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Phenotypic Characterization of Village Chicken Populations in Ampara District, Sri Lanka

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***Abstract*—**The present study was directed to characterize the native breeds of chicken populations in Ampara District, Sri Lanka. A total of 277 chickens were sampled randomly in five veterinary ranges. The morphological characteristics such as features of plumage, comb, shank, eye, and earlobe, were observed, while number of morphometric measurements were also documented. One-way ANOVA was performed to test the significant difference between linear measurements and body weight among groups. Six well-defined phenotypic classes could be observed in the study area such as common village (CVC), naked neck (NNC), long-legged (LLC), frizzle feathered (FFC), crested (CRC), and booted bantam (BBC). The result of morphological characterization revealed many variations in plumage color and patterns. The dominant plumage color was black. Single and rose comb types were primarily found in the chicken population. A red color comb was a unique feature in all types of chicken. The presence of red color earlobes was the prominent feature of all village chickens. The regression analysis results revealed that body weight has significant relationships with all linear body measurements while BC and SL were the finest predictors of live weight. These findings could be useful as characterize local chicken in Ampara, Sri Lanka.

***Keywords*—**Gallus gallus, Morphological characterization, Native chicken, Qualitative traits, Quantitative traits

I. Introduction

Rural populations hold most indigenous chicken breeds in tropical and sub-tropical nations (Ajayi, 2010). Due to a lack of information, village chickens are generally classified as non-descriptive types worldwide (FAO, 2012). The domestic chicken (*Gallus gallus domesticus*) is inherited from South East Asian Red Jungle Fowl ((*Gallus gallus*). The Ceylon Jungle Fowl ((*Gallus lafayetti*) is a unique endemic species to Sri Lanka (Lawal *et al.*, 2020; Silva *et al.*, 2016). According to Silva et al. (2008), Sri Lankan native chickens are the most diverse and unique group of birds with strong genetic ties to Red Jungle Fowl and Grey Jungle Fowl, while Ceylon Jungle Fowl has no genetic ties to the country's native chickens. Tolerance to high temperatures, resistance to diseases and meat flavor, hard eggshells, high fertility and hatchability, high dressing percentage, specific hardiness, ability to adapt to a harsh environment, ability to live on little or no feed, medications, and shelter is known as some desirable traits of native chickens (Pampori, Iqbal, 2007; Ajayi, 2010; Apuno *et al.*, 2011).

The indigenous chicken sector has aided in poverty reduction, food safety and security, and economic empowerment for vulnerable communities, including children and women (Mengesha, Tsega, 2011; Cabarles *et al.*, 2012). In Sri Lanka, approximately 43% of country chicken products are used at home, and backyard chickens provide non-monetary or nonmeasurable advantages such as backyard manure production, weeds and pests control, waste matter recycling, and genetic resource conservation (Wijayesena *et al.*, 2014).

Several village chicken types have been described based on quantitative and qualitative characteristics, and they have not been phenotypically characterized (Silva *et al.*, 2008). According to FAO (2012) guidelines, standard qualitative and quantitative features are defined for the characterization of chicken types. Quantitative traits are criteria that have a direct connection to production, such as body part dimensions and live weight, while qualitative traits are breed/type characteristics and indirect measures of production and physiological conditions. The most popular indigenous chicken types available in Sri Lanka are the common village chicken with different plumage colors such as red, black, brown, white or multicolor, naked neck, long-legged, crown chicken, and frizzled feathers (Silva *et al.*, 2016).

