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Phenotypes, production systems and reproductive performance of indigenous chickens in contemporary Rwanda

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This study aimed at characterizing phenotypes, production systems and the reproductive performance of indigenous chickens in Rwanda. Indigenous chickens (n=529) from 265 chicken rearing households drawn from all the five provinces of Rwanda were used in this study and analysis was performed using Statistical Analysis Systems (SAS, version 9.2) software. Four comb types were observed, with strawberry (51%) being most dominant, as was whiteness of ear lobes (57%). Rounded ear lobe shape (92%) and curved beaks (99.6%) were both almost universal. Beak colour varied between green, black, yellow and brown with the latter most prevalent (51%). Evenly distributed feathers were most common (99.8%) whereas naked-neck phenotype was rare (0.2%). Almost all chickens had brown eyes, and thick skins (88.4%) that were yellow-coloured (69%). Most chickens (39%) had yellow coloured shanks. Significant variations were observed in age at sexual maturity for both male and female chickens across provinces (p>0.05). The biggest egg clutches were from the western province (14.7 eggs) while the smallest was 6.6 eggs in the southern. Egg hatchability was highest (85%) in the western province and lowest (52%) in the eastern province.We conclude that the Rwanda indigenous chickens might have useful genetic potential, and planning for proper and sustainable utilization of this indigenous chicken genetic resource is the best way forward.

Key words: Indigenous chickens, phenotypes, production, reproduction, population structure.

INTRODUCTION

In many African countries indigenous chickens kept under village systems are the major suppliers of poultry products (Gueye, 1998; Faruque et al., 2010; Okeno et al., 2012). The poultry industry is growing seven times faster than typical smallholder livestock system and in villages, chickens still make substantial contributions to

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household food security. Throughout the developing world in emerging economies like Brazil, China, and Africa, livestock are still largely in the hand of smallholders (Muchadeyi et al., 2007; Kingori et al., 2010). Native chickens possess several valuable characters that are not found in exotic/commercial chickens and are also appropriate for traditional low input-low output farming systems. However, they are slow growers and lay very few eggs that are also small-sized, and their management is predominantly free range, a typical feature of poultry rearing in sub-Sahara Africa and much of the developing world (Mebratu, 1995). Rwanda is characterized by the coexistence of two production systems: rudimentary village poultry and industrial poultry at its infancy, the two systems face scarcity of inputs to fully exploit the potential of the poultry sector (Guèye, 2003; FAO, 2016).

In 2009, the poultry flock size in Rwanda was estimated at 2.9 million, which predominantly was made up of indigenous birds with a broad range of phenotypes, and adapted to an equally wide range of environmental conditions (MINAGRI, 2012) (Figure 1). Compared to the human population of 11 million then (NISR, 2014), the flock size and their productivity were too low and provided approximately only 10% of meat and about 19% of eggs consumed in Rwanda then. The balances were provided by imports from neighbouring countries especially Uganda. Nevertheless, consumer preference for indigenous poultry meat and eggs then and now dominate the market. Till date, approximately 90% of eggs consumed in Rwanda are imported, and the main source is still Uganda. The characteristically white-shelled eggs from indigenous and local hens sell at higher retail prices (120 RwF) than eggs from commercial lines that sell for 90 RwF each. These opportunities are also encapsulated in the price of chicken, which is relatively high at 2,300 RwF per kg of chicken meat and 4,000-6,000 RwF for a whole chicken carcass. The sale of chicken cuts would increase demand among lower-income customers (Niang, 2012; Tareke et al., 2018).

In addition, indigenous chickens are ideal mothers, excellent foragers and are well known for their tropical adaptability and disease resistance, while their plumage colour helps in protecting them against predators (Brannang and Persson, 1990). Indigenous chickens provide livelihood security to the family for availability of food, and unemployed youth and women can also earn an income through poultry farming (Alabi et al., 2006). In Rwanda, local chicken breeds are very important because of many valuable characteristics such as diseases resistance, production in hash environment, ability to use low quality forage and cultural values. So, without plans to improve and strengthen the current conservation activities, there could be risk of extinction leading to total loss of this genetic material. It is important to note that for an effective cross breeding program, parent stock has to be maintained, with a selection program for each of them to improve the genetics and maintain the specific traits of that line. So, in case of Rwanda where crossbreeding is encouraged to increase production through improved genetics, the local chicken breed must be characterized and if possible breeding plans should be designed to improve them. This study aims to determine the phenotypic and morphometric characteristics of indigenous chicken breeds in Rwanda and decipher their distribution. Secondly, it was to assess their productive and reproductive performance under the current systems of production and management in order to enable chicken breeders and policy makers to make appropriate decision for their future utilization.

