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Phenotypic and morphobiometric characterisation of local chicken *(Gallus gallus)* in family breeding on the outskirts of Lubumbashi, Democratic Republic of Congo

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Abstract

This study, with a main goal to characterise the local chicken at phenotypic and morphobiometric level, was conducted from September 2019 to January 2020 in three outlying districts of Lubumbashi city in the Democratic Republic of Congo (DRC). A total of 116 adult females and 64 adult males were photographed, described, and measured individually. The main results indicated that the phenotypic traits of the local chicken studied were very heterogeneous. Indeed, four main types of feather distribution were observed – normal feathering (80.56%), crested head (17.22%), naked-neck (1.67%), and feathered shank (0.56%). For feather morphology, normal plumage (98.33%) dominated frizzled plumage (1.67%). Plumage colouring varied with the predominance of black (15.00%), millefiori (10.56%), salmon pink (9.44%), and fawn (8.89%) colours. The single comb was the most common (96.67%) having usually the red (51.67%) or pink (35.56%) colour. The colour of wattles was dominated by red (58.89%) followed by pink (33.89%), while the predominant earlobe colour was red (32.78%) followed by red-white (23.33%) and white (21.67%). Among the eye colours, orange-red predominated (73.33%) followed by dark-brown (11.11%) and yellow-brown (9.44%). Most of the birds were having white skin colour (56.67%) followed by pink (22.22%) and yellow (21.11%). The shank colour was predominantly white (34.44%) followed by yellow (23.89%), grey (19.44%), black (16.67%), and green (5.56%). Regarding morphobiometric traits, the average live body weight of the local peri-urban chicken of Lubumbashi was 1.25 ± 0.52 kg in males and 1.06 ± 0.29 kg in females. Body weight and other body measurements vary significantly (p<0.001) depending on sex and in favour of males. Body weight was strongly and significantly correlated with shank circumference and chest circumference with a coefficient of 0.86 and 0.80, respectively.

1. Introduction

The domestic chicken (*Gallus gallus domesticus*) is the most studied species of phasianids, whose major economic interest has enabled much more precise studies, especially in the context of genetic diversity within and between different populations, history, origin, and mapping of genes and markers. The local chicken has the adaptive qualities necessary for the success of livestock projects in rural conditions, especially in Africa (Akouango et al. 2004).

Undernutrition is a long-standing problem in sub-Saharan Africa and progress in this regard is uneven within the region. Although it has declined from 33% in 1990-92 to 23% in 2014-16, the percentage of undernourished people is still the highest in the world (McGuire 2015). The Democratic Republic of Congo (DRC), like most African countries, suffers from substantial food insecurity. To meet this challenge, local chicken are a significant alternative. Constituting around 80% of the total poultry population in Africa, local chicken contribute a considerable proportion to meat (25-70%) and egg production (12-36%) (Gueye 1998). These local poultry products contribute significantly to food security by supplying protein directly to families. They are also at the centre of many social and cultural circumstances (Galal 2006). However, despite its vital role, the local chicken are still neglected in conservation and improvement programs. The phenotypic and genetic characterisation of traditional poultry populations has not been done systematically in several African countries and in particular the Democratic Republic of Congo (DRC).

These local breeds, which are for the most part poorly known and poorly described in the literature, are currently threatened with extinction. Their continued disappearance constitutes a disaster for the universal genetic heritage by the irremediable loss of traits currently ignored and potentially useful in the future (Moula et al. 2009; Lariviere and Leroy 2008). It is now proven that the best knowledge of the genetic variability of animal populations requires phenotypic and molecular characterisation to decide their potential in the contribution to food production (FAO 2013). Hence, this study aimed primarily to contribute to a better knowledge of the local chicken in order to have a database indispensable for its improvement and its better exploitation in the peri-urban environment of Lubumbashi, economic capital and second city of the DRC.

2. Materials and methods

2.1 Description of the study area

This study was conducted in outlying districts of Lubumbashi in the DRC. Given their accessibility, three districts were chosen in the eastern region of the city (Fig. 1). Located at 1230 m above sea level, the city of Lubumbashi covers an area of 747 km^2. It is an area consisting of a slightly hilly plateau between 11°20' and 12° South Latitude and 27°10' at 27°40' East Longitude. Classified as the CW-6 type (according to the Koppen-Geiger climate map), the city of Lubumbashi has a tropical climate, with a rainy season from November to April and a dry season from May to October. Precipitation is spread over 6 months with an average rainfall of 1228 mm. The rainy season is wet and overcast while the dry season is mostly clear. The average temperature is around 20°C and can be as low as 15°C during the coldest months and as high as 38°C during the warmest months. In general, the vegetation throughout the outskirts of the city of Lubumbashi is the wooded savannah dotted with some forest galleries in the North. Agriculture is dominated by food crops (maize, groundnuts, cassava, and sweet potato). Small livestock farming is dominant, especially poultry.