Many village chicken types are becoming extinct and identified as vulnerable birds, leaving us with only the most rudimentary understanding of their traits and possible advantages. In such situations, phenotypic characterization of available village chicken types are essential for the proper management of these valuable genetic resources (Bekele *et al.*, 2021). The

first stage of indigenous chicken characterization entails identifying populations using morphological descriptors, which can also provide information on breed selection procedures (Ajayi *et al.*, 2012). Liyanage et al. (2015) investigated the identification, characterization, and description of the phenotypic variation of village chicken populations found in North Central and North-Western provinces in Sri Lanka. No previous studies for the identification and characterization of local populations of village chicken types have been carried out in the Ampara district, and no morphological traits of village chickens have been recorded. As the importance of the above context, the objectives of the present study were to identify, systematically characterization, and description the phenotypic variations, quantitative and qualitative traits of village chicken types found in Ampara district (Eastern Province), Sri Lanka, following standard FAO guidelines.

II. METHODOLOGY

A. Description of the study area

The present study was conducted in the Ampara district of Sri Lanka, located in the southeast part of Sri Lanka in the eastern province. The site is located 37 m above mean sea level. The selected region receives an annual average rainfall and an average temperature of 1813 mm and 30°C, respectively.

Figure 1: Map of the study area, Ampara District (Nintavur, Akkaraipattu, Karaitivu, Kalmunai and Sammanthurai)

B. Sampling techniques and data collection procedures

Five veterinary ranges (Nintavur, Akkaraipattu, Karaitivu, Kalmunai, and Sammanthurai) were selected in the Ampara district. Birds were selected for the study were scavenging countryside chickens kept by the farmers in the selected study area. Twenty farm families who kept village chicken were randomly selected in each veterinary range, and their birds were studied. Thus, the final samples were comprised of five veterinary ranges and 100 respondents. A pre-tested structured questionnaire was used for the data collection. Primary data were collected from village chicken farmers by face-to-face interview and field observation. Secondary data were collected from the Department of Animal Production and Health (DAPH) of each veterinary region regarding farmers' details.

C. Morphological characterization of indigenous poultry

The FAO (2012) recommended standard breed descriptor list for poultry was followed in selecting qualitative and quantitative traits. Data for qualitative variables like plumage color (PC), shank and foot color (SFC), feather color pattern (FCP), eye color (EC), skin color (SC), ear-lobe color (ELC), comb color (CC), and comb-type (CT) were recorded by visual observation of the chicken.

Quantitative traits like body weight, body circumference (BC), wing length (WL), shank length (SL), keel length (KL), back length (BL), breast width (BW), and pelvis width (PW) were measured using a measuring tape. Bodyweight was measured using a spring hanging balance having 50 kg capacity.

D. Data Analysis

All the collected data were subjected to analysis by using the statistical package SPSS, version 25. All the collected qualitative data were analyzed using descriptive statistics, frequencies, and percentages. A one-way analysis of variance (ANOVA) was performed for the analysis of all collected quantitative data. Regression analysis and Correlation analyses also were performed to test the correlation between variables.

III. RESULTS AND DISCUSSION

A. Qualitative traits of Indigenous Chicken

Qualitative traits such as feather color/plumage color, color patterns of the feather, types of comb, comb color, ear lobe color, eye color, the skin color of the local breeds of the chicken population in the selected study area are presented in Table 1.

1) Plumage colour descriptions of local chicken breeds: As stated in Table 1, approximately nine plumage color patterns were observed in the local chicken population in Ampara District. The plumage colors influence the market demand and supply chains of local breeds, and it plays a vital role in breeding practices in developing countries (Assefa and Melesse, 2018).

The presence of black plumage color (22.4%) primarily common among the studied village chicken populations followed by the mixed plumage colors of brown and white (18.4%), brown with lack (16.3%) Many other variations of brown (10.2%), golden mix (8.2%), gray/Ash (6.1%), multi-colored (4.1%), and black with white (2.0%) were also observed. Silva et al. (2016) made a similar observation.

Gray/ash color plumage was mainly observed in the naked neck (20.5%) chicken type. The brown color plumage was present in 18.2%, and the black plumage was 15.9%. Black with white and brown with black was the same in 11.4%.