MATERIALS AND METHODS

Study design and sampling procedures

All the four geographical zones (Eastern, Western. Southern and Northern Rwanda were targeted and selected for this study. 260 farmers from 14 districts were selected during the baseline study. Two questionnaires were developed one to gather the farmers' responses and a second one to gather the morphometric characteristics; both questionnaires were first pretested and the aims of this pre-test were to evaluate the appropriateness of the questionnaire design, and assess the suitability and clarity of questions. A total of 529 unrelated indigenous chickens were used for the characterization study across the country. Body length was determined by measuring the length from beak to tail with a measuring tape. Comb and wattle length were measured using a measuring tape as a distance between the upper and the lower point of the organ. Shank length was determined by measuring the length from top of hock joint to the footpad (AU-IBAR, 2016). The filled questionnaires were then coded and entered into the SPSSv. 21 software. Data analysis was thereafter performed usingSAS v. 9.2 (SAS, 2004). Reproductive parameters and other quantitative variables were assessed using general linear models (GLM) multivariate analysis, with breed and location as fixed effects. Similarly, the qualitative variables were analyzed using descriptive statistics and compared as percentages using the same software package.

RESULTS

Socio-economic characteristics of the chicken-rearing households

The responses that are based on to arrive at the conclusions of the study are reliable, since they were given by adults, even though 11% of the respondents are indicated as children of the household head (Table 1). Surprisingly, in the northern, southern provinces and Kigali city, all respondents were either heads of households or children, and yet, analysis of marital status showed that almost three quarters of all were married. Many were single especially in Kigali (50%), while 4.7% were widowed across the country. The heads of households were exclusively male in Kigali and the north, and overall, only one third of the households were female-headed in the rest of the zones. A significant

Figure 1. Photographic illustration of the various indigenous chickens in Rwanda.

Table 1. Socio-economic characteristics (%) of the chicken farming households in Rwanda.

Variable (n = 265)	Level	Province					Overall	P - value
		East	West	North	South	Kigali		
Position of respondent	Head of household	56.8	54.5	85.7	83.3	75.0	63.1	0.242
	Spouse	37.8	27.3	0.0	0.0	0.0	26.2	
	Child	5.4	18.2	14.3	16.7	25.0	10.8	
Gender of head of household	Female	43.2	27.3	0.0	16.7	0.0	31.2	0.103
	Male	56.8	72.7	100	83.3	100	68.8	
Marital Status of head of household	Married	81.1	63.6	71.4	66.7	50.0	73.8	0.631
	Single	16.2	27.3	14.3	33.3	50.0	21.5	
	Widowed	2.7	9.1	14.3	0.0	0.0	4.7	
Education of head of household	University	5.6	12.5	42.9	0.0	25.0	12.1	0.020
	Vocational	5.6	0.0	0.0	0.0	0.0	3.4	
	Secondary	11.1	62.5	42.9	0.0	50.0	24.1	
	Primary	52.8	25.0	14.3	100	25.0	44.8	
	Analphabet	25.0	0.0	0.0	0.0	0.0	15.5	
Indigenous chicken production	Free range	89.2	81.8	85.7	50.0	50.0	81.5	0.079
System	Semi-scavenging	10.8	9.1	14.3	50.0	50.0	16.9	
	Intensive	0.0	9.1	0.0	0.0	0.0	1.5	
Objective for rearing indigenous	Income	97.3	100	100	100	100	98.5	0.877
Chickens	Conservation	2.7	0.0	0.0	0.0	0.0	1.5	
Sources of income	Crop	25.7	90.9	83.3	0.0	33.3	41.0	0.000
	Livestock	0.0	9.1	16.7	0.0	66.7	6.5	
	Both	74.3	0.0	0.0	100	0.0	52.5	
Owner of indigenous chickens	Children	21.6	54.5	57.1	16.7	25.0	30.8	0.245
	Father	18.9	18.2	28.6	33.3	25.0	21.5	
	Mother	18.9	18.2	0.0	16.7	25.0	16.9	
	Other relatives	2.7	0.0	14.3	0.0	25.0	4.6	
	Joint family owned	37.8	9.1	0.0	33.3	0.0	26.2	
Mode of acquisition of indigenous	Purchased	75.7	100	100	100	100	86.1	0.708
Chickens	Gifts	16.2	0.0	0.0	0.0	0.0	9.3	
	Exchange for labour	8.1	0.0	0.0	0.0	0.0	4.6	

Table 1. Contd.

