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Breeding Practices and Traits of Economic Importance for Indigenous Chicken in South Sudan

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Abstract. The current study aimed at generating essential information on breeding practices and traits of economic importance of indigenous chicken (IC) farmers in the three historical regions of South Sudan (Bhar el Gazel, Upper Nile and Equatoria). Data on perceived important traits according to farmers (n=385), marketers (n=100) and consumers (n=100) were collected and analyzed through computation of indices which represented the average weight of all ranks of a specific trait. The results of the indices indicated that farmers selected body weight (3.16), disease tolerance (3.02), drought tolerance (2.70) and fast growth rate (2.44) for breeding cocks. For hens, high indices were observed on disease tolerance (2.95), hatchability (2.78), egg size (2.63), egg number (2.48). Large Baladi (LB) and Naked Neck (Na) genotypes were the dominant genotypes raised by 64.8% and 27.7% of all farmers, respectively, for their superiority in mothering ability (40%), heat tolerance (20%) and disease tolerance (17%). Traits perceived by farmers as the primary economic importance were body weight (0.207), survival rate (0.11), egg yield (0.084) and meat quality (0.084). While marketers perceived body weight (0.234), egg yolk colour (0.150), disease tolerance (0.145), and plumage colour (0.133) as the most important traits, consumers emphasize egg yolk colour (0.202), plumage colour (0.204), and survival rate (0.156) as crucial. Body weight had a positive and favourable significant correlation with growth rate (0.561), egg fertility (0.412), disease tolerance (0.062), and a negative and unfavourable correlation with meat quality (-0.191). Meat quality was negatively correlated with fertility (-0.312) and growth rate (-0.381). Prolificacy had positive and favourable correlations with drought tolerance (0.603), disease tolerance (0.091) and heat tolerance (0.091). Regarding preferences rank correlation of marketers and consumers, positive and significant correlations were reported for body weight with growth rate (0.092) and meat quality (0.056). IC ecotypes that can perform well and are adaptable to the local environments in South Sudan should be identified. Selections should be based on traits preferred by farmers, marketers, and consumers.

Keywords: breeding practices, indigenous chicken, trait preferences, South Sudan

Introduction

The production systems of indigenous chicken (IC) at village level are recognized as the main source for capital build up, poverty elevation, and hunger reduction among households in developing countries (Okeno et al., 2011; Dana et al., 2010a). This is because IC production is characterized by short-lived cycle, limited space, good adaptability to harsh local environment, and tolerance to most diseases (Okeno et al., 2011; Dana et al., 2010a; Kingori et al., 2010).

The productive performance of indigenous chicken in scavenging system is relatively low due to the poor genetic potentials for egg and meat production, poor management practices, high mortality, and lack of knowledge among farmers (Magothe et al., 2012). Farmers in many tropical countries generally practise selection for indigenous hens and cocks in order to improve production by crossing with exotic breeds (Dana et al., 2010b; Magothe et al., 2012). Attempts for cross breeding were not successful due to lack of information on farmers' breeding objectives, farmers' traits preferences, and market requirements (Dana et al., 2010b).

The traits for selection of breeding stock are important when describing the adaptive attributes and genetic merits of indigenous chicken and identification of indigenous chicken's breeds preferred by farmers (Dana et al., 2010a). South Sudan, like many other tropical countries, lacks definite breeding program to develop indigenous chicken. To improve the

production and productivity of indigenous chickens, breeding programs should be set by defining a clear breeding objective that address the need of the production system under which indigenous chickens are reared and traits of economic importance to the farmers (Bett et al 2011; Okeno et al., 2011; Mahoro et al., 2018). Therefore, this study was conducted to identify farmers' breeding practices, IC genotype raised in South Sudan, and traits of economic importance perceived by farmers, markets, and consumers.

Material and method

Site and Scope of The Study

This study was carried out in Central Equatoria (Jubeek), Jonglei and Western Bhar el Gazel (Wau) states of South Sudan representing three historical regions of South Sudan Equatotia, Upper Nile, and Bhar el Gazel, respectively. These regions lie between the latitudes of 3° and 13° N and longitudes of 24° and 36°E, with a total size of 619,745 km^2 covered by tropical forest swamps and grass.

The climate conditions range from tropical semi-humid with a short rainy season in North to tropical wet-dry and tropical rainy with a longer wet season in south. The minimum and maximum rainfall recorded was 600 and 1,500 mm annually and the temperature ranges between 20°C and 32°C.