Silva et al. (2016) reported that mainly Black, Brown with Black, and multi-colored plumage were primarily present in Naked Neck, which agrees with the current finding. Multi-colored plumage is predominant (31.8%) in long-legged chicken, followed by brown color (22.7%), Brown with White (18.2%), and Gray/Ash (13.6%). The finding of Silva et al. (2016) indicated that the frequent plumage colors of Long-Legged chicken were multi-colored, Golden, and Brown with Black. Frizzle Feathered and Crested Chicken plumage color mainly were the same in all variations. White color was mainly in Booted Bantam Chicken (60.0%).

2) Plumage colour pattern of native chicken breeds: As stated in Table 1, around three feather colour patterns were observed among the local chicken population in the study area. Laced feather pattern was more frequent in common village chicken (44.9%) while the barred pattern was frequent in naked neck (45.5%). Laced and mottled feather patterns were equal in Booted Bantam Chicken (40.0%). The overall barred feather pattern was mostly observed in indigenous chicken.

3) Comb type and comb colour descriptions of indigenous chickens: Four types of comb types and five types of comb colors were observed in the chicken population (Table 1). Single is the typical comb-type across all the groups, which often carried rose and walnut comb types. Pea combs were absent in LLC, FFC, CRC, and BBC. The findings on single comb distribution patterns were very similar to the statements of Liyanage et al. (2015) in Sri Lanka and Egahi et al. (2010) of Nigerian Local Chicken. However, this current finding differed from Fathi et al. (2017), the V-shaped comb-type was found in the 8% of NNC, and 20% of FFC possesses V-shaped comb-type in Saudi local chicken.

Furthermore, the carnation comb style is more common in the FFC than in other breeds. Double comb-type was observed in nearly one-third of NNC bird populations. Red is the typical comb color across all the groups, which commonly carried pink and white with red comb colors. White with red was absent in BBC.

4) Ear lobe, shank and foot colour of local chicken breeds: As exhibited in Table 1, four types of ear lobe color and five types of shank and foot color were observed in the studied chicken population. The overall red color was the majority in all types of chicken population and mainly in NNC and CVC. White with red was also present in all types of chickens. Yellow with red was present only NNC, FFC, and CRC. The red color was the most frequently observed ear lobe color, which supports Assefa Melesse (2018) statements in South-Western Ethiopia and Egahi et al. (2010) in Nigerian Local Chicken.

The proportion of black shank and foot was dominant in all chicken populations. Chicken with Black shank and foot were highest in CVC (41.3%), followed by NNC (36.9%) and LLC and CRC (8.6%). White color shank and foot were present mainly in NNC (35.5%), followed by CVC (33.3%) and LLC (15.5%). Fathi et al. (2017) reported that Saudi local chickens had the highest in black and white shank colors, consistent with the current finding.

5) Eye colour and Skin colour descriptions of indigenous chickens: Of the sampled chicken population, 12.22%, 11.48%, 10.47%, and 10% respectively showed yellow with black, orange with black, black, and brown with black eye colour (Table 1). The percentage of Brown with Black is 29.5% in NNC. Yellow with Black, Orange with Black, and Black colours were also present in the chicken population. These findings support the observations of Silva *et al.*, (2017) who stated that Brown with Black is the most common eye colour in Sri Lankan indigenous chickens.

The color variation of the skin of Indigenous chicken is shown in Table 1. White and pink were the possible skin color of the chicken population. The predominant skin color was white (73.5%), followed by pink (14.3%) and then yellow (12.2%). The white, yellow, and pink colors were equally present in FFC. Similar findings from Silva *et al.*, (2016) reported that White skin color was predominant in Indigenous and Native Fowls of Sri Lanka.

Skin color is determined by either presence or absence of melanin pigments in the dermis and epidermis of the upper and lower layers of the skin. Recently consumers from developed countries mostly prefer yellow skin coloration, and carotenoid color pigments are associated with the epidermis, which is received through dietary sources (Duguma, 2006).

