EXCELLENT PUBLISHERS

International Journal of Current Research in Biosciences and Plant Biology

ISSN: 2349-8080 Volume 1 Number 4 (November-2014) pp. 1-8

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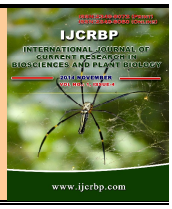

Original Research Article

Phenotypic Diversity of Local Chickens (*Gallus domesticus*) in Three Ecological Zones of Chad

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Abstract

The study was conducted in three ecological zones, namely the Hadjer-Lamis and Lake Chad region in the East, the Guera region in the middle belt and the West Mayo Kebbi, region in the South-West in the Sudanian zone of Chad. In total 925 local chickens, of which 569 males and 356 females were subjected to phenotypic characterization. Multicolored plumage is dominant (73.7%), within which the tawny feathers represent 16.0% followed by black or gray (13.4%) and silver (12.4%). Monochrome individuals represent 26.3% of the total number, with black/gray dominant in the Hadjer-Lamis/Lake Chad (49.5%) and West Mayo Kebbi region (53.0%) and dominance of white in the Guera (80.0%). More than half of the surveyed chickens had a black or gray beak in Guera (57.4%) and West Mayo Kebbi (52.2%) and whitish in the Hadjer-Lamis/Lake Chad region (50.0%). The orange color of the eyes is more common (73.7%), followed by red (12.9%) and yellow (7.3%). White color of eggs was dominant (97.9%) over brown. The Hadjer-Lamis/Lake Chad region has the strongest rate of brown eggs (20%). All eggs found in West Mayo Kebbi were white. Different types of comb were observed in both Sahelian regions, against a majority of single comb in the Sudanian region (90%) with differences between sexes. The simple comb was predominant in all three areas and among sexes. This study showed that 98.9% of the chickens had smooth plumage. The frizzled type is rare (1.1%). 'Naked neck' and 'feathered shanks' phenotypes have not been found in West Mayo Kebbi and Guera. Crested individuals are present in all three sites (22.6%). A relatively high proportion of crested chickens were encountered in the Hadjer-Lamis/Lake Chad region (19%) as against 10.9% in West Mayo Kebbi and 15% in Guera. The multiplicity of phenotypes reflects the variability of genetic resources of local chickens in the three areas and provides a basis for selection and strategies for sustainable development and improvement of local chickens in Chad.

Keywords

Local chicken
Phenotypic diversity
Ecological Zones
Chad

Introduction

Chad, country with agropastoral vocation has a highly diversified livestock (consisting of cattle, sheep, goats, camel, equids, pig and poultry) and a large land area suitable for agriculture development. Despite other countries in the Sahel region, these two main agricultural activities are the economic udder of the country. The animal breeding produces annual cash flow of about 110 billion FCFA or 18% of gross domestic product (GDP) in Chad. Poultries, found in many farms are not very considered whereas their number is estimated at 26,659,019 birds in Sahel, 22,441,995 in Sudanian region and 145,719 birds in Sahara (Mopaté 2010). These figures show importance of this sector for poultry development.

In addition, the development of livestock production is hindered by socio-economic, zoo technical, sanitary and genetics constraints and also by behavioral of action. Morphologically different chicken ecotypes exist in different parts of the country. However, few studies on characterization of these types were conducted and their productivity is poorly studied.

Now, any development activity or conservation of the national gene pool must necessarily be based on reliable baseline data. Therefore, a better understanding of this breeding by studies of different types of local chickens and productivity is essential. ME/LRVZ (2003) reported that in Chad, they are chicken with different biometric characteristics in north part of the country and subjects with smaller size are localized in center of the country or mixed in South. This situation requires a phenotypic characterization, which is the object of this study in order to make recommendations.

Materials and methods

Choice of sites

Three sites were selected, including two in the Sahel and one in the Sudanian region of Chad. These zones correspond to the country's first level administrative divisions, i.e. the Regions.

