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Phenotypic Characterization of Indigenous Chicken Ecotypes in Bahi and Songea Districts Population, Tanzania

Rhoda Lucas[1*], Christopher J. Kasanga[1], Elisa D. Mwega[1], Sissa Gotifred Ackrey[2]

[1]Department of Veterinary Microbiology, Parasitology and Biotechnology, Sokoine University of Agriculture, Morogoro, Tanzania
[2]Department of Zoology and Wildlife Conservation, University of Dar es Salaam, Dar es Salaam, Tanzania
Email: *lucasrhoda7@gmail.com

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Abstract

Indigenous chickens (ICs) are common and significant species of fowl raised by many people worldwide. Most of them are adapted to stressful and harsh environmental conditions. In Tanzania, ICs are estimated to be above 37 million with most of them being kept at the central corridor of the country. They provide a higher proportion of animal nutrients in the human diet and act as a source of income and poverty alleviation at the family level. The indigenous chicken (IC) ecotypes are losing their innate genetic variety due to the increased use of prevalent breeds worldwide. The purpose of this study was to assess the sustainability of the ICs ecotypes phenotypically based on qualitative and quantitative characteristics by employing a descriptive study. A diversity study was conducted in two districts of Tanzania, Bahi-Dodoma and Songea-Ruvuma. A random sampling method of one hundred (100) sample size was involved. Each district employed 50 ICs and the univariate analysis was used to examine both qualitative and quantitative traits. Data from the qualitative and quantitative analysis were analyzed by using a statistical package for social sciences (SPSS) version 16.0 and Origin Pro. Version 2019. *P*-value < 0.05 was used as a cut-off point for statistical significance. Phenotypic variations were observed between the two study areas. There is a statistically significant difference in body length, wingspan and shank length between Bahi and Songea chickens at $p < 0.05$, for the case of body weight and chest circumference there is no statistically significant difference between chickens from Bahi and Songea at $p < 0.05$. The shank length between females and males had a significant difference. There also existed an association between shank colours and plumage colour. The predomination of the single comb type was also identified. This study revealed a significant phenotypic variation between the chicken ecotypes. This variation serves as an important

tool for ICs conservation purposes.

Subject Areas

Animal Behavior, Biodiversity

Keywords

Indigenous Chicken, Bahi District, Songea District

1. Introduction

The majority of rural Tanzanian households raise indigenous chickens (ICs), a widespread and important type of poultry [1]. They are approximated to number more than 37 million, according to [2]. Most of the indigenous chickens are adapted to difficult and demanding environmental conditions, claim [3]. Their flesh is typically preferred over that of foreign species because of their lower fat contents, flavour, and pigment contributing to a larger percentage of animal protein in the human diet [4]. Moreover, [5] pointed out that indigenous chickens help families by providing a source of income and reducing poverty.

Given that indigenous chickens are found in every place with human settlements, most of them are reported to be kept in the central corridor region of Tanzania, as noted by [6]. They differ morphologically from one location to another due to variations in terms of climatic conditions [7].

Understanding different morphological features between and among the populations is a prerequisite for characterizing local genetic resources [8]. This classification includes body weight, body length, chest circumference, shank length, wingspan, plumage colours, feather morphology and distribution, comb type, eye colour and earlobe colour, as reported by [9] [10] [11] and [12].

Few studies including one by [6] have been carried out in Tanzania Therefore, taking into these considerations, this study aimed to characterize the indigenous chickens of Bahi and Songea districts, Tanzania based on their phenotypic traits by focusing on the qualitative and quantitative characteristics.

2. Materials and Methods

2.1. Study Area

This study was carried out in two different districts: Bahi in the Dodoma region, and Songea in the Ruvuma region, both of them are located in Tanzania, specifically, Bahi is situated in the central part of Tanzania, with coordinates of 05˚57'10"S35˚18'43"E. On the other hand, Songea is located in the southern highlands of Tanzania, with coordinates of 10˚41'S35˚39'E. The detailed map shown in **Figure 1** below indicates the proper illustrations of the mentioned districts covering specific wards from which sampling was conducted.