B. Quantitative traits of Indigenous Chicken

1) Morphometric measurement variations: The body weight was highly significant at $P<0.01$ for BC, BL, BW, KL, SL, and WL. The relation between body weight and BC, KL, and SL were good (BC-62.9%, KL-64.1%, SL- 62.5%). The relation of BL, BW, and WL with body weight was slight (BL-39.3%, BW-21.1%, WL-30.5%). There is no significant difference between body weight and PW($P>0.05$). There is a significant difference between BC and BL ($P<0.05$) and a highly significant difference between BW, KL, SL, and WL ($P<0.01$).

BC was non-significant with PW ($P>0.05$). There is a negative relation between BC and BL (13.9%). The relation of BC with BW and WL was good (BW-64%, WL-62.2%), and KL and SL were moderate (KL-55.7%, SL-47.5%). The BL was a highly significant difference ($P<0.01$) for BW, KL, SL, and WL. There is a negative relation of BL with BW, PW, and WL. BL was no significant with PW ($P>0.05$). The relation of BL with KL and SL was moderate (KL- 34.3%, SL- 33.3%). The BW was showed a significant difference at $P<0.05$ for KL, WL, and SL. BW was no significant with PW. There is a good relationship between BW and WL (64.7%) and moderate with KL and SL (KL- 32.3%, SL- 13.4%). KL was showed a highly significant difference at $P<0.01$ for PW, SL, and WL. KL with PW was a negative relationship, and SL and WL were moderate (SL-55.2%, WL- 34.7%). PW

Table I: Qualitative traits of village chicken types in the study area.

Qualitative Traits		Types					
		CVC % (N)	NNC % (N)	LLC % (N)	FFC % (N)	CRC % (N)	BBC % (N)
Plumage colour	Brown + Black	16.3 (8)	11.4 (5)	4.5 (1)	22.2 (2)	-	20.0 (1)
	Brown + White	18.4 (9)	2.3 (1)	18.2 (4)	11.1 (1)	11.1 (1)	-
	Black + White	2.0 (1)	11.4 (5)	4.5 (1)	22.2 (2)	22.2 (2)	20.0 (1)
	Black	22.4 (11)	15.9 (7)	-	11.1 (1)	22.2 (2)	-
	White	12.2 (6)	6.8 (3)	4.5 (1)	-	-	60.0 (3)
	Gray / Ash	6.1 (3)	20.5 (9)	13.6 (3)	11.1 (1)	11.1 (1)	-