Data collection

Data were collected from 385 chicken farmers and 200 marketers and consumers who were selected among households in three regions through random sampling procedure according to Cochran, (1977) formula to calculate a representative sample for population as:

$$n_0 = \frac{z^2pq}{e^2} = \frac{1.96^2x0.5x0.5}{0.05^2} = 385$$

where: n0 is the sample size, z2 (1.96)2 is the selected critical value of desired confidence level, p is the estimated proportion of an attribute that is present in the population (0.5), q= 1-p and e (0.05) is the desired level of precision. In this study, a multi-stage sampling method was used by selecting regions with the highest population of indigenous chickens and then as subsequently a state within the region, three counties from each region, two Bomas (sub county) from each county, and two villages from each Boma. In the three regions, marketers and consumers were randomly selected in the rural and urban markets for interview to collect information about farmer's selection practices, IC genotype and their attributes and, and the perceived important traits by farmers, marketers, and consumers.

Figure 1. Chicken under backyard (a) and intensive (b) production systems in South Sudan

Three sets of pre-tested questionnaires (one for each category) were distributed to farmers, consumers, and marketers, and chicken management practices were subject to direct observations. The first set of the questionnaire was administered to selected households who owned indigenous chickens and were willing to participate in this study. This was followed by group discussions with farmers to probe deeper and detailed information on parameters unattained in the questionnaire. The second and the third sets of questionnaires were administered to marketers and consumers, respectively. Marketers and consumers were included in this study because of their vital role in the value chain of indigenous chicken. Local enumerators from each state were selected, employed, and trained by researchers and representatives from the Ministry of Animal Resources and Fishers at the state level in order to advocate acceptability and ease of communication with local communities. The aim of the survey and the benefits were explained to the farmers during the interview.

Data Analysis

Data were analyzed using the GLM procedure of SAS (SAS, 2004). Frequency and descriptive statistics were analyzed using PROC FREQ and PROC MEANS, respectively. Non-parametric test Kruskal-Walli's test (NPAR1 WAY) procedure of SAS was used to calculate the mean ranks for genotype and attributes. Kurskal-Walli's test was utilized to determine the effect of region on genotypes, selection practices and traits of economic importance. Indices were formed to provide the overall ranking for traits of economic importance as perceived by farmers, marketers, and consumers. The indices were weighted as averages for all rankings of particular traits. To compute the index (I_i) for each trait the following equation from Bett et al. (2011) was adopted:

$$I_i = \binom{3}{2}{1}\left[\sum_{i=1}^{3} X_i\right]_j \Big/ \sum_{k=1}^{n}\left[\binom{3}{2}{1}\sum_{k=1}^{3} X_i\right]_k$$

where X_i is the percentage of respondents ranking trait j in the i^{th} rank and k is the sum of ranks for n number of traits. Spearman's non-parametric correlation coefficient (r) procedure was used to compare the relationship between the perceived important traits by farmers, marketers, and consumers. The r was estimated as: $\boldsymbol{r}=\mathbf{1}-(\mathbf{10}\boldsymbol{\Sigma d2/n}(\boldsymbol{n2}-\mathbf{1}))$. where d is the difference between the ranks of corresponding pairs of two traits and n is the number of observations

Results and discussion

Farmer's Selection Practices

Table 1 shows the mean rank of characteristics considered by farmers when selecting breeding stock. Farmers in all three regions of South Sudan implement traditional methods when selecting their breeding stock based on their indigenous knowledge, experience, and performance history of chicken breeding without creating record database for IC production and productivity. Pullets were selected from households in which hens produced more eggs, had a high mature body weight, fast growth rate, good mothering ability, feed conversion and efficiency, good hatchability, and disease tolerance. The selections for breeding cocks considered high body weight, high prolificacy and survival rate, big size, heat tolerance and fast growth. Similar results were reported by Yakubu et al. (2019) in Nigeria, Mahoro et al. (2018) in Rwanda and Okeno et al. (2011) in Kenya. In contrast, Dana et al. (2010a) and Addisu et al. (2014) reported that farmers in Ethiopia practiced selection for breeding and replacement of male and females based on plumage colour, live weight, and comb type.