- The Guera Region, having the city Mongo as the capital is the tenth largest city in Chad by the number of its inhabitants (20,676 in 1993 census) and is located between 12.190° N latitude and 18.690 ° E longitude;
- Hadjer-Lamis and Lake Chad Regions, whose support center is Massakory. The survey covers the area extending up to Lake Chad Region of which the town of Bol is the capital. The latter is located between 12°10' and 14°20' North latitude and between 13°30' and 15°40' East longitude;
- West Mayo-Kebbi Region, which the city of Pala is the regional capital. It is the seventh city in Chad by the number of its inhabitants (26,100 inhabitants according to 1993 census) and is located between 9.360° N latitude and 14.900° E longitude. West Mayo-Kebbi Region is a high cotton and cereals production area, while the other two sites have animal breeding as their dominant activity.

Data Sampling and Collection

The study was conducted using a sheet based on observations of the outward appearance of the animal:

Keys to phenotypic characterization:

- Format of chicken: long-legged, short-shank or illegible.
- Plumage: Type and distribution.
- Plumage color: dominant colors and appearance.
- Color of some visible traits: comb, earlobe, beak, shank, eye and bard.
- Eggs color.
- Type of comb, earlobe, barb and crest.

During the data collection phase, each interviewer, after being trained on data collection techniques, was visited twice during the survey in order to ensure the proper functioning of the work and the completed sheets are validated as the work progressed. In case of any dissatisfaction, sheets were removed from them. The number of surveyed chickens is distributed in the following (Table 1).

Table 1. Number of surveyed chickens per site, village, household and sex

Site	Village	Household	Female	Male	Total
Guera	21	165	215	165	380
Hadjer-Lamis	17	73	118	87	276
Lake Chad	8	34	51	20	
West Mayo Kebbi	14	90	185	84	269
Total	60	362	569	356	925
In total, 925 chickens were surveyed coming from 362 households distributed across 60 villages in the three sites.					

Statistical analysis

Data were entered into a spreadsheet (Excel) and analyzed using the SPSS-PC software (SPSS, 2009). Frequencies were calculated for all data as the number of observed phenotypic divided by the number of individuals sampled for the strait x 100. Categorical data were analyzed by using Chi-square ($\chi 2$) test of independence. In all the analyses, a value of $p < 0.05$ was considered significant.

Results

Plumage color

Overall, the appearance of the multicolored plumage appeared most often (73.7%), within which the tawny color represents 16.0% followed by the black/gray (13.4%) and silver (12.4%).

The colors of the remaining feathers are mostly illegible (25.0%). Monochrome individuals represent 26.3% of all three areas, with dominance of the black/gray color in Hadjer-Lamis/Lake Chad (49.5%) and West Mayo Kebbi (53.0%) and white in Guera (80.0%).

The proportions of dominant feather colors, set on a scale of four colors (white - yellow - black/gray - red) show some balanced proportions. However there is a predominance of black/gray in Hadjer-Lamis/Lake Chad (34.2%), black/gray (32.6%) and red (30.4%) in the West Mayo Kebbi and white (36.4 %) in Guéra (Table 2).

Table 2. Frequency (%) of plumage appearance and dominant feathers color of local chicken in three regions of Chad.

Plumage color	Hadjer-Lamis/Lake chad n = 276	Guera n = 380	West Mayo Kebbi n = 269	Total n = 925
Appearance				
Monochrome	26.5	18.5	28.6	26.4
White	27.2	**80.0**	35.5	32.6
Yellow	13.6	-	11.8	12.4
Black/gray	49.5	20.0	53.0	47.3
Red	9.7	-	-	7.8
Multicolored	73.5	81.5	71.4	73.7
Tawny	14.8	18.5	17.4	16.0
Silver	12.2	14.8	12.7	12.4
Fawn	6.9	14.8	1.6	7.0
Black/gray	14.0	18.5	9.5	13.4
Illegible	25.5	14.8	30.2	25.0
Dominant color				
White	23.9	36.4	21.7	24.2
Yellow	19.7	18.2	15.2	20.2
Black/gray	34.2	22.7	32.6	32.3
Red	22.1	22.7	30.4	23.1