Source of knowledge on indigenous Chickens	Own initiative	78.4	90.9	85.7	83.3	100	83.1	0.606
	Parents	8.1	9.1	0.0	16.7	0.0	7.7	
	Neighbours	10.8	0.0	0.0	0.0	0.0	6.2	
	Training	2.7	0.0	0.0	0.0	0.0	1.5	
	Others	0.0	0.0	14.3	0.0	0.0	1.5	

variation (P<0.05) was observed between the zones regard to education status. Whereas most heads of households in the eastern province (52.8%) and southern (100%) were of primary level education, majority in the west (62.5%) and Kigali (50%) had attained secondary education, while in the north, the highest proportion was 42.9% for both university and secondary. Also importantly, only the eastern zone had heads of household who had never been to school (25%). It was surprising that despite the south being a famous hub for higher education, all heads of households had attained education only to primary level.

In the east, west and north, almost all households used the free range production system for their indigenous chickens. In Kigali and the south, half of the farmers used free range while the rest used semi-scavenging, with minimal supplementation, and this caused a significant variation (P<0.1) among the provinces. Overwhelmingly, despite providing minimal care (considering the production system), when asked about the objective of rearing indigenous chickens, income generation was the exclusive objective, in all provinces except the eastern province. Other sources of income mentioned were crop and/ or livestock production at different levels of importance (P<0.05). Whereas all the farmers in the south earn from both livestock and crops, in the west, income was from crops for 91% of the households and in Kigali for over two thirds of the farms, livestock was the dominant source of income (Table 1). In most households, chickens were owned by children (31%). Joint family ownership was also common, as reported by one quarter of the households. All the surveyed households in the west, north, south and Kigali acquired their indigenous chickens by purchase, and only in the eastern zone were gifts and exchange for labour alternative modes of acquisition. Knowledge on management of chickens was acquired through own initiative in 83% of the households, as parents (east, west, south), neighbours (east), formal training (east) and other avenues (north) were of little role in the respective zones, and almost inconsequential overall.

Management practices of indigenous chickens in Rwanda

Chickens in all the zones were housed in enclosures except in the eastern province where a non-significant portion (P>0.05) of the households (2.8%) keeps their chickens in the trees (Table 2). Significant variation (P<0.01) was observed between provinces regarding the modes of utilization of eggs and chickens. Whereas in the east and south, most eggs are for both sale and home use, in the west and north, most households use eggs for sell and in Kigali, half of the households use eggs for home use, and the rest use them either for hatching or sale to earn income. Overall, 77% of the households sell the eggs, 61% use the eggs for home consumption (of these 15% exclusively), and 13% use the eggs for hatching chicks. These results show that a staggering 40% of the households do not consume eggs their flock produces. Almost 37% of all households exclusively sell their indigenous chickens for income, while 15% exclusively use them for home use (Table 2). With exception of 14% of the households in eastern province who reported to have no use for the chicken waste, all the other households use the chicken waste as manure for gardening.

Mortality mostly occurred among chicks in the western province; the proportions of households that reported to mostly lose cocks and hens were fairly high. Mortality of indigenous chickens was attributed by farmers to coccidiosis (28%), Salmonellosis (22%), Newcastle (15%) and other diseases (Table 3). We also observed that provinces were ravaged by differing factors. Whereas in the eastern province coccidiosis was the dominant cause of mortality, in the west, it was influenza, in the north it was fever while in the south, predators predominated. In all zones, most indigenous chickens were reported to die during the dry season. Mortality is mostly controlled by (a) daily hygiene of the house, (b) treatment of the sick chickens by the head of household(c) vaccination, (d) treatment by a veterinarian, as well as (e) isolation of sick birds; in that order of,

Table 2. Management practices (%) of the indigenous chicken farming households in Rwanda.