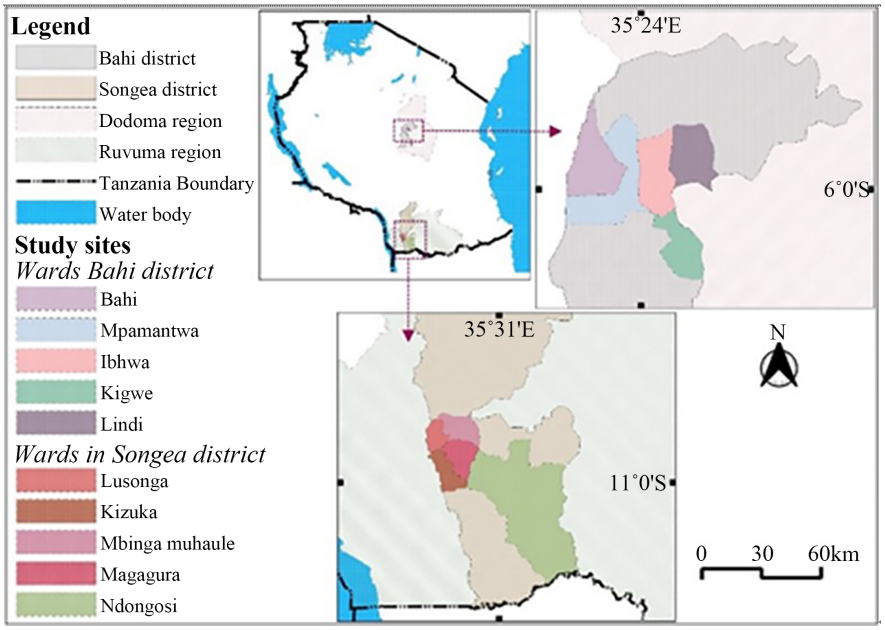

Figure 1. Tanzania sketch map showing Dodoma and Ruvuma regions portraying two study sites: Bahi and Songea districts with their respective Wards from which, sampling of indigenous chicken was conducted from December 2022 and July 2023.

2.2. Sample Collection

A total of one hundred (100) free-range indigenous chickens were collected randomly from both of the districts, accounting for 50 chickens from each District. These chickens were approximately 6 to 18 months old and included both males and females. Out of their total district-wise, 30 females and 20 males were from the Bahi, while 29 females and 21 males were from Songea. The chickens were kept at a station and provided with water and food ad libitum.

2.3. Data Collection

Measurements were conducted based on the guidelines and illustrations provided by FAO (2012). To do so, a measuring tape and a portable digital scale were used to measure five quantitative measurements, which included body weight, body length, chest circumference, wingspan, and shank length. The measuring tape allowed measuring the length and circumference of the subject in centimeters (cm), while the portable digital scale measured the body weight in kilograms (kg). In addition to these quantitative measurements, several qualitative measurements, such as shank colour, eye colour, plumage colour, comb type, and ear lobe colour were recorded. This activity relied on the observation method to ensure accuracy when recording these details. Measurements taken in this case, were useful for the purposes for which they are intended.

2.4. Data Analysis

The collected data for quantitative measurements were analyzed using Origin Pro version 2019, where the means and standard error of the means were compared.

One-way analysis of Variance (One-way ANOVA) was used for comparisons within and between groups, and a special t-test was used for other comparisons on significant differences. Furthermore, data for the qualitative analysis were analyzed using a statistical package for social science (SPSS) version 16. This analysis included sex, earlobe colour, comb type, head type, eye colour, shank colour, plumage colour, and feather morphology and distribution for a particular chicken. Finally, the data were compared at a significance level of $p < 0.05$.

2.5. Ethical Clearance

The study received ethical clearance from the Sokoine University of Agriculture with Reference number SUA/DPRTC/R/186 VOL IV 65, and permission to conduct the research in Bahi-Dodoma and Songea-Ruvuma was granted by the President's Office regional administration and local authority Reference number AB.307/323/01/187.

3. Results

3.1. Qualitative Measurements

Based on the proportional analysis, it was found that the study population had a higher percentage of normal feather morphology. The results further revealed that neither, Songea nor Bahi had frizzle feathers morphology. Interestingly, Songea registered a relatively higher normal feathered chickens (94%) compared to Bahi (84%). The crested head was observed in Bahi (6%) and Songea (4%), which made up a total of (5%) of the population as shown in Figure 2 and Table 1. In terms of feathered shank, there was none observed in Songea, while in Bahi, it was observed at (6%). The frequency of the necked neck was (4%) in Bahi and (2%) in Songea as shown in Figure 2 and Table 1.