The results relating to the plumage colors of this study are in accordance with those of Msoffe et al. (2001) on local chicken ecotypes in Tanzania. Similar research work in Uganda (Ssewannyana et al., 2008) and Ethiopia (Duguma, 2006) reported also the occurrence of various plumage colors of

local chickens. The presence of observed several plumage colors among native chicken populations in this study could be the result of uncontrolled breeding in these three rural areas since random mating is a traditional farming practice.

Under predation conditions, black or gray and multicolored feathers would provide a camouflage to avoid being detected by predators. This could be the main reason for the higher frequency of black/gray and multicolored plumage. However the preferences of producers or consumers in this study area for the black and multicolored plumage could also explain the predominant occurrence of these colors.

Assegie (2009) reported that white and red feathers are the favorite and predominant colors in Ethiopia. The wide distribution of plumage color in local chickens in these areas indicates probably the existence of high genetic variability. These colors are certainly due to the presence of genes with major effects and interactions between some of them. Multiple uncontrolled crossbreeding over several decades between animals with different colors of plumage gives birth to other combinations, probably those found in small proportions. The predominance of colors encountered in all three zones led to believe that we are in present of not selected and locally adapted strains.

Color of some visible traits

In the regions covered by this study, more than half of the surveyed chickens had a black or gray beak in Guera (57.4%) and West Mayo Kebbi (52.2%) and pallid in Hadjer-Lamis/Lake Chad (50.0 %). The other colors, red and yellow, are poorly represented with distinction in West Mayo Kebbi where the rate of yellow was 10.9%. These two major colors occur at shank and earlobe in nearly same proportions (Table 3).

Table 3. Frequency (%) of color of some visible traits of local chicken in three regions of Chad.

Visible trait	Hadjer-Lamis and Lake Chad	Guera	West Mayo Kebbi	Total
Beak				
Black/gray	57.4	27.3	52.1	55.1
Whitish	30.1	50.0	28.3	30.9
Red	5.2	-	10.9	5.4
Yellow	7.3	22.7	8.7	8.6
Shank				
Black/gay	38.4	40.9	34.8	39.2
Whitish	50.5	40.9	47.8	48.7
Red	4.2	-	8.7	4.3
Yellow	6.9	18.2	8.7	7.8
Earlobe				
Black/gay	14.2	36.4	19.6	16.1
Whitish	50.2	36.4	41.3	46.8
Red	24.9	13.6	21.7	25.5
Yellow	10.7	13.6	17.4	11.6
Eye				
Red	10.4	18.2	28.3	12.9
Red-orange	75.4	68.2	65.2	73.7
Yellow	7.3	13.6	2.2	7.3
Gray	6.9	-	4.3	6.1
Egg				
White	80.0	98.5	100.0	97.9
Brown	20.0	1.5	-	2.4

The orange eye color seems to be the most frequent (73.7%), followed by red (12.9%) and yellow (7.3%). The appearance of chickens with orange eyes was higher in the Hadjer-Lamis/Lake Chad region (75.4%) than in other two regions that had an approximately equal distribution (68.2% in Guera and 65 2% in West Mayo Kebbi). The appearance of orange eye may be due to the absence of color pigment in eyes or to the accumulation of blood flowing in blood vessels of eye. Eye color in large

measure depends on the pigmentation (carotenoid pigments) of the structures within eyes (Crawford, 1990). The dominance of orange coloration in local chickens' populations was found in Uganda (Ssewannyana et al., 2008) and Cambodia (FAO 2009). However, mixed results have been reported in Ethiopia (Duguma, 2006) where all chickens had black eyes.