Variable	Level	Province					Overall	P - value
		East	West	North	South	Kigali		
Type of housing for indigenous chickens	Enclosure	97.2	0.0	0.0	0.0	0.0	98.4	0.951
	Trees	2.8	0.0	0.0	0.0	0.0	1.6	
Mode of egg utilisation	Sell for income	18.2	63.6	71.4	0.0	25.0	31.1	0.002
	Home consumption	9.1	27.3	14.3	0.0	50.0	14.8	
	Hatching	6.1	9.1	14.3	0.0	25.0	8.2	
	Sell and home use	60.6	0.0	0.0	83.3	0.0	41.0	
	Sell, home & hatching	6.1	0.0	0.0	16.7	0.0	4.9	
Mode of egg utilisation‡	Sell for income	84.9	63.6	71.4	100	25.0	77.0	
	Home consumption	75.8	27.3	14.3	100	50.0	60.7	0.049
	Hatching	12.2	9.1	14.3	16.7	25.0	13.1	
Mode of chickens utilisation	Sell for income	14.8	77.8	100	0.0	25.0	36.5	0.000
	Home consumption	11.1	22.2	0.0	0.0	75.0	15.4	
	Cultural functions	3.7	0.0	0.0	0.0	0.0	1.9	
	Exchange for labour	3.7	0.0	0.0	0.0	0.0	1.9	
	Sell and home use	66.7	0.0	0.0	100	0.0	44.2	
Mode of chicken waste disposal	Use as manure	86.1	100	100	100	100	92.1	0.396
	No use	13.9	0.0	0.0	0.0	0.0	7.9	

‡Modes of egg utilization are not mutually exclusive and therefore do not add to 100%.

Table 3. Causes, occurrence and control of mortality in indigenous chicken farming households in Rwanda.

Variable	Level	Province					Overall	P - value
		East	West	North	South	Kigali		
Chicken group most affected by Mortality	Chicks	91.2	66.7	100	100	100	90.0	0.599
	Cocks	2.9	22.2	0.0	0.0	0.0	5.0	
	Hens	2.9	11.1	0.0	0.0	0.0	3.3	
	Pullets	2.9	0.0	0.0	0.0	0.0	1.7	
Cause of mortality	Coccidiosis	40.5	9.1	14.3	0.0	25.0	27.7	0.000
	Salmonellosis	37.8	0.0	0.0	0.0	0.0	21.5	
	Fever	0.0	18.2	71.4	0.0	75.0	15.4	
	Newcastle	13.5	0.0	0.0	83.3	0.0	15.4	
	Predators	5.5	27.2	0.0	16.7	0.0	9.3	
	Influenza	0.0	27.3	0.0	0.0	0.0	4.6	

Table 3. Contd.

	Diarrhoea	0.0	18.2	0.0	0.0	0.0	3.1	
	Cold plate	0.0	0.0	14.3	0.0	0.0	1.5	
	Old age	2.7	0.0	0.0	0.0	0.0	1.5	
Period of the year with highest mortality	Dry season	85.3	100	100	100	75.0	90.0	0.369
	Rainy season	14.7	0.0	0.0	0.0	25.0	10.0	
How mortality is controlled	Daily hygiene of the house	8.1	36.4	85.7	0.0	100	26.0	0.040
	Give them treatment	18.9	0.0	0.0	50.0	0.0	15.3	
	Vaccination	8.1	9.1	14.3	16.7	0.0	9.7	
	Call a vet	5.5	27.2	0.0	0.0	0.0	7.6	
	Isolation of sick birds	5.4	18.2	0.0	0.0	0.0	6.1	
	Cull all sick chickens	2.70	0.0	0.0	0.0	0.0	1.5	
	Give birds a shelter	2.7	0.0	0.0	0.0	0.0	1.5	
	Nothing is done	2.7	0.0	0.0	0.0	0.0	1.5	
	No response	45.9	9.1	0.0	33.3	0.0	30.8	

importance. Surprisingly, one third of all households did not give a response to the question on control of chicken mortality. It was not clear whether this category is similar to the 1.5% who reportedly did nothing. The highest mean age of the heads of households was 43 years in the eastern province, while the lowest was 32 years in the southern province with the overall national mean of 41 years. The number of children per household was one in the south and four in the east, the number of adults was two in the south and highest was five in Kigali and the total household size on average was five persons (Table 4).

The number of eggs consumed annually per household was highest in the west (14), and the average was 10 eggs per household across provinces. The mean number of chickens consumed annually per household was lowest in the south (two chickens) and was highest in the east (six chickens). Experience in rearing indigenous chickens was exceptionally long (6.5 years) in the east and just above one year in the west, north and Kigali. Flock composition varied for the different provinces (Table 4) and total flock size was lowest in the western province (9.7) and highest in the north (23.3). The Price of chickens varied widely across the provinces. Cocks cost 4565 Rwf (US$ 5) in the east, 6000 Rwf (US $6.8) in the south and Kigali, 6818 Rwf (US $ 7.7) in the west and the highest cost was recorded in the north, at 7285 Rwf (US$ 8.2). The overall mean price per cock was 5700 Rwf (US$ 6.5) while the price of a hen was 3294 Rwf (US$ 3.7).