Furthermore, the study identified a total of eight plumage colours namely; Black, Black and white, Black mottled, Brown mottled, Brown and white, Brown, White, and White mottled. Among them, brown mottled was found to be the predominant plumage colour, accounting for (27%) of the entire study population, followed by black and white (18%), and brown (14%), and black (14%). Other plumage colours identified were white mottled (9%), white (7%), brown and white (7%), and black mottled (4%). These findings are summarized in Table 1.

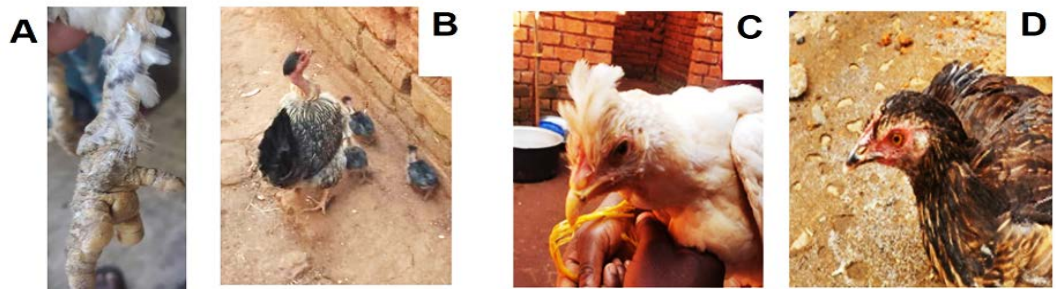

Figure 2. Representing feather distribution of the indigenous chickens (Feathered shanks "A", Necked neck "B", Crested head "C" and normal feather distribution "D") from Bahi and Songea districts, Tanzania.

Table 1. Proportional occurrence (%) of various characteristics (including colour and feathers distribution, comb and head type) in indigenous chickens collected from Bahi district Dodoma.

Character	Expression	Districts		
		Bahi (%)	Songea (%)	Total %
Comb type	Cushion	6	6	6
	Pea	30	6	18
	Rose	2	0	1
	Single	62	88	75
	Total	**100**	**100**	**100**
Head type	Crest	6	4	5
	Plain	94	96	95
	Total	**100**	**100**	**100**
Earlobe colour	Red	38	46	42
	Red and White	30	40	35
	Black	4	0	2
	White	32	10	21
	Total	**100**	**100**	**100**
Eye colour	Brown	42	62	52
	Orange	58	28	42
	Yellow	6	4	5
	Total	**100**	**100**	**100**
Shank colour	Black	36	34	35
	Grey	0	4	2
	White	22	18	20
	Yellow	42	44	43
	Total	**100**	**100**	**100**
Plumage colour	Black	16	12	14
	Black and white	20	16	18
	Black mottled	4	4	4
	Brown mottled	20	34	27
	Brown and white	6	8	7
	Brown	12	16	14
	White	12	2	7
	White mottled	10	8	9
	Total	**100**	**100**	**100**
Feather distribution	Crested head	6	4	5
	Feathered shank	6	0	3
	Necked neck	4	2	3
	Normal feather	84	94	89
	Total	**100**	**100**	**100**

A total of four comb types namely; Cushion, Pea, Rose and Single comb were identified in this study, it was observed that among the studied population, the single comb type was observed in higher frequency, accounting for 75% of the observations. This was followed by the pea comb type (18%), cushion comb type (6%), and Rose comb type (1%). Notably, there were no observations of the Rose comb type in Songea chickens. For the case of head type, it was observed that there were two types of head types observed plain and crested head type. However, the plain head type was found to be more predominant, accounting for 95% of the observations, and only 5% accounted for the crested head type. Among the studied locations, Songea had a higher percentage (96%) of the plain head type, whereas Bahi had a slightly higher percentage (94%) presented in Figure 2 and Table 1.