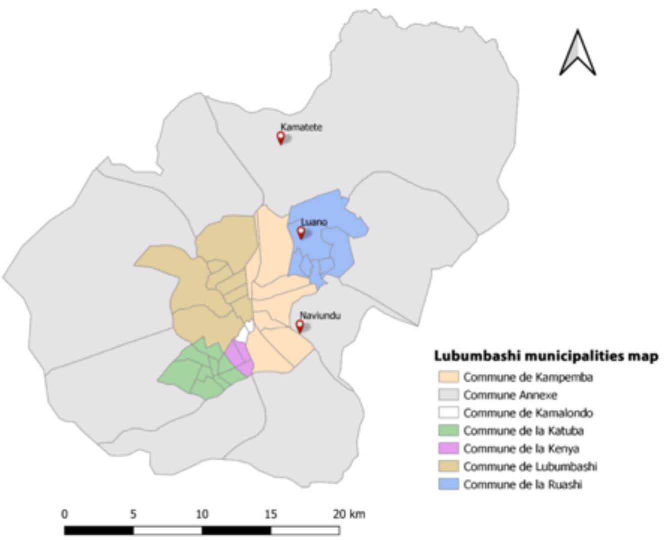

***Fig. 1** Presentation of the study area*

2.2 Sampling technique and methods of data collection

A descriptive study was conducted between September 2019 and January 2020, in the households chosen in three outlying districts east of the city of Lubumbashi (Kamatete, Luano and Naviundu). The selection criteria included the time span of the household in the breeding activities of the local chicken, the accessibility of the area, the absence of breeding the exotic chicken, and the availability of the breeder. A total of 116 adult females and 64 adult males were randomly selected, each of which was completely described by direct observation, weighing, and measuring according to FAO (2013) recommendations. A semi-structured questionnaire was also used to collect data on production systems, qualitative, and quantitative traits of local chicken.

2.3 Measurements of phenotypic and morphobiometric traits

Qualitative phenotypic traits such as feather morphology, feather distribution, plumage colour, shank colour, skin colour, comb colour, comb type, earlobe colour, wattle colour, eye colour, beak shape, beak colour, and presence/absence of polydactyly were recorded by visual observations following the recommended descriptors for chicken genetic resources (FAO 2013).

Morphobiometric traits were measured in sampled local chicken of both sexes using a digital electronic scale with a capacity of 5000 g and a sensitivity of 1 g for body weight (BW). For linear traits, a digital calliper with a precision of 1 mm and a range of 150 mm was used. It was used for measurements of small dimensions such as comb height (CH), wattle length (WL), shank length (SL), and shank circumference (SC). The number of fingers was counted. Measurements of body length (BL), wingspan (WS), and chest circumference (CC) were obtained using a measuring tape.

2.4 Statistical analysis

Descriptive analysis was performed to estimate, for each study site as well as for the total population, the frequencies of qualitative traits and the mean and standard deviation of quantitative traits. Sex effects were assessed by analysis of variance (ANOVA) for body weight and linear traits. The correlation between different body measurements was evaluated by the Pearson correlation coefficient. Statistical analyses were performed using R (version 4.1.1) and XLSTAT (version 2020.1.3) software.

3. Results

3.1 Phenotypic traits of the local peri-urban chicken of Lubumbashi

3.1.1 Morphology and distribution of feathers by sex

Morphology and distribution of feathers on the body of the local peri-urban chicken of Lubumbashi are presented in Table 1. Two types of feather morphology were observed with a predominance of smooth (normal) plumage (98.33%) in both sexes. Frizzled plumage was rare in frequency (1.67%). As for the distribution of feathers on the body, four types of feathering were observed – normal feathering (80.56%), crested head (17.22%), naked-neck (1.67%), and feathered shank (0.56%). Normal feathering was observed with high frequency in males (90.63%) while the crested head was much more frequent in females (23.28% vs 6.25%). Regarding other types of feathering, the naked-neck was observed with a frequency of 1.56% in males and 1.72% in females and feathered shanks were observed only in males (1.56%). Fig. 2 and 3 illustrate the diverse types of feather morphology and distribution found in the local peri-urban chicken of Lubumbashi.