	Brown	10.2 (5)	18.2 (8)	22.7 (5)	-	11.1 (1)	-
	Golden Mix	8.2 (4)	9.1 (4)	-	22.2 (2)	11.1 (1)	-
	Multi Colored	4.1 (2)	4.5 (2)	31.8 (7)	-	11.1 (1)	-
Feather Color Pattern	Barred	42.9 (21)	45.5 (20)	27.3 (6)	33.3 (3)	33.3 (3)	20.0 (1)
	Laced	44.9 (22)	31.8 (14)	50.0 (11)	11.1 (1)	22.2 (2)	40.0 (2)
	Mottled	12.2 (6)	22.7 (10)	22.7 (5)	55.6 (5)	44.4 (4)	40.0 (2)
Comb type	Strawberry	36.7 (18)	13.6 (6)	27.3 (6)	33.3 (3)	33.3 (3)	-
	Rose	34.7 (17)	9.1 (4)	22.7 (5)	22.2 (2)	33.3 (3)	20.0 (1)
	Single	18.4 (9)	56.8 (25)	31.8 (7)	33.3 (3)	22.2 (2)	60.0 (3)
	Pea	6.1 (3)	9.1 (4)	-	-	-	-
	Walnut	4.1 (2)	11.4 (5)	18.2 (4)	11.1 (1)	11.1 (1)	20.0 (1)
Comb Color	Red	77.6 (38)	54.5 (24)	50.0 (11)	44.4 (4)	33.3 (3)	60.0 (3)
	White + Red	2.0 (1)	2.3 (1)	22.7 (5)	33.3 (3)	44.4 (4)	-
	Pink	20.4 (10)	43.2 (19)	27.3 (6)	22.2 (2)	22.2 (2)	40.0 (2)
Ear Lobe Color	Red	65.3 (32)	54.5 (24)	36.4 (8)	44.4 (4)	33.3 (3)	60.0 (3)
	White	14.3 (7)	11.4 (5)	54.5 (12)	22.2 (2)	11.1 (1)	-
	White + Red	20.4 (10)	25.0 (11)	9.1 (2)	22.2 (2)	33.3 (3)	40.0 (2)
	Yellow + Red	-	9.1 (4)	-	11.1 (1)	22.2 (2)	-
Shank and Foot Color	Yellow	16.3 (8)	13.6 (6)	13.6 (3)	44.4 (4)	22.2 (2)	-
	Greenish	4.1 (2)	-	18.2 (4)	22.2 (2)	11.1 (1)	-
	Black	38.8 (19)	38.6 (17)	18.2 (4)	11.1 (1)	44.4 (4)	20.0 (1)
	White	30.6 (15)	36.4 (16)	31.8 (7)	11.1 (1)	11.1 (2)	80.0 (4)
	Pink	**10.2 (5)**	**11.4 (5)**	**18.2 (4)**	**11.1 (1)**		-
Eye Color	**Yellow + Black**	**18.4 (9)**	**25.0 (11)**	**13.6 (3)**	**55.6 (5)**	**33.3 (3)**	**40.0 (2)**
	Orange + Black	24.5 (12)	22.7 (10)	27.3 (6)	11.1 (1)	11.1 (1)	20.0 (1)
	Black	22.4 (11)	22.7 (10)	18.2 (4)	22.2 (2)	22.2 (2)	-
	Brown + Black	34.7 (17)	29.5 (13)	40.9 (9)	11.1 (1)	11.1 (1)	40.0 (2)
Skin Color	White	73.5 (36)	52.3 (23)	59.1 (13)	33.3 (3)	44.4 (4)	100.0 (5)
	Yellow	12.2 (6)	15.9 (7)	9.1 (2)	33.3 (3)	33.3 (3)	-
	Pink	14.3 (7)	31.8 (14)	31.8 (7)	33.3 (3)	22.2 (2)	-