Based on the data presented in Table 1, it seems that the red earlobe out of four earlobe types observed (Red, Red and White, Black and White) was the most common type, accounting for 42% of the total sample. Followed closely by the red and white earlobes, which made up 35% of the sample, meanwhile, white earlobes accounted for 21%. Something strange is that black earlobes were only found in Bahi. Dragging on to eye colour, it appears that brown eyes were the most frequent in this study, making up 52% of the total sample. In the case of Songea, brown-eyed individuals were the most abundant, accounting for 62% of the sample, while in Bahi, orange-eyed individuals were much more common, comprising 58% of the sample. However, yellow-eyed individuals were the least frequent, with only 6% and 4% of the sample in Bahi and Songea, respectively.

Findings presented in Table 1 show the observed various shank colours including black, grey, white and yellow in which, yellow was found to be the most prominent at 43%, followed by black at 35%, white at 20%, and grey at only 2%. Interestingly, the Bahi district did not express any grey shank colour. When it comes to plumage colour, brown mottled colour was found to be the predominant one in both Songea and Bahi districts, with a higher frequency in Songea at 34% compared to Bahi at 20%. In general, the brown mottled colour accounted for 27% of the population, followed by 18% for black and white, and 14% for black and brown colour.

3.2. Quantitative Characteristics

Based on data presented in Figure 3 chickens from the Bahi district had an average body weight of 1.037 Kg, while Songea chickens had an average body weight of 1.139 Kg, hence there was no statistical significant difference in body weight between the chicken from Bahi and Songea at $p < 0.05$. Interestingly, male chickens seemed to be heavier than females. Additionally, at $p < 0.05$ body length between chicken from Bahi and Songea was significant. Chickens from Bahi had a higher body length of 41.58 cm compared to those from Songea District, which was 38.2 cm. When we look at chest circumferences, it appears that both Bahi and Songea district chickens had similar chest circumferences of 29.46 cm and 29.3 cm, respectively.

Further examination revealed that the wingspan of chickens from the Bahi district was higher compared to chickens from the Songea district, with the former measuring 39.82 cm and the latter measuring 37.35 cm. Additionally, the shank length of chickens from the Bahi district was also higher, with a measurement of 8.41 cm compared to the 7.55 cm length of shanks from chickens in the Songea district. Male and Female shanks varied, with chickens from the Bahi district exhibiting higher shank lengths compared to chickens from the Songea district, as shown in Figure 4.

It was noted that male chickens had a higher mean body weight of 1.25 kg compared to females with 0.96 kg in both districts examined. Male chicken's body lengths of 42.0 cm were superior over females amounting to 38.37 cm. Following further examination, it was revealed that the chest circumference, shank length, and wing spans of male chickens from the Bahi and Songea districts were higher than those observed in female chickens. These findings are shown in Table 2.

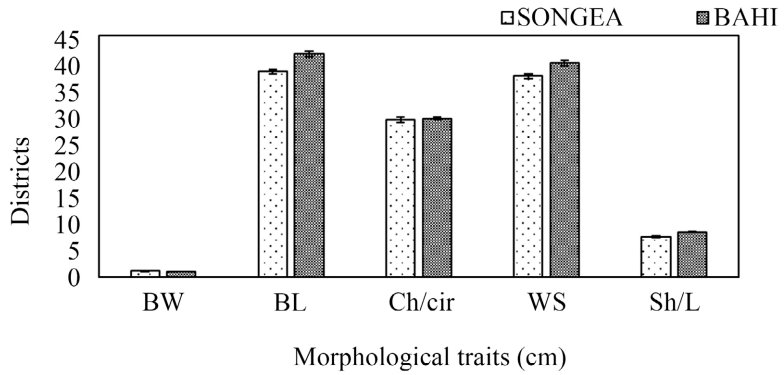

Figure 3. Morphological characteristics of the indigenous chickens from Bahi and Songea districts. There is no significant difference in body weight, Chest circumference and Shank length between Bahi and Songea chickens at $p < 0.05$. One way ANOVA, n = 100, p-value = 0.06152.