Table 1. Indices indicating mean rank of characteristics considered by farmers when selecting breeding stock

	Bhar el Gazel	Equatoria	Upper Nile	Mean
Breeding hens				
Disease tolerance	3.26	2.31	2.68	2.95
Fast growth of hen	2.65	2.32	2.06	2.27
Number of eggs per hen	3.50	2.07	3.00	2.48
Mature weight of hen	2.33	2.02	2.49	2.26
Mother ability	2.11	1.39	3.29	2.45
Large eggs	2.48	2.57	3.25	2.63
Hatchability	3.03	2.00	2.82	2.78
Breeding cocks				
Body size	1.60	1.78	2.59	2.16
Disease tolerant	3.25	2.06	3.53	3.02
Drought tolerant	2.80	2.25	4.00	2.70
Fast growth	2.26	2.36	3.00	2.44
Body weight	4.50	2.93	3.20	3.16
Heat tolerance	3.20	2.00	4.00	2.27
High survival rate	1.87	1.86	2.30	2.08
Feather colour	2.18	1.37	1.65	1.66

*An index of 1=most important to 4=least important, such that the lower the index the more important is the trait

Table 2. Number (n) and proportions of farmers (%) rearing different chicken genotypes in South Sudan

Genotype	Bhar el Gazel n=130	Equatoria n=131	Upper Nile n=124	Mean 385
Crosses	4.35	29.77	14.52	16.21
Dwarf	19.30	1.53	-	6.94
Frizzled	4.35	-	1.61	1.99
Large Baladi	53.04	67.94	73.39	64.79
Naked Neck	61.74	7.63	13.71	27.69
Others	0.00	0.76	0.00	0.25

Indigenous Chicken Genotypes

Table 2 indicates the proportion of different chicken genotypes reared farmers in South Sudan. The genotypes included Large Baladi (LB), Naked Neck (Na), Crosses and dwarf or Betwil (BT). While Large Baladi was the most common in all regions of South Sudan, dwarf or BT and frizzled were least common in Upper Nile and Equatoria regions, respectively. In general, wide uses of LB genotype by farmers all over the country can be attributed to it well adaptation to various climates in the country (Wani, *et al.,* 2014). In Bhar el Gazal region farmers preferred Na genotype when compared to Equatoria and Upper Nile regions because of high number of eggs they produce and their ability to resist disease (Binda *et al.,* 2010) and most importantly, the production rate of Na genotype remains optimum despite the hot climates when compared to other genotypes (Bett *et al.,* 2011).

Percentage may add up to more than 100% because some farmers reared more than 1 chicken genotype. Table 3 shows that there were no significant differences across the ranking attributes of different genotype as perceived by farmers. Large Baladi and Naked Neck ecotypes were superior in mothering ability, disease tolerance, and heat tolerance. Similarly, Mahoro et al. (2018) reported that regarding heat tolerance, Naked Neck and normal feathers ecotypes were generally considered as superior to Betwel ecotype. In Kenya, Magothe et al. (2010) and Okeno et al. (2011) reported that farmers raised a high number of Naked Neck and

frizzled feathered ecotypes in West Pokot because of the positive relationship between their genotype and good performance in heat tolerance, growth rate, body weight, feed conversion ratio, egg production, and disease tolerance in hot climate. Although Sudanese indigenous chickens are typically small, BT strain's much smaller size is an indication of the presence of dwarfism, which is due to a sex-linked recessive gene that tends to reduce body and egg size (Wani et al., 2014). In addition, the small number of BT ecotypes in the study area can be attributed to that fact that the indigenous inhabitants who rear this ecotype live on the border with Sudan in Nuba Mountain (Yousif et al., 2015). Meanwhile, market consumers prefer large-sized chickens to the smaller ones (Bett et al., 2011). In Table 4, the number in parentheses is the number of households but these percentage does not add up to 100% because some households owned more than one ecotype while others had no opinion on ranking.

Table 4 shows that there were no significant differences ($P \leq 0.05$) reported across all trait categories as perceived by farmers. Traits like body weight, survival rate, egg yield and meat quality were ranked to be most important to the farmers. However, traits like drought tolerant, plumage colour and heat tolerant were also mentioned by farmers' but considered to be less important. This study indicated that egg yolk, plumage colour, egg yield body weight and survival rate were the perceived most important factors by marketers and consumers. Similar results were reported in Rwanda (Mahoro et al., 2018) in Kenya by (Bett et al., 2011 and Okeno et al., 2011) where farmers preferred ICs because they are well adapted to local enlivenment, had good mothering ability, and produce tastier meat compared to improved breeds and their cross. Furthermore, Padhi et al. (2016) reported that consumers with high income are willing to pay more in order to get IC meat. Addisu et al. (2014) reported that in addition to body size, meat quality, growth rate and other traits like plumage colour, comb type influence the markets and consumers preferences in Ethiopia.