Reproductive performance of indigenous chickens in Rwanda

Age at laying did not vary between provinces and was six months in eastern and over seven months in western, northern, southern provinces and in Kigali (Table 5). Significant variations were observed for age at sexual maturity for both male and female chickens across the provinces, but the variation was rather wide and not congruent with the age at laying hence data on age at sexual maturity should be used cautiously. On number of eggs laid per hen per year, data were available only for eastern and western provinces with a very wide varation recorded. The biggest egg clutches were found in the western province (14.7 eggs) while the lowest clutch size was 6.6 eggs in the southern province. Egg hatchability was highest (85%) in the western province and lowest (52%) in the eastern province. Across the provinces, embryo mortality was low, at 30% or lower, except in the east where a staggeringly high 80% was reported. Again, the value of 80% should be handled cautiously considering that with that level of mortality, the flocks would be almost absent since chick mortality would wipe out the remainder.

Morphometric characteristics of indigenous chickens of Rwanda

The data on phenotypes were analysed as one data set and it did not show variation across provinces in most traits. Four comb types were

Table 4. Means of demographic and flock structure characteristics of chicken farming households in the provinces of Rwanda.

Variable	Province					Overall
	East	West	North	South	Kigali	
Age of head of household (years)	43.5	38.5	41.7	31.8	38.0	41.1
No. of children	3.6	2.8	2.6	1.0	-	3.2
No. of adults	3.7	2.8	2.3	2.0	5.0	3.4
Total household size	-	5.6	4.6	2.3	5.0	4.5
No. of eggs consumed at home/hh/yr	9.9	14.2	10.6	8.2	14.0	10.9
Chickens consumed at home/hh/yr	6.1	2.7	2.7	2.0	5.0	4.8
Experience in rearing chickens (yrs)	6.5	1.3	1.3	3.8	1.6	5.1
No. of cocks	2.1	2.6	2.1	2.8	1.3	2.2
No. of hens	6.9	4.8	7.3	11.5	7.8	7.1
No. of pullets	6.2	3.0	4.3	2.2	4.0	4.7
No. of cockerels	4.1	2.3	2.2	3.0	8.0	3.9
No. of chicks	6.9	6.5	12.0	6.3	15.0	8.3
Total flock size	13.5	9.7	23.3	20.2	20.8	14.9
Price of cocks (Rwf)	4565	6818	7285	6000	6000	5700
Price of hens (Rwf)	2500	4545	4142	2800	3750	3294
Price of pullet (Rwf)	1181	3250	-	1333	-	1468
Price of cockerels (Rwf)	1000	4500	800	1500	-	1557

Means with no superscripts within rows were not significantly different (P>0.05), US$ 1=900 Rwf.

Table 5. Means of reproductive paramemeters of indigenous chickens in the five zones of Rwanda.

Variable	Province					LSD
	East (n = 200)	West (n = 114)	North (n = 67)	South (n = 92)	Kigali (n = 47)	
Age at laying (months)	6.15^{a}	7.46^{a}	7.55^{a}	7.6^{a}	7.80^{a}	1.97
Age at sexual maturity for females (months)	5.88^{a}	5.94^{a}	6.47^{a}	6.00^{a}	9.08^{b}	1.99
Age at sexual maturity for males (months)	5.75^{a}	8.00^{b}	9.00^{b}	7.40^{b}	7.00^{b}	2.00
Number of eggs per year	30.55^{a}	62.66^{b}	-	-	-	17.41
Number of eggs per clutch	11.10^{a}	14.70^{b}	13.40^{c}	6.61^{d}	14.44^{e}	1.97
Egg Hatchability (%)	52.53^{a}	85.03^{b}	81.37^{c}	61.93^{d}	70.05^{e}	1.98
Embryo mortality (%)	80.0^{a}	30.0^{b}	18.5^{c}	18.5^{c}	20.0^{d}	2.10

Means within row with similar superscripts are not different (P>0.05).

observed (Figure 2), with the strawberry type being the most dominant (51%).

White ear lobes were most common (57%), round ear lobe shape was almost universal (92%) as was the curved beak structure (99.6%). Beak colour varied between green, black, yellow and brown, the latter being was most prevalent (51%). Evenly distributed feathers were the most common phenotype (99.8%) whereas naked neck phenotype was rare (0.2%), other types such as frizzling and cresting were not recorded. Most chickens had brown eyes, though yellow, pearl and red eyes were also observed (Table 6). Thick skins were most common (88.4%), and yellow skin colour was prevalent (69%) among the sampled chickens. Most chickens (39%) had yellow coloured shanks, though white (37%) steel blue (16%), black, green and pink coloured shanks were also observed. Universality was observed on sleletal variation where the normal phenotype was recorded for all the chickens used in the study across the entire country. When data on body dimensions were analysed, an interesting trend emerged. Body weight ranged from one kilogram to five kilogram, and showed a mean of 1.4 kg. The rest of the traits considered are presented in Tables 7 and 8.