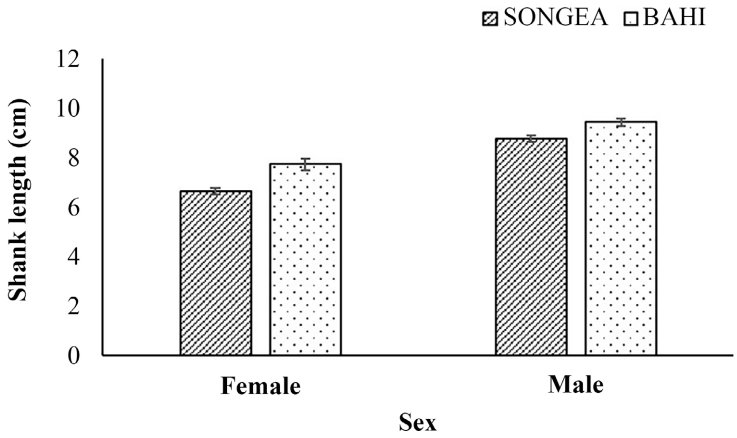

Figure 4. Comparison of chickens Shank length (Male and Female) between Bahi district and Songea districts, Tanzania. Scale bars = standard error of the mean, $p < 0.05$, n = 100. There was a significant difference in shank length between Bahi and Songea districts chickens for both males and females. One Way ANOVA, n = 100, p value = 6.50799E − 22.

Table 2. The influence of sex on the distribution of the morphological characteristics of the indigenous chickens collected from Songea and Bahi districts, Tanzania, shown as mean and Standard error of the mean (SEM), n = 100.

Quantitative traits	Sex	Bahi	Songea	Mean	SEM
Body weight (kg)	Male	1.19 ± 0.03	1.31 ± 0.06	1.25	0.04
	Female	0.93 ± 0.04	1.00 ± 0.05	0.96	0.04
Body length (cm)	Male	43.85 ± 0.03	40.16 ± 0.46	42.0	0.24
	Female	40.06 ± 0.03	36.69 ± 0.40	38.37	0.39
Chest circumference (cm)	Male	30.6 ± 0.33	30.04 ± 0.75	30.32	0.54
	Female	28.7 ± 0.26	28.81 ± 0.63	28.75	0.44
Shank length (cm)	Male	9.42 ± 0.16	8.77 ± 0.21	9.09	0.18
	Female	7.72 ± 0.12	6.62 ± 0.13	7.17	0.12
Wings pan (cm)	Male	42.6 ± 0.49	39.71 ± 0.67	41.15	0.58
	Female	37.96 ± 0.64	35.55 ± 0.49	36.75	0.56