The multiple colors of organs demonstrate the variability of local chickens in all three zones. Thus Missohou et al. (1998) reported that in Senegal, the most encountered colors of shanks are white, yellow and pink and can also be black or blue. The strong presence of yellow shanks could also reflect the penetration degree of exotic genes in the local chickens' populations. The observed predominance of yellow shanks was reported by Cabarles et al. (2012), Ssewannyana et al. (2008), Daiwo al. (2011) and Guni and Katule (2013). However, Egahi et al. (2010) and El-Safty (2012) reported the dominance of black shank in their studies. Msoffe et al. (2001) also observed differences in shank color variation between the ecotypes. Different color types of organs in this study may be due to a combination of the genes responsible for determining the pigment color. Petrus (2011) reported that the production of the dermal and epidermal carotenoid is monitored by W and w +; Id and id + and E and E + genes which make possible the consecutive appearance of different shades of shanks' color.

Across all three regions, two egg colors, white and brown, were observed with the dominance of white (97.9%). Hadjer-Lamis/Lake Chad region has the highest rate of brown eggs (20%) while the chickens of Guera had white eggs by 98.5% and only 1.5% brown eggs. All the eggs found in the Sudanian zone (i.e. West Mayo Kebbi) were white. Nonga et al. (2010) reported the presence of only two types of shell color (white and brown). On the other hand, Assegie (2009) in Ethiopia and Guni and Katule (2013) in Tanzania reported several types of egg color from local chickens. Cavero et al. (2012) reported that the pigment produced in the uterus at the time of eggshell formation is responsible for the shell color. The shell color itself is not an indication of egg quality or its nutritional value, but it can play a major role in its marketing because some people prefer eggs with certain colors compared to others.

Phenotypic variation of some visible traits

The comb and the barb contribute to heat adaptation of chickens. Different types of comb (single, double, rose and pea) were observed in both Sahel regions against a majority of single comb in South (90%). Some differences were observed between sexes ($p \leq 0, 05$). The simple type was predominant in all three regions and sexes. Other comb types (rose, pea and double) occurred in small proportions and were more frequent in Sahel than in humid zone (Table 4).

Table 4. Frequency (%) of comb and barb types of local chicken in three regions of Chad.

Visible trait	Hadjer-Lamis and Lake Chad		Guera		West Mayo Kebbi		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Comb								
Simple	74.4	5.2	75.0	-	90.0	3.0	77.6	4.6
Double	6.6	-	8.3	-	-	-	5.7	-
Rose	9.9	0.7	-	-	-	-	7.5	0.9
Pea	0.8	0.7	-	-	-	-	0.6	0.6
Dropped	5.8	0.8	16.6	-	-	-	4.5	0.6
Illegible	2.5	92.6	-	100	10.0	97.0	3.4	93.2
Barb								
Short	71.4	1.2	81.8	-	90.5	2.5	85.5	8.3
Mid-long	14.8	-	8.3	-	5.6	0.6	5.7	0.2
Long	7.6	-	6.5	-	2.3	-	4.5	-
Illegible	6.2	98.8	3.4	100	1.6	97.9	4.3	91.5

As in most studies conducted under tropics (Missohou et al., 1998; Juarez et al., 2000; Fotsa and Pone, 2001), the simple comb is most common in the all three regions, followed by rose and double types among males and single comb followed by rose among females. It must however be noticed that these last forms are more represented in our study area, compared with frequencies obtained by

Fotsa and Pone (2001) in the Northwest Province of Cameroon. Results from Msoffe et al. (2001) indicated that some comb types occur more frequently than others among chickens' ecotypes depending of the environment. Other research results (Cabarles et al., 2012; Egahi et al., 2010 El-Safty 2012; Apuno et al, 2011) also noted the predominance of single combs in local chickens' populations.

Simple combs encountered mainly in the tropics play not only a thermoregulatory role in heat loss (Van Kampen, 1974; Msoffe et al., 2001), but would also promote body weight and egg laying (Ikeobi, 2000). The presence of several comb types observed in this study and elsewhere may be due to interactions of the various genes for the comb expression. Crowford (1990) argued that the inheritance of type comb in chickens is attributed to two pairs of autosomal gene (RR for the 'rose' type and PP for the 'pea' type).