Table 1. Morphology and distribution of feathers by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Feather morphology						
Frizzled	2	3.12	1	0.86	3	1.67
Normal	62	96.88	115	99.14	177	98.33
Total	64	100.00	116	100.00	180	100.00
Feather distribution						
Naked-neck	1	1.56	2	1.72	3	1.67
Crested head	4	6.25	27	23.28	31	17.22
Normal	58	90.63	87	75.00	145	80.56
Feathered shank	1	1.56	0	0.00	1	0.56
Total	64	100.00	116	100.00	180	100.00

N = number

Fig.2 *Feather morphology in the study population: normal (A) and Frizzled (B)*

Fig.3 *Feather distribution in the study population: normal (A); crested head (B); naked-neck (C); feathered shank (D)*

3.1.2 Distribution of plumage colours by sex

Table 2 shows the diverse colours of plumage of the local peri-urban chicken of Lubumbashi. The most common colours are black (15.00%), millefiori (10.56%), salmon pink (9.44%), fawn (8.89%), black-tailed red (8.33%), ermined (6.67%), and white (6.11%). In addition, 12 out of 27 (44.44%) colours found were not present in males. The main plumage colours found in this study are illustrated in Fig. 4.

Fig.4 *Plumage colours seen in the study population*

3.1.3 Distribution of comb shapes and colours by sex

The distribution of comb shapes and colours of the local peri-urban chicken of Lubumbashi are presented in Table 3. Three types and seven colours were observed. The proportion of chicken with single comb was the highest (96.67%). A low frequency (1.67%) was observed for the other two types of combs – pea and rose comb. The different comb shapes found are illustrated in Fig. 5. The most common comb colour was red (51.67%) followed by pink (35.56%). The red colour was

Table 2. Distribution of plumage colours by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Mahogany	0	0	1	0.86	1	0.56
White	1	1.56	10	8.62	11	6.11
Black-tailed white	1	1.56	1	0.86	2	1.11
Curdled	0	0	2	1.72	2	1.11
Ash	0	0	2	1.72	2	1.11
Cuckoo	5	7.81	3	2.59	8	4.44
Fawn	3	4.69	13	11.21	16	8.89
Fawn with black camail	0	0	4	3.45	4	2.22
Black-tailed fawn	0	0	1	0.86	1	0.56
Wheaty	2	3.13	2	1.72	4	2.22
Grey	1	1.56	7	6.03	8	4.44
Ermined	8	12.50	4	3.49	12	6.67
Millefiori	14	21.88	5	4.31	19	10.56
Black	8	12.50	19	16.38	27	15.00
Gold-black	3	4.69	1	0.86	4	2.22
Black with white camail	0	0	1	0.86	1	0.56
Black with golden camail	1	1.56	3	2.59	4	2.22
Black with red camail	0	0	1	0.86	1	0.56
Silver partridge	0	0	4	3.45	4	2.22
White partridge	0	0	1	0.86	1	0.56
Ash partridge	0	0	1	0.86	1	0.56
Golden partridge	0	0	8	6.90	8	4.44
Wild partridge	0	0	1	0.86	1	0.56
Black partridge	1	1.56	4	3.45	5	2.78
Red	0	0	1	0.86	1	0.56
Black-tailed red	13	20.31	2	1.72	15	8.33
Salmon pink	3	4.69	14	12.07	17	9.44

N = number

most common in males (79.69%) than in females (36.21%), while the opposite was observed in case of pink comb colour. The pigmented, blue, and white colours were observed in small frequencies.

3.1.4 Colour distribution of wattle, earlobe, and eyes by sex

The characteristics of wattle, earlobe, and eyes of the local peri-urban chicken of Lubumbashi are mentioned in Table 4. Three colours of wattle have been found in the local peri-urban chicken population of Lubumbashi. Wattles of red colour were the most represented (58.89%) followed by pink (33.89%), and rarely of pigmented colour (7.22%). The red colour of wattle was more common in males (85.94%) while in females, the pink colour predominated (45.69%). Earlobes were mostly red (32.78%), red-white (23.33%), and white (21.67%). However, the red colour of earlobes was more dominant in males (57.81%) while white earlobe were more common in females (31.03%). The orange-red (wild type) colour of the eye was predominant (73.33%), followed by black-brown (11.11%), and yellow-brown (9.44%). The other eye colourations were rare in frequency. The main eye colours found in the peri-urban local chicken of Lubumbashi are illustrated in Fig. 6.