DISCUSSION

Socio-economic characteristics of the chicken-rearing households

The current study showed that 89% of the respondents

Table 6. Phenotypic characteristics of indigenous chickens of Rwanda.

Variable (n= 520)	Level	Proportion (%)
Comb type	Single	42.4
	Strawberry	51.1
	Double	5.9
	Pea	0.6
Ear lobe colour	White	56.9
	Yellow	21.6
	Red	21.4
Ear lobe shape	Round	91.8
	Oval	8.2
Beak structure	Curved	99.6
	Straight	0.4
Beak colour	Brown	50.6
	Yellow	21.9
	Black	20.5
	Green	0.2
Feather distribution	Even	99.8
	Naked neck	0.2
Eye colour	Brown-orange	60.9
	Yellow	27.7
	Pearl	10.6
	Red	0.8
Skin thickness	Thick	88.4
	Thin	11.6
Skin Colour	White	31.0
	Yellow	69.0
Shank Colour	Yellow	38.6
	White	36.5
	Steel blue	15.6
	Black	6.0
	Green	3.1
	Pink	0.2
Skeletal variation	Normal	100.0

were adults and that significant variation exists in their education status. In the Eastern 52% and Southern province 100% of households have a primary level; majority in the west (62.5%) and Kigali (50%) had attained secondary education, while in the north, the highest proportion was 42.9% for both university and secondary. This is the good level for understanding the management and good returns for poultry production enterprise in Rwanda. This is almost similar with the report of Mahoro et al. (2017). The study indicated that Easten province had 25% of household who did not receive the education level. In this study, it was observed that all households in the East, West and North were using the free range production system (Mahoro et al., 2017). It was also found that in Kigali and South, half of the farmers were using free range, while the rest were

Table 7. Body dimensions of indigenous chickens of Rwanda.

Variable	n	Mean	Std. Error	Min	Max
Body Weight (kg)	501	1.44	0.02	1	5
Body Length (cm)	520	20.71	0.14	1.5	42
Wing Span (cm)	519	36.62	0.26	3.6	54
Neck Length (cm)	520	12.6	0.13	3	25
Skull Length (cm)	520	5.97	0.13	2.5	72
Skull Width (cm)	519	3.05	0.09	1.3	32
Comb Length (cm)	501	3.73	0.09	0	23
Comb Width (cm)	498	1.45	0.04	0	7
Beak Length (cm)	518	1.85	0.01	0.9	3.5
Beak Width (cm)	519	1.11	0.01	0.5	9
Ear Lobe Length (cm)	507	1.8	0.06	0	29
Ear Lobe Width (cm)	501	1.6	0.03	0	4.2
Wattle Width (cm)	481	1.56	0.06	0	13
Keel Length (cm)	519	10.14	0.09	0	18
Tail Length (cm)	515	14.66	0.15	5	38
Thigh Length (cm)	519	13.49	0.09	0.7	21.5
Tarsus Length (cm)	519	8.01	0.06	1	15
Tarsus Diameter (cm)	513	1.51	0.06	0.9	16
Centre Toe Length (cm)	517	5.02	0.04	1.2	14
Comb Size (cm)	490	1.68	0.04	1	3
Breast Circumference (cm)	462	24.21	0.37	1	38
Number of eggs laid per clutch	143	11.96	0.4	5	30
Number of egg clutches per year	131	9.86	0.73	2	60
Egg weight (g)	140	4.25	0.27	2	13
Egg Produced per year	112	38.58	5.29	14	80
Pulse Length (cm)	123	16.92	2.36	1	50

using semi –scavenging, with minimal supplementation. This result is similar to that of Mahoro et al. (2017) and Okeno et al. (2012).

In all provinces, the farmer reared indigenous chicken for income generation except the eastern province reported that those chicken are for home consumption. The respondents in South reported that the income came from both livestock and crops. Except the western province, the respondent indicated that ony 9% of income is coming from livestock. In line with this Alem et al. (2014) reported that farmers attach importance to generating cash income from chicken and eggs. Mostlty smallholder households sell surplus chicken and use the income to buy other essential food and services. This study found that 31% of indigenous chicken were owned by children, 22% by male and 17% by female, while the only 30% of indigenous chicken were shared in joint family. This is also reported by Yisehak (2008) that women in Ethiopia own a small proportion of chicken.