Table 3. The attributes of different indigenous chicken genotypes as perceived by the farmers

Trait	Dwarf	Frizzle feathered	Improved breed	Large Baladi	Naked Neck	Other
Carcass weight	3.2(12)	1.1(4)	2.9(11)	10.7(40)	9.7(36)	0.8(3)
Disease tolerance	3.8(14)	1.3(5)	2.1(8)	23.6(88)	16.9(63)	-
Egg weight	2.7(10)	1.1(4)	3.2(12)	8.3(31)	5.6(21)	0.5(2)
FCR	3.8(14)	1.3(5)	2.4(9)	13.9(52)	13.4(50)	0.5(2)
growth rate	3.2(12)	1.3(5)	5.1(19)	11.5(43)	9.4(35)	0.8(3)
Heat tolerance	4.0(15)	1.3(5)	4.0(15)	21.2(79)	16.9(63)	0.3(1)
Mothering ability	12(46)	3(12)	9.9(37)	49.3(184)	40(149)	1(5)
Prolificacy	1.1(4)	0.8(3)	2.7(10)	11.5(43)	6.4(24)	0.3(1)
Carcass weight	3.2(12)	1.1(4)	2.9(11)	10.7(40)	9.7(36)	0.8(3)

Note: FCR: Feed conversion efficiency

Table 4. Ranking of traits perceived as the primary economic importance by farmers, marketers, and consumers in South Sudan

	Farmers					Markers					Consumers				
Trait	Rank1	Rank2	Rank3	Sum	Index	Rank1	Rank2	Rank3	Sum	Index	Rank1	Rank2	Rank3	Sum	Index
Body weight	171	118	65	354	0.207	45	36	-	81	0.234	57	4		61	0.123
Survival	68	78	42	188	0.110			-			65	12		77	0.156
Growth rate	29	40	46	115	0.067	23	3	-	26	0.075	-	-		-	-
Disease tolerance	14	24	58	96	0.056	39	9	2	50	0.145	-	-		-	-
Drought tolerance	3	7	4	14	0.008	-	-	-	-	-	-	-		-	-
Feed conversion efficiency	2	4	15	21	0.012	-	-	-	-	-	-	-		-	-
Heat tolerance	10	9	5	24	0.014	-	-	-	-	-	-	-		-	-
Meat quality	56	67	21	144	0.084	45	1		46	0.133	69	5		74	0.150
Egg yield	87	34	22	143	0.084	-	-	-	-	-	73	8		81	0.164
FCE	65	34	22	121	0.071	-	-	-	-	-	-	-		-	-
Temperament	44	49	44	137	0.080	-	-	-	-	-	-	-		-	-
Plumage colour	31	45	23	99	0.058	41	5	-	46	0.133	78	23		101	0.204
Egg yolk	43	34	45	122	0.071	49	3	-	52	0.150	98	2		100	0.202
Prolificacy	78	34	21	133	0.078	43	2	-	45	0.130	-	-		-	-

Table 5. Correlation between rankings of traits of economic importance for farmers, marketers, and consumers in South Sudan