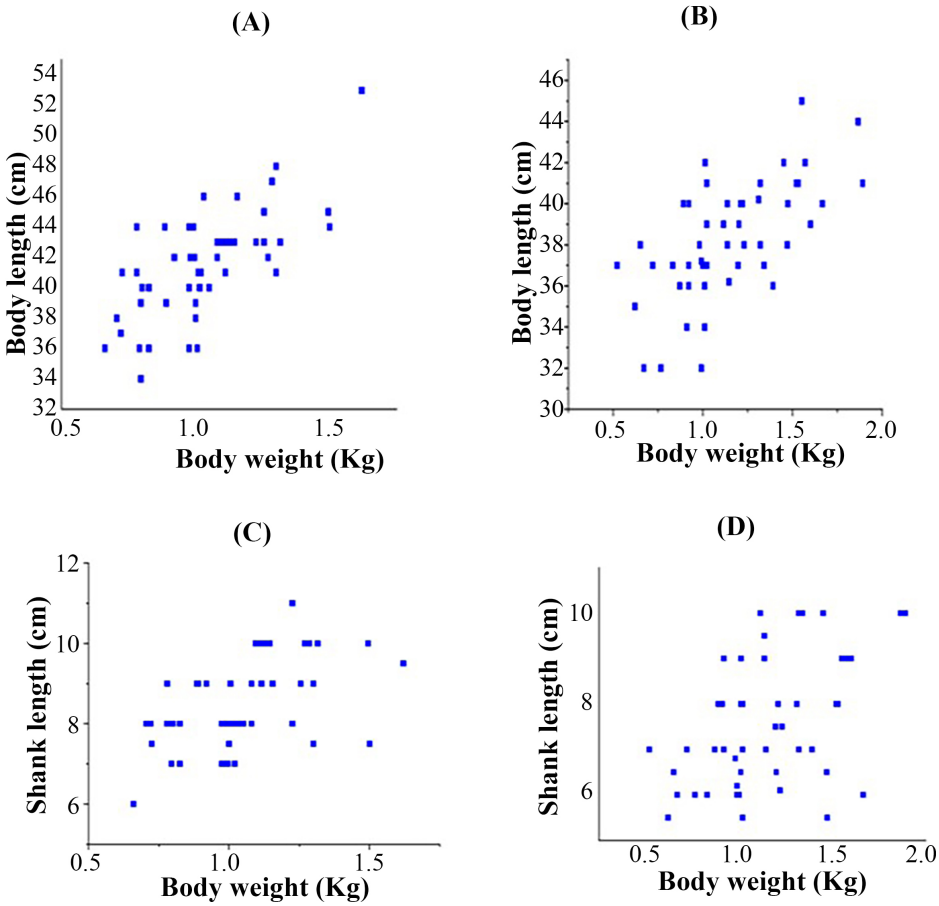

Figure 5. Correlation between body weight and body length (A and B), and Body weight and shank length (C and D) of the indigenous chickens collected from two districts (Bahi and Songea), Tanzania. There was a moderate correlation at $p < 0.05$, $n = 100$.

The correlation analysis between body lengths and body weight revealed that the Bahi chickens correlated 0.60, while Songea district chickens correlated 0.63.

This correlation was a bit moderate when compared meaning that, the relationship between body weights to body length was likely moderate. Additionally, the correlation between body weight and shank length noted that chickens from the Bahi district correlated at 0.53, whereas chickens from the Songea district correlated at 0.47. Therefore, it relieved a moderate correlation between the two localities. These findings were visually presented as shown in **Figure 5**.

4. Discussion

Phenotypic characterization of indigenous chickens (ICs) is a very important tool in poultry production for conservation purposes. The predomination of normal feather morphology and distribution in this study indicates the absence of heat stress and other harsh environmental conditions, as previously described [13]. These findings are consistence with the findings of the study reported by [14] and [15]. The observation of the necked neck from Bahi district suggests the predomination of this ecotype in the identified region, Bahi being a semi-arid area favours the performance and reproduction of the necked neck due to its ability to adapt under hot climatic conditions such that, it contributes to heat dissipation and adverse heat effects reduction, as early noted by [16]. Ornamental chickens as observed in females from both regions are represented by crested head chickens suggesting that, apart from food, these ICs can serve as attractants and decorative of oneself home. A small percentage of crested head chickens agreed with the findings from Tolon Ghana which reported that most of the chickens had plain heads and few of them had crested heads [17]. In addition, the occurrence of the crested head in only females was in agreement with that reported by [18].

Despite the shortcomings associated with the feathered shanks in ICs, the situation was not problematic in the studied regions since its predomination was not significant. This indicates that egg lying ability and quality (egg weight) influenced by sexual attractions, as early noted by [13] and [19] is successful in these regions, and, the burden of ecto-parasitism is low. On the other hand, feathering shank in indigenous chickens is a genetic trait and not a health problem, in a cold climate it provides additional insulation however, the situation is not successful in the regions under study due to their low existence. The presence of fewer feathered shanks in a population is in agreement with the study conducted in Karnataka state in India [20], in addition, Sekela Woreda in Northern Ethiopia observed no feathered shank in the population [21].

Self-defence is very important in fowl being practised either through escape or camouflage. In this study, chickens are successful in terms of escape from predation signified by the predomination of brown-mottled plumages. Furthermore, the predominant of this colour is consistent with findings reported in Ethiopia by [22]. On the other hand, a study conducted by [23] in Southern highland Tanzania, reported the black plumage colour to be the dominant one. Additionally, the existence of a variety of plumage colours of ICs from both Bahi and

Songea districts indicates a non-mating restriction hence many genes governing the traits, early described by [24]. Moreover, the diversity of plumage colour in indigenous chickens might be due to the adaptation to the living environmental conditions, as noted in Pakistan [25].