Management practices of indigenous chickens in Rwanda

It was observed that the mortality of indigenous chickens was attributed by farmers to coccidiosis (28%), Salmonellosis (22%), Newcastle (15%) and other diseases. The study indicates that in the eastern province, coccidiosis was the dominant cause of mortality, in the west, it was influenza, in the north it was fever while in the south, predators predominated. Similarly, the major causes of death for local chicken ecotypes in eastern province were seasonal outbreaks of chicken diseases, specifically Newcastle. According to the interviewed farmers hign mortarity occurred at the end of dry season. The increase of temperature and moisture might create a favorable condition to bacterial or viral disease outbreak (Alem, 2014; Fisseha et al., 2010). It is also reported that poor protection from adverse climatic condition might raise the severity of diseases outbreak.

In this study it was observed that in East the use of chickens for home consumption and the use of eggs for hatching were the primary purposes of rearing chickens. It is in conformity with Tadelle et al. (2003) who reported that in southern Ethiopia eggs produced were used for hatching, home consumption and sale while chicks produced were used for sale, replacement and consumption respectively, in decreasing order of

Table 8. Pearson Correlation Coefficients for various pairs of traits in indigenous Rwandan chickens.

	BW	BL	WS	EP	NL	CL	CW	TL
Body Weight (BW)								
Body Length (BL)								
Wingspan (WS)						0.443 **0.001**		
Eggs Produced/yr (EP)	-0.413 0.18	-0.526 **0.07**	0.595 **0.04**					
Neck Length (NL)			0.578 **0.001**	0.711 **0.009**				
Comb Length (CL)	0.250 **0.001**		0.443 **0.001**	0.605 **0.03**	0.370 **0.001**			
Comb Width (CW)	0.276 **0.001**				0.396 **0.001**	0.771 **0.001**		
Wattle Width (WW)						0.526 **0.001**	0.555 **0.001**	
Keel Length (KL)		0.494 **0.001**		0.401 **0.001**				
Thigh Length (TL)		0.414 **0.001**						
Comb Size (CS)						0.625 **0.001**		
Tarsus Length (TL)		0.427 **0.001**						0.635 **0.001**
Age at Laying (AL)				-0.657 **0.001**				

importance. Such prioritization may contribute to improving the nutritional status of the poor households mainly in eastern province. In other provinces namely West, Kigali and South, chicken and egg sale for income source was considered as third priority in this area. This is attributed to the poor access of urban market and other market outlets to poultry producers found in East. Long distance of the area by itself might have an impact on shaping the attitude of the farmers towards the importance of poultry and poultry products. It was observed that the number of eggs consumed annually per household was highest in the West (14), and the average was 10 eggs per household across provinces.

The results show that the average of chickens consumed annually per household was lowest in the south (two chickens) and was highest in the east (six chickens); simirality appeared in Alem et al. (2014)'s report that average consumption of chicken per household was 5.4 and .4.4 chicken in male and female headed households. This indicated that poultry production in Southern province used chicken as important source of income. It was reported in study of Natukunda et al. (2011a; 2011b) that farmers attach greater importance to generating income from eggs and chickens.

In the eastern province, it was revealed that the experience in rearing indigenous chickens was exceptionally long (6.5 years). But for the other provinces such as West, North and Kigali, the experience was above one year; which means that there are new in rearing the indigenous chicken.

In this study the total flock size was lowest in Western province and the highest in the northern province. 83% of the households got knowledge on management of chicken by their own initiatives.

Reproductive performance of indigenous chickens in Rwanda

The primary purpose of egg production in the study area was for income generation (37%); 61% use eggs for home consumption and rear chickens also for breeding purpose to produce birds for flock replacement (13%).

In this study the biggest egg clutches were found in the western province (14.7 eggs) while the lowest clutch size was 6.6 eggs in the southern province; the overall mean of number of egg per clutch was 12.05. It is in agreement with Assefa et al. (2019) and Alem (2014) who reported that the total number per clutch was 13.6 eggs.