Category	Traits	BW	FERT	GRT	DSTOL	DTOL	HTL	MQ	FCE	TEMP	PCOL	EYC	PRL
Farmer	FERT	0.412**											
	GRT	0.561**	0.501**										
	DSTOL	0.062**	0.015	0.281									
	DTOL	0.081	0.212**	0.121	-0.038								
	HTL	-0.021	0.014	-0.002	0.054	0.331							
	MQ	-0.191**	-0.312**	-0.381**	0.021	0.023	0.075						
	FCE	0.017	-0.001	0.031	0.013	-0.039	0.065	-0.002					
	TEMP	-0.023	-0.002	0.012	0.218	-0.001	0.187	0.003	-0.041				
	PCOL	-0.210	0.013	-0.011	0.009	-0.017	0.030	-0.091	0.119	0.059			
	EYC	0.051	-0.018	0.003	-0.078	0.004	0.074	0.011	-0.017	0.003	0.030		
	PRL	0.032	0.431**	0.141	0.091**	0.603**	0.091**	0.098	0.016	0.036	0.411	0.013	
	ESCL	-0.101	-0.021	-0.091	-0.012	0.397	-0.010	-0.005	0.096	0.031	0.152	-	-0.031
Marketers	GRT	0.092**											
	DSTOL	-0.010	-	-0.097			0.058						
	MQ	0.056*	-	0.011	0.451	0.316	0.006	0.098			-0.019		
	TEMP	0.038	-	0.136	-	-							
	PCOL	0.131	-	-0.089	0.065	-0.021	0.023						
	EYC	0.163	-	0.301	0.286	0.216	0.085				0.189		
	PRL	0.043	-	0.069	0.217					0.432			
	ESCL	0.212	-	-0.198	0.080	0.054	-0.063	0.048			-0.137	0.087	
Consumers	GRT	0.032											
	MQ	0.112	-	0.051	-	-	-	-	-	-	0.129	-0.021	-
	PCOL	0.005	-	0.021	-	-	-	-	-	-	-	-	-
	ESCL	0.091	-	0.121	-	-	-	-0.019	-	-	-0.087	0.062	-
	EYC	0.134	-	0.012	-	-	-	-	-	-	0.031	-	-

DSTOL = Disease tolerance, MQ = meat quality, BW = body weight, FERT = egg fertility, GRT = growth rate, DTOL = drought tolerance, HTL = heat tolerance, FCE = feed conversion efficiency, TEMP = temperament, PCOL = plumage colour, EYC = egg yolk colour, PRL = prolificacy.

Table 5 shows the correlations between traits that have been put in ranking based on the level of perceived importance by farmers, marketers, and consumers. Based on the results, it was indicated a positive and significant correlation between body weight (BW), growth rate (GR) and egg fertility (FERT), and positive correlations between prolificacy (PRL), drought tolerant (DTOL), disease tolerant (DSTOL) and heat tolerant (Htol). This indicates that farmers wanted chicken with high growth rate, high egg fertility rate, and larger body size (heavy body weight) to increase their flock size (Mahoro et al., 2018). BW had a positive correlation with meat quality (MQ), growth rate (GR), but negatively correlated with temperament (TEMP), heat tolerance (HTOL), plumage colour (PCOL), and eggshell colour (ESCL). There was a significant negative correlation between MQ and BW, and between FERT and GR. Disease tolerance (DSTOL) was moderately correlated with BW and GR. DTOL was positively correlated with BW, FERT, and GR but negatively correlated with DSTOL. A moderate correlation was between feed conversion efficiency (FCE) and BW, GR and PRL but negatively correlated to FERT this explain that poor nutrition of IC affects their fertility (Mahoro et al., 2018).

The correlations between marketers' and consumers' preference ranking in Table 5 were positive and significant between body weight and growth rate and meat quality. Preference for body weight was positively correlated with prolificacy, eggshell colour, plumage color, egg yolk colour, but negatively correlated with disease tolerant for both marketers and consumers. Consumer's preference for body weight was positively correlated with prolificacy, eggshell color, plumage color, egg yolk color. A moderate positive correlation was observed between growth rate and meat quality, temperature, egg yolk color, and prolificacy. Traits perceived by farmers, marketers, and consumers must be considered when developing breeding goals for improvement programs (Mbuthia et al., 2015) because breeding goals that are developed without considering the needs of all stakeholders will likely to be rejected by the users. A previous study reported negative correlations between productive, reproductive, and functional traits of chicken breeding, which made breeding development difficult, and therefore, needed to advocate farmers to improve their management practices, such as feeding healthcare, housing, artificial incubation, and brooding (Okeno et al., 2011). Other traits can be improved through selection of appropriate ecotype which can be utilized effectively under harsh environment (Mahoro et al., 2018).

Conclusions

Farmers in South Sudan select chickens from household level based on high egg production, growth and fertility traits, and the most popular genotypes of indigenous chickens are Large Baladi (LB) and Naked Neck (Na). The top-ranking traits according to farmers, marketers, and consumers were body weight, survival rate, egg yield and meat quality egg yolk, plumage colour traits. Therefore, these traits should be considered when developing breeding objectives for improving indigenous chickens.

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