Based on the adopted subjective classification' criterion of barb size, it was observed that there were differences between regions and sexes. Generally, chickens with short barbs were most frequent (85.5% among males followed by those with mid-long while chickens with long barbs were less observed in each region. Missing or illegibility of barbs was higher among females (91.5%) and was not observed in Guera region. Similar results have been reported in Nigeria (Ige et al., 2012). The predominant presence of minor combs and small barbs within local chickens and especially among females suggests that the head appendages size could be under the influence of related reproduction's hormones (Ige et al., 2012). Sexual dimorphism is most pronounced for these two visible traits because all males in the current study seem to have larger beards than females.

This study showed that 98.9% of the chickens had smooth plumage. The frizzled type was only observed in Guera and proportions in the other two sites were low (1% in Hadjer-Lamis/Lake Chad and 2.2% in West Mayo Kebbi). 'Naked neck' and 'feathered tarsus' phenotypes, two mutations compared to the wild status, have not been encountered in West Mayo Kebbi and Guera. Proportions in Hadjer-Lamis/Lake are 0.3% and 0.7% for respectively the naked neck and feathered shanks. However, tufted individuals (with hoopoe) are present at all three sites (22.6%). There were no differences between sites in relation to the development of comb. A relatively high proportion of tufted chickens has been encountered in Hadjer-Lamis/Lake Chad (19%) than in the other two sites (10.9% in West Mayo Kebbi and 15% in Guera). Differences ($p \leq 0.01$) were observed between males and females (Table 5).

Table 5. Frequency (%) of feather type and distribution of local in three regions of Chad.

Visible trait		Hadjer-Lamis and Lake Chad	Guera	West Mayo Kebbi	Total
Plumage type	Smooth	99.0	100	97.8	98.9
	Frizzled	1.0	-	2.2	1.1
Feathered shanks	Presence	0.7	-	-	1.1
	Absence	99.3	100	100	98.9
Naked neck	Presence	0.3	-	-	0.3
	Absence	99.7	100	100	99.7
Hoopoe	Presence	19.0	15	10.9	22.6
	Absence	73.7	85	76.1	70.1
	Illegible	7.3	-	13.0	7.3

The plumage distribution found among surveyed populations is probably the result of the genotype and environment interaction (Santoni et al., 2000; Bahy et al., 2003). Thus, the lack of feather distribution widely represented would be the consequence of the relative homogeneity of climatic conditions in the studied areas in contrast to studies conducted with geographical diversity (Ji et al., 2005).

Some major genes acting on the feather distribution, the plumage type as the comb size improve adaptation to heat. Thus, NA 'naked neck and F frizzled' mutations have, in the homozygous, significant effects on adaptation to heat, especially by improving performance efficiency (Merat, 1986; Haaren-Kiso et al., 1988). For Somes (1990), the presence of these mutations and others may indicate the preferred choice of farmers in the absence of

demonstrated adaptive value in the case of the 'feathered tarsus' and 'tufted' phenotypes for which no major effect has been described but contribute to differentiate between animals.

Understanding the relationship between qualitative traits is very important because visible traits such as feather color, comb type, naked neck and others are able to influence consumer preference and market price. According Duguma (2006) geneticists make use of the heritability of these traits to produce chickens required by the market (consumer demand).

Conclusion

This study was conducted to describe the phenotypic variability of local chicken in three ecological zones of Chad. The results show significant variability of the visible traits. Local chicken's populations of the study area have various types and colors of visible traits vary in frequency from one location to another. It can be concluded by comparing the information from the literature and the frequencies of observed qualitative characteristics that the local studied chicken populations in the three ecological zones are not different from the rest of the population of African indigenous chickens. However, other studies on the morph biometry, productivity parameters and others molecular analyzes are needed to complete exhaustive characterization. The results provide a basis for conservation, selection and strategies for sustainable improvement of the studied local chickens.

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