Egg hatchability was highest (85%) in the western province and lowest (52%) in the eastern province, and

Figure 2. Comb types of indigenous chickens in Rwanda.

the overall mean of egg hatchability is 70.18%. Assefa et al. (2019) also reported that the hatchability rate was 74.1%. As reported by Alem (2014) it could be attributed to the high temperature in the eastern province that may affect the quality of the eggs; and also broody hens would be restless during higher temperature. This is in line with the reported 70.5% hatching rate (Tadelle et al., 2003) and 78.6% hatchability of local eggs (Abera, 2000) for Northern Ethiopia, 61.8% hatchability in Botswana (Aganga et al., 2000) and the hatchability ranged from 77 to 81% in Kashmir (Iqbal and Pampori, 2008). This variation might be due to the difference in management practices of the poultry producers in the indigenous chicken in Rwanda across the provinces, embryo mortality was low (0%), except in the East where a staggeringly high 80% was reported.

The present study showed that the egg production of indigenous chicken in Rwanda is between 30-62 eggs per year per hen; it was reported in similar study of Kidane (1980) that the average annual egg production of the indigenous chicken was between 30-60 eggs under village based production conditions. Also Tadesse (2014) reported that the average egg production per year for local hen was 43.4eggs; Tadelle et al. (2000) reported that average annual egg production of a native chicken was 40 eggs under farmer's management , but the highest was 54.3 eggs /year /hen

Morphometric characteristics of indigenous chickens of Rwanda

Phenotypic characterization is the process of identifying distinct breed populations and describing their characteristics and those of their production environments (Lopez and Vega, 2013; Deneke, 2013). In this study it was found that diverse color and type of comb and earlobe is observed within and between the ecotypes

studied. According to Nesheim et al. (1979); Duguma (2006) and Lopez and Vega (2013), the size and color of the comb and wattles are associated with gonad development and secretion of sex hormones. Large combs, large wattles and long legs are important morphological traits that allow better heat dissipation in the tropical hot environment. The comb and wattles have a large role in sensible heat losses. Three types of indigenous chicken, normal feather, dwarf and naked neck phenotype were rare with low proportion (0.2%). This is in contrast with Mahoro et al. (2017) who reported that the naked neck in Rwanda has proportion of 8.34%; it was reported that the use of this gene for feather restriction (Na) is particularly relevant for the tropics. Research into the effects of this gene on economic factors has been undertaken in Malaysia (Duguma, 2006; Brown et al., 2017). The result indicated that feather restriction (Na) or Naked Neck gene results in 40% less feather coverage overall, with the lower neck appearing almost "naked". This considerably reduces the need for dietary nutrition to supply protein input for feather production, and protein is a limiting factor in many scavenger feed resource bases (Horst, 1989). Thus, protein is shifted to meat and egg production than to feather synthesis. The shank lengths were comparable to some of the indigenous of Ethiopia (Duguma, 2006; Dana et al., 2010; Lopez and Vega, 2013).

In the current study, the body weight ranged from one kilogram to five kilogram, and showed a mean of 1.4 kg; it is in conformity with the previous study of indigenous chicken (LMP, 2017). These findings are supported by the results of Assefa et al. (2019); Lopez and Vega, (2013), where they found that indigenous chicken had lower live weight than normal chicken at all ages. Also Tadelle (2014) reported the average weight of mature males (cocks) was 1.694 kg. The body weight of hens was 1.37 and 1.356 kg. These differences in body weight observed for the different classes could be attributed to non genetic factors like supplementary feeding, watering and health care (Tadelle et al., 2014).

Conclusion

From this study, it is is necessary to conclude that the indigenous chickens in the study location had distinct physical varioutions for different traits in traditional management systems. There is a need to improve local chickens and further research is needed to check the potential of the indigenous chickens by molecular characterization. The study showed presence of a considerable diversity of phenotypic characters within and between the Rwandan chicken ecotypes. More phenotypic and genetic information that involves all traits and all ecotypes of the country together with the role of the traits and the underlying genes on socio-economic factors should be assessed to fully characterize them for promotion of their utilization, conservation of genetic variability and preservation of further adulteration.

RECOMMENDATIONS

The low production performance of indigenous breeds of chickens may be improved through improvement in up gradation of the native breeds of chickens through different breeding technique. It will help to increase the productivity of the germplasm and their conservation in their natural habitat. The breeding programme targeting improvement of indigenous chickens should focus on within breed selection rather than crossbreeding with commercial chicken breeds.

ABBREVIATIONS

BL, Body length; **BW,** Body Weight; **WS,** Wingspan; **EP,** Egg produced per year; **NL,** Nech length; **CL,** comb length; **CW,** comb width, **WW,** wattle width; **KL,** keel length; **TL,** thigh length; **CS,** comb size; **TL,** Tarsus length; **AL,** age at laying.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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