Fig.5 *Comb shapes found in the study population: single comb (A); rose comb (B); pea comb (C)*

Table 3. Distribution of comb shapes and colours by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Comb shape						
Rose	3	4.69	0	0	3	1.67
Pea	1	1.56	2	1.72	3	1.67
Single	60	93.75	114	98.28	174	96.67
Total	64	100.00	116	100.00	180	100.00
Comb colour						
White	0	0	1	0.86	1	0.56
Blue	0	0	4	3.45	4	2.22
Pink	10	15.63	54	46.55	64	35.56
Red	51	79.69	42	36.21	93	51.67
Pigmented	3	4.69	15	12.93	18	10
Total	64	100.00	116	100.00	180	100.00

N = number

Table 4. Colour distribution of wattles, earlobes, and eyes by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Wattle colour						
Pink	8	12.50	53	45.69	61	33.89
Red	55	85.94	51	43.97	106	58.89
Pigmented	1	1.56	12	10.34	13	7.22
Total	64	100.00	116	100.00	180	100.00
Earlobe colour						
White	3	4.69	36	31.03	39	21.67
Blue	0	0	4	3.45	4	2.22
Pink	2	3.13	26	22.41	28	15.56
Red	37	57.81	22	18.97	59	32.78
Dark red	0	0	5	4.31	5	2.78
Black-tinged red	0	0	3	2.59	3	1.67
Red-white	22	34.38	20	17.24	42	23.33
Total	64	100.00	116	100.00	180	100.00
Eye colour						
Dark-brown	1	1.56	1	0.86	2	1.11
Black-brown	4	6.25	16	13.79	20	11.11
Yellow-brown	7	10.94	10	8.62	17	9.44
Black	0	0	4	3.45	4	2.22
Pearlish	2	3.13	3	2.59	5	2.79
Orange-red	50	78.13	82	70.69	132	73.33
Total	64	100.00	116	100.00	180	100.00

N = number

Fig.7 *Skin colours found in the study population: white (A); pink (B); yellow (C)*

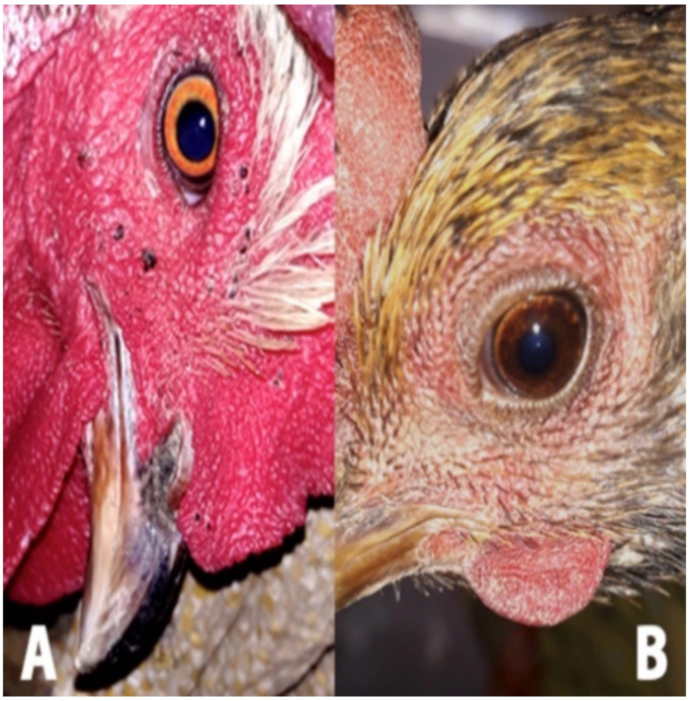

Fig.6 *Main eye colours in the study population: orange-red (A) and black-brown (B)*

3.1.5 Distribution of skin and shank colours by sex

Table 5 summarizes the colouring of skin and shank of the local peri-urban chicken of Lubumbashi. Three skin colours and five shank colours were found, with white skin (56.67%) and shank (34.44%) being the most common in the total population and much more so in males (62.50%; 39.06%). As for the skin, white colour (56.67%) is followed by the pink colour (22.22%), and yellow colour (21.11%). Regarding

Table 5. Distribution of skin and shank colours by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Skin colour						
White	40	62.50	62	53.45	102	56.67
Yellow	11	17.19	27	23.28	38	21.11
Pink	13	20.31	27	23.28	40	22.22
Total	64	100.00	116	100.00	180	100.00
Shank colour						
White	25	39.06	37	31.90	62	34.44
Grey	7	10.94	28	24.14	35	19.44
Yellow	25	39.06	18	15.52	43	23.89
Black	4	6.25	26	22.41	30	16.67
Green	3	4.69	7	6.03	10	5.56
Total	64	100.00	116	100.00	180	100.00

N = number

shank, white colour (34.44%) is followed by yellow (23.89%), grey (19.44%), black (16.67%), and rarely green (5.56%). Fig. 7 and 8 show skin and shank colours observed in the peri-urban local chicken of Lubumbashi.

