00	0.00	12.50	0.00	4.76	0.00	0.00	5.26
Yellow	40.00	13.46	0.00	12.50	33.33	14.29	12.50	23.68	10.53
Orange	0.00	11.54	20.00	12.50	11.11	19.05	12.50	13.16	13.16
Brown	0.00	15.38	0.00	12.50	11.11	9.52	16.67	7.89	13.16
Brown-yellow	40.00	32.69	20.00	25.00	22.22	33.33	37.50	28.95	28.95
Red-yellow	0.00	3.85	0.00	0.00	0.00	0.00	0.00	0.00	5.26
White	0.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	2.63
Brown-barred	0.00	1.92	40.00	0.00	11.11	0.00	4.17	2.63	5.26
Wing plumage color			0.1481					0.4658	
Red	80	84.62	60	75	77.78	71.43	75	78.95	81.58
Pale yellow laced with black	0	0	0	12.5	0	4.76	0	0	5.26
Yellow	0	1.92	0	0	0	0	4.17	0	0
Orange	0	0	0	12.5	0	9.52	4.17	5.26	0
Brown	20	9.62	0	0	11.11	14.29	12.5	13.16	5.26
White	0	1.92	0	0	0	0	0	0	2.63
Brown-white	0	1.92	40	0	11.11	0	4.17	2.63	5.26
Long curving tail color			0.0038					0.7746	
Black-green	100	96.15	60	100	100	100	95.83	97.37	94.74
White	0	1.92	0	0	0	0	0	0	2.63
Brown-white	0	1.92	0	0	0	0	4.17	2.63	2.63
Back tail color			0.0038					0.7746	
Black-green	100	96.15	60	100	100	100	95.83	97.37	94.74
White	0	1.92	0.	0	0	0	0	0	2.63
Brown-white	0	1.92	0.	0	0	0	4.17	2.63	2.63
Shank color			0.9195					0.63	
Black	60	40.38	40	50	55.56	42.86	41.67	50	39.47
Grey	40	59.62	60	50	44.44	57.14	58.33	50	60.53
Spur type			0.9678					0.4387	
Normal	100	98.08	100	100	100	100	100	97.37	100
Twin	0	1.92	0	0	0	0	0	2.63	0
Scale type			0.6039					0.6452	
Plod	20	23.08	40	12.5	44.44	33.33	20.83	31.58	26.32
Jorakhe Khob Fan	80	76.92	60	87.5	55.56	66.67	79.17	68.42	73.68

Note: *Means with a superscript in a row are significantly different ($p<0.05$)

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REFERENCES

Akaboot P, Duangjinda M, Phasuk Y, Kaenchan C, Chinchiyanond W. 2012. Genetic characterization of Red Junglefowl (*Gallus gallus*), Thai indigenous chicken (*Gallus domesticus*), and two commercial lines using selective functional genes compared to microsatellite markers. Genet Mol Res 11 (3): 1881-1890. DOI: 10.4238/2012.July.19.7.

Arsirapoj S. 2008. Morphology, calling and habitat utilization of the Red Junglefowl *Gallus gallus spadiceus* in Huai Kha Kaeng wildlife breeding station, Uthai Thani Province. [Dissertation]. Chulalongkorn University, Bangkok. [Thailand]

Brisbin IL, Peterson AT, Okimoto R, Amato G. 2005. Characterization of the genetic status of populations of Red Junglefowl. J Bombay Nat Hist Soc 99 (2): 217-223.

Buranawit K, Chailungka C, Wongsunsri C, Laenoi W. 2016. Phenotypic characterization of Thai native black-bone chickens indigenous to northern Thailand. Thai J Vet Med 46: 547-554.

Charoensook R, Incharoen T, Wichaporn J, Masunari S, Oba T, Patamadilok S, Inyawilert W, Numthuam S, Yeamkong S, Soipeth U. 2020. Indigenous Chicken and Thai Ways of Life in Phitsanulok. Naresuan University, Phitsanulok.

Choicharoen T. 2009. Morphological changes related to the growth of Red Junglefowl *Gallus gallus spadiceus* in captivity at Huai Kha Khaeng wildlife breeding station. [Dissertation]. Chulalongkorn University, Bangkok. [Thailand]

Department of Livestock Development. 2021. Kai Tang. Biodiversity Research Section, Bureau of Animal Husbandry and Genetic Improvement. http://breeding.dld.go.th/biodiversity/chm/pvp_chm/provineculture/Kai%20tong.htm. [Thailand]

Dorji N, Duangjinda M, Phasuk Y. 2012. Genetic characterization of Bhutanese native chickens based on an analysis of Red Junglefowl *(Gallus gallus gallus and Gallus gallus spadecieus)*, domestic Southeast Asian and commercial chicken lines *(Gallus gallus domesticus)*. Genet Mol Biol 35 (3): 603-609. DOI: 10.1590/S1415-47572012005000039.

Duguma R. 2006. Phenotypic characterization of some indigenous chicken ecotypes of Ethiopia. Livest Res Rural Dev 18: 131.

Egahi JO, Dim NI, Momoh OM, Gwaza DS. 2010. Variations in qualitative traits in the Nigerian local chicken. Intl J Poult Sci 9 (10): 978-979. DOI: 10.3923/ijps.2010.978.979.

Emebet M, Harpal S, Tesefaye S, Johansson AM. 2014. Phenotypic characterization of indigenous chicken population in South West and Part of Ethiopia. Br Poult Sci 3 (1): 15-19. DOI: 10.5829/idosi.bjps.2014.3.1.8370.