CVC=Common Village Chicken, NNC=Naked Neck Chicken, LLC=Long Legged Chicken, FFC=Frizzle Feathered Chicken, CRC=Crested Chicken, BBC=Booted Bantam Chicken

Table II: Correlations between body weight and linear body measurements.

	Body Weight	BC	BL	BW	KL	PW	SL	WL
Body Weight	1							
BC	.629**	1						
BL	.393**	-.139*	1					
BW	.211**	.640**	-.442**	1				
KL	.641**	.557**	.343**	.323**	1			
PW	-.102^{NS}	-.019^{NS}	-.044^{NS}	.088^{NS}	-.432**	1		
SL	.625**	.475**	.333**	.134*	.552**	-.067^{NS}	1	
WL	.305**	.622**	-.317**	.647**	.347**	.004^{NS}	.213**	1

Ns = Non-significant (P>0.05); * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed); BC=Body Circumference; BL= Back Length; BW = Breast Width; KL= Keel Length; PW = Pelvis Width; SL= Shank Length.

Table III: Mean values (standard error in parentheses) of morphological characters of the chicken types.

	Common Village (n=98)	Naked Neck (n=87)	Long Legged (n=42)	Frizzle Feather (n=20)	Crested Chicken (n=18)	Booted Bantam (n=5)	F-ratio	sig
BDW	1478.57 ±48.58	1509.48 ±53.19	1592.74 ±64.98	1484.50 ±123.44	1381.39 ±75.49	1347 ±195.75	.782	.563
BC	35.126 ±0.51	35.621 ±0.58	34.531 ±0.68	31.216 ±0.80	36.033 ±1.16	33.58 ±1.18	2.788	018
BL	19.635 ±0.83	19.071 ±0.84	24.007 ±1.36	22.944 ±1.69	15.833 ±1.66	22.43 ±3.54	3.756	.003
BW	12.341 ±0.52	12.763 ±0.52	11.883 ±0.90	9.188 ±0.68	18.905 ±3.25	9.92 ±0.79	5.919	000
KL	10.546 ±0.25	10.68 ±0.29	11.116 ±0.42	8.222 ±0.59	9.383 ±0.90	9.7 ±0.91	3.757	.003
PW	2.133 ±0.16	2.467 ±0.24	2.321 ±0.10	3.005 ±0.71	3.266 ±0.88	1.81 ±0.21	1.483	.196
SL	13.92 +0.29	14.519 +0.29	15.376 +0.51	11.822 +0.52	12.355 +0.40	12.94 +0.86	5.319	.000
WL	19.467 ±0.51	22.475 ±0.48	18.926 ±0.80	17.833 ±0.61	22.266 ±1.56	17.7 ±0.67	6.962	000

n, number of animals analysed. BDW = body weight BC= body circumference; BL= back length; BW = breast width; KL= keel length; PW = pelvis width; SL= shank length.

was no significant difference with other linear measurements (P>0.05). The SL was highly significant with WL (P<0.01) and moderate relation (21.3%).

The high degree of correlation between body weight and body measurements was supported by Assefa Melesse (2018) where they stated a higher level of correlation between body weight and other linear body measurements. They observed a perfect correlation with chest circumference and wingspan, while Ige *et al.*, (2012) found bodyweight of chicken in Nigeria highly correlated with shank length and shank width. Table 3 shows the results of the morphological measurements for all sampled birds. The F-ratio and their significance revealed, a statistically significant difference between means of the six types except BDW and PW for eight morphometric measurements (p<0.05). The variable that presents the highest variable is wing length (F=6.962). The lower variable is body wight (F=0.782). According to the Table 4, the MBW significantly effected by BC, BL, SL

Table IV: Regression Coefficient of quantitative parameters.

Model (cm)	Coefficient	SE	t-value	Sig.
BC	51.555	5.710	9.029	.000
BL	19.382	3.111	6.231	.000
BW	-6.099	4.586	-1.330	.185
KL	22.827	11.529	1.980	.049
PW	.016	10.567	.002	.999
SL	30.857	7.817	3.947	.000
WL	4.058	4.782	.848	.397

BC: body circumference, BL: back length, BW: breast width, KL: keel length, PW: pelvis width, SL: shank length.

and KL. Except BW, other parameters positively influenced on MBW.

IV. CONCLUSION

This analysis reveals a wide range of morphological characters between the rural chicken phenotypes. The finding of this present study shows that laced, barred, and mottled plumage patterns, black shank, and shank colors, red comb, red ear lobes were the phenotypic characteristics that are most prevalent in Ampara, Sri Lanka. The most prevalent plumage color in all types of chickens was black. The red color comb was predominant and followed by white with red and pink. White skin color was most frequent in Ampara District village chicken. Poultry breeders, researchers, and poultry farmers can use the knowledge about phenotypic variables as selection criteria. Therefore this study provides a basis for genetic improvements of the genetic resources of indigenous chicken types in Ampara.

REFERENCES

Ajayi, O.O., Adeleke, M.A., Sanni, M.T., Yakubu, A., Peters, S.O., Imumorin, I.G., Ozoje, M.O., Ikeobi, C.O.N. & Adebambo, O.A. (2012). Application of principal component and discriminant analyses to morpho-structural indices of indigenous and exotic chickens raised under intensive management system. *Tropical Animal Health and Production, 44*(6), 1247-1254.

Ajayi, F. O. (2010). Nigerian indigenous chicken: A valuable genetic resource for meat and egg production. *Asian journal of poultry science, 4*(4), 164-172.