The existence of various combs identified in this study was evidence that the interaction of different genes responsible for comb expression could be the cause of the occurrences of varieties of the comb type [13]. Chickens from the studied regions seem to be more fertile and capable of losing under prevailing environmental conditions as far as single comb domination is concerned hence successive reproduction due to a satisfactory cooling mechanism. Furthermore, the identified single comb type in this study is in agreement with the previous study conducted in Kenya by [26]. Chicken sexual maturity hormones are closely related to the white earlobe [27]. Variation in earlobes might be influenced by ancestral lineages and the adaptation of the indigenous chicken to their local environment [28] and Nutritional status [29]. The observation of various earlobe types in this study is consistent with the results reported by [13] in Rwanda and reported by [30] in Indonesia, although India one study by [20] reported a high percentage of red earlobes. On top of this, a study conducted by [31] and [17] noted white earlobes to be predominant, But the predomination of brown-eyed colour in this study was significant. However, contrasting results have been reported from Nigeria where yellow eye colour was the most prevalent and it was found more in birds from Yelwata and Lafia [32]. The findings in the present study are in agreement with the findings by [33]. Ly, the variation in eye colour depends on the pigmentation and blood supply to several structures within the eye as noted by [34] that eye colour depends on the carotenoid pigments and blood supply.

Shank colours are so important in identifying dietary nutrients in ICs. The predomination of yellow shank is an indication of the dietary carotenoids which result from high free scavenging in a variety of natural vegetation. This can also suggest that chickens raised in these studied regions are rich in vitamins and hence better for human consumption. The findings from this study is similar to the reported study from Ethiopia [35] and India [36]. In contrast to the findings, [37] reported a high frequency of white shanks in their studies which is the absence of pigmentation in the epidermis.

The morphological features based on the measurement of chickens were then described after the qualitative characteristics. The average body weight of indigenous adult chickens reported in this study seems to be lower than the value reported in Ng'ong'ona Dodoma [6]. The variation in body weight in the present results and that from the literature could be attributed to the harvesting season because dietary protein availability influences chicken growth and body weight gain [38]. On the other hand ecotype differences among various indigenous chickens might cause the difference in body weight [38]. The findings observed in this study are consistent with the report from Nigeria [39]. In addition, variation in body weight between male and female chickens is due to sexual dimor-

phic characteristics, as noted by [40].

The variation of linear measurement in this study is evidence of the diversity of these ICs from the two studied regions. Although the variation in chest circumferences of Bahi and Songea was not significant, the findings of this study were contrary to values reported by [8] in Central Southern Ethiopia and lower than the value noted by [41].

The findings on wingspan and shank lengths in this study might be caused by the heat dissipation in the semi arid region [42]. Previous studies by [11] reported a strong central zone correlation of the linear measurement. However, this study shows a moderate correlation between shank length and body weight for the Bahi and Songea indigenous chicken. The existence of a moderate correlation between the two parameters indicates that the increase in body weight in this case could not have any influence on the increase of the shank length and body length. In other words, as the body length of a chicken increases, its body weight is also likely to increase but this was not effective in this study. A moderate correlation can be caused by several factors, including shared genes, if two chickens are closely related, they are likely to have similar body lengths and body weights. Similar environment, if two chickens are raised in the same environment, they are likely to have similar body lengths and body weights because they receive the same environmental pressures and diet [43]. Other factors, such as age and health, can also affect the body length and body weight of a chicken because healthy birds have high feed intake hence weight gain [44]. It is important to note that since the correlation between shank length and body weight is only moderate it means that other factors also influence body weight, such as genetics, diet, and environment. However, the correlation does suggest that shank length could be used as a predictor of body weight especially in rural areas where standard weighing scales availability is not effective.

5. Conclusion

There is a notable diversity in phenotype among both chicken ecotypes. Normal feather distribution and morphology are prevalent within and across the populations. Conversely, the availability of scavenging food causes Songea chickens to weigh superior to Bahi chickens. There is no influence of shank length and body length on body weight in the study population hence cannot predict economic values.

6. Recommendations

These varying traits could then be integrated into breeding programs to enhance and select specific chicken characteristics for conservation and sustainable use. This study recommends further morphological analysis with a large sample size from different regions to identify valuable traits that can be preserved and utilized sustainably. For further investigation, a large sample size should be employed.

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Conflict of Interest

No conflict of interest exists according to the authors.

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