FAO. 2012. Phenotypic Characterization of Animal Genetic Resources. FAO Animal Production and Health Guidelines, Rome.

Guni FS, Katule AM. 2013. Characterization of local chickens in selected districts of the Southern Highlands of Tanzania: I. Qualitative characters. Livest Res Rural Devel 25 (9): 153.

Halima H, Neser FW, van Marle-Koster E, de Kock A. 2007. Phenotypic variation of native chicken populations in northwest Ethiopia. Trop Anim Health Prod 39 (7): 507-13. DOI: 10.1007/s11250-007-9032-2.

Ismoyowati S, Susanto A. 2012. Genetic diversity of kedu chicken based on phenotypic characteristics and microsatellite loci. Intl J Poult Sci 11 (9): 605-610. DOI: 10.3923/ijps.2012.605.610.

Knizetova H, Hyanek J, Hyankova L, Belicek P. 1995. Comparative study of growth curves in poultry. Genet Sel Evol 27: 365-375.

Koonawootrittriron S, Elzo MA, Yeamkong S, Suwanasopee T. 2012. A comparative study on dairy production and revenue of the dairy farms supported by a private organization with those supported by a dairy cooperative in Central Thailand. Livest Res Rural Dev 24 (4): 61.

Kumpala K, Kuha K, Termsombatthaworn P, Nasinporn N. 2016. Study on morphology of Thai native chickens of ethnic groups in Nan province. Khon Kaen Agr J 44: 377-381. [Thailand].

Laenoi W, Kunkalw W, Buranawit K. 2015. Phenotypic characterization and farm management of indigenous chicken reared in highland region of northern Thailand. Agric Agric Sci Procedia 5: 127-132. DOI: 10.1016/j.aaspro.2015.08.019.

Maw AA, Kawabe K, Shimogiri T, Rerkamnuaychoke W, Kawamoto Y, Masuda S, Okamoto S. 2015. Genetic diversity and population structure in native chicken populations from Myanmar, Thailand and Laos by using 102 indels markers. Asian-australas J Anim Sci 28 (1): 14. DOI: 10.5713/ajas.14.0212.

Mekchay S, Supakankul P, Assawamakin A, Wilantho A, Chareanchim W, Tongsima S. 2014. Population structure of four Thai indigenous chicken breeds. BMC Genet 15: 1-9. DOI: 1471-2156/15/40.

Nguyen-Phuc H, Berres ME. 2018. Genetic structure in Red Junglefowl (*Gallus gallus*) populations: Strong spatial patterns in the wild ancestors of domestic chickens in a core distribution range. Ecol Evol 8 (13): 6575-6588. DOI: 10.1002/ece3.4.

Phromnoi S, Lertwatcharasarakul P, Phattanakunanan S. 2022. Genetic diversity and phylogenetic analysis of Khiew-Phalee chickens based on mitochondrial DNA cytochrome b gene sequences. Biodiversitas 23 (2): 750-756. DOI: 10.13057/biodiv/d230220.

Rofii A, Saraswati TR, Yuniwarti EYW. 2018. Phenotypic characteristics of Indonesian native chickens. J Anim Behav Biometeorol 6 (3): 56-61. DOI: 10.31893/2318-1265jabb.v6n3p56-61.

Rotimi EA, Egahi JO, Adeoye AA. 2016. Phenotypic characterization of indigenous chicken population in Gwer-West, Benue State, Nigeria. World Sci News 53 (3): 343-353.

SAS. 2004. SAS 9.13 Help and Documentation. SAS Institute Inc., Cary, North Carolina.

Setianto J, Sutriyono S, Prakoso H, Zain B, Adwiyansyah R, Amrullah AHK. 2019. Phenotypic diversity of male Burgo chicken from Bengkulu, Indonesia. Biodiversitas 20 (2): 532-536. DOI: 10.13057/biodiv/d200232.

Tabassum F, Hoque MA, Islam F, Ritchil CH, Faruque MO, Bhuiyan AKFH. 2014. Phenotypic and morphometric characterization of indigenous chickens at Jhenaigati upazila of Sherpur district in Bangladesh. SAARC J Agric 12 (2): 154-169. DOI: 10.3329/sja.v12i2.21927.

Tadele A, Melesse A, Taye M. 2018. Phenotypic and morphological characterizations of indigenous chicken populations in Kaffa Zone, South-Western Ethiopia. Anim Husb Dairy Vet Sci 2 (1): 1-9. DOI: 10.15761/AHDVS.1000128.

Tungtakanpoung N. 2015. Phitsanulok Province Naresuan Fighting Cock. Dtra goon Thai Printing Ltd., Phitsanulok, Thailand. [Thailand]

Wikipedia. 2014. Thailand adm location map. https://en.m.wikipedia.org/wiki/File:Thailand_adm_location_map.svg

Workneh A, Rowlands J. 2004. Design, Execution and Analysis of the Livestock Breed Survey in Oromia Regional State, Ethiopia. ILRI, Nairobi, Kenya.

Yaemkong S, Ngoc TN. 2016. Phenotypic Characterization of Native Chicken Ecotypes in Lower Northern, Thailand. The 17th Asian-Australasian Association of Animal Producction Societies Animal Science Congress. Fukuoka, 22-25 August 2016.

Yaemkong S, Ngoc TN. 2019. Diversity of phenotypic characteristics of White Tailed-Yellow Chicken populations reared under free range system in Phitsanulok Province, Thailand. Biodiversitas 20 (5): 1271-1280. DOI: 10.13057/biodiv/d200517.