Assefa, H., & Melesse, A. (2018). Morphological and morphometric characterization of indigenous chicken populations in Sheka Zone, South Western Ethiopia. *Poult Fish Wildl Sci, 6*(200), 2.

Apuno, A. A., Mbap, S. T., & Ibrahim, T. (2011). Characterization of local chickens (Gallus gallus domesticus) in shelleng and song local government areas of Adamawa State, Nigeria. *Agriculture and Biology Journal of North America, 2*(1), 6-14.

Cabarles, J. C., Lambio, A. L., Vega, S. A., Capitan, S. S., & Mendioro, M. S. (2012). Distinct morphological features of traditional chickens (Gallus gallus domesticus L.) in Western Visayas, Philippines. *Animal Genetic Resources/Resources génétiques animales/Recursos genéticos animales, 51,* 73-87.

Duguma, R. (2006). Phenotypic characterization of some indigenous chicken ecotypes of Ethiopia. *Development, 18*(9).

Egahi, J. O., Dim, N. I., Momoh, O. M., & Gwaza, D. S. (2010). Variations in qualitative traits in the Nigerian local chicken. *International Journal of Poultry Science, 9*(10), 978-979.

FAO (Food and Agricultural Organization). (2012). Phenotypic characterization of animal genetic resources. FAO Animal Production and Health Guidelines No.11. Rome.

Fathi, M. M., Al-Homidan, I., Motawei, M. I., Abou-Emera, O. K., & El-Zarei, M. F. (2017). Evaluation of genetic diversity of Saudi native chicken populations using microsatellite markers. *Poultry science, 96*(3), 530-536.

Ige, O. O., Umoru, L. E., & Aribo, S. (2012). Natural products: a minefield of biomaterials. International Scholarly Research Notices, 2012. Liyanage, R. P., Dematawewa, C. M. B., & Silva, G. L. L. P. (2015). Comparative study on morphological and morphometric features of village chicken in Sri Lanka. *Tropical Agricultural Research, 26*(2).

Lawal, R. A., Martin, S. H., Vanmechelen, K., Vereijken, A., Silva, P., Al-Atiyat, R. M., Aljumaah, R.S., Mwacharo, J.M., Wu, D.D., Zhang, Y.P. & Hanotte, O. (2020). The wild species genome ancestry of domestic chickens. *BMC biology, 18*(1), 1-18.

Mengesha, M., & Tsega, W. (2011). Phenotypic and genotypic characteristics of indigenous chickens in Ethiopia: A review. *African Journal of Agricultural Research, 6*(24), 5398-5404.

Pampori, Z. A., & Iqbal, S. (2007). Haematology, serum chemistry and electrocardiographic evaluation in native chicken of Kashmir. *International Journal of Poultry Science.*

Silva, G.L.L.P., Rajapaksha, R.R.B., Madushani, L.C., & Himali, S.M.C. (2017). Effect of different feeding systems on the quality and functional properties of backyard chicken eggs. *Sri Lanka Journal of Animal Production, 9,* pp. 30-46.

Silva, P., Liyanage, R. P., Senadheera, S. & Dematawewa, C. M. B. (2016). Monograph on indigenous chicken in Sri Lanka. *UNEP-GEF-ILRIFAnGR Asia Project, University of Peradeniya, Sri Lanka.*

Silva, P.,Guan, X., Ho-shing, O., Jones, J., Xu, J., Hui, D., Notter, D. & Smith, E. (2008). Mitochondrial DNA-based analysis of genetic variation and relatedness among Sri Lankan indigenous chickens and the Ceylon Jungle Fowl *(Gallus lafayetti). Animal Genetics,* 40(1), 1 - 9.

Wijayasena, A. M. P. S. S., De Alwis, D. J., Silva, G. L. L. P., & Abeykoon, M. N. D. F. (2014). Cost benefit Analysis of village chicken production in Puttlam district of Sri Lanka: a case study. *Proceedings of the Peradeniya University International Research Sessions, Peradeniya, Sri Lanka on July,* 4-5.