Fig.8 *Shank colours found in the study population: white (A); yellow (B); grey (C); black (D); green (E)*

3.1.6 Distribution of shape, beak colour, and frequency of polydactyly by sex

Table 6 shows the characteristics of the beak and the number of fingers of the local peri-urban chicken of Lubumbashi. In this study, only the curved shape of the beak was found in the population of the local per-urban chicken of Lubumbashi. In addition, several beak colours were observed with the predominance of "hornish" type colouring (51.67%) followed by white (20.00%), black (19.44%), and rare yellow (8.89%). Polydactyly was low (3.33%) in the study population and was observed only in females (5.17%). The various beak colours seen in this study are illustrated in Fig. 9.

Table 6. Distribution of beak shape, beak colour, and polydactyly by sex

Features	Males		Females		Total	
	N	(%)	N	(%)	N	(%)
Beak shape						
Curved	64	100.00	116	100.00	180	100.00
Straight	0	0.00	0	0.00	0	0.00
Total	64	100.00	116	100.00	180	100.00
Beak colour						
White	11	17.19	25	21.55	36	20.0
Hornish	38	59.38	55	47.41	93	51.67
Yellow	7	10.94	9	7.76	16	8.89
Black	8	12.50	27	23.28	35	19.44
Total	64	100.00	116	100.00	180	100.00
Polydactyly						
No	64	100.00	110	94.83	174	96.67
Yes	0	0.00	6	5.17	6	3.33
Total	64	100.00	116	100.00	180	100.00

N = number

Fig.9 *Beak colours found in sampled chicken: black (A); hornish (B); yellow (C); white (D*

3.2 Morphobiometric traits of the local peri-urban chicken of Lubumbashi by sex

Table 7 summarizes the morphobiometric traits of the local peri-urban chicken of Lubumbashi. In this study, all morphobiometric traits varied significantly ($p<0.001$) with respect to the sex of birds. Live body weight and body measurements were significantly higher in males. The average body weight of the total population studied was 1.13 ± 0.40 kg with a coefficient of variation of 34.96%. With an average body weight of 1.25 ± 0.52 kg, males were significantly ($p<0.001$) heavier than females (1.06 kg ± 0.29 kg). The mean chest circumference value was 25.90 ± 3.61 cm with a coefficient of variation of 13.93%. Males were significantly ($p<0.001$) larger in size (27.45 ± 4.10 cm) than females (25.04 ± 3.00 cm).

The average body length was 39.93 ± 3.96 cm with a coefficient of variation of 9.92%. Males were significantly longer ($p<0.001$) (42.13 ± 4.20 cm) than females (38.72 ± 3.25 cm). The average shank length was 76.51 ± 14.45 mm with a coefficient of variation of 18.88%. Males had significantly ($p<0.001$) long shank (87.19±11.89 mm) than females (70.63 ± 12.21 mm). The mean shank circumference value was 11.14 ± 1.47 mm with a coefficient of variation of 16.96%. Again, males had significantly ($p<0.001$) large shank (12.71 ± 2.37 mm) than females (11.14 ± 1.47 mm).

Sexual dimorphism is also expressed when the wingspan is measured. At 43.11 ± 4.55 cm, males had significantly larger wingspan ($p<0.001$) than females (39.07 ± 4.27 cm). The average wingspan of the population was 40.50 ± 4.77 cm with a coefficient of variation of 11.79%. The average comb height was 2.30 ± 1.19 cm with a coefficient of variation of 51.80%, with males having significantly ($p<0.001$) higher combs (3.46 ± 1.14 cm) than females (1.67 ± 0.60 cm). For wattle length, the mean value for the total population was 2.17 ± 0.88 cm with a coefficient of variation of 40.61%. As with the other parameters, males had significantly long wattles ($p<0.001$) (3.04 ± 0.83 cm) than females (1.49 ± 0.43 cm).

Table 7. Mean and standard deviation of morphobiometric traits in local chicken studied

Features	Males		Females		Total		Statistical analysis		
	M±SD	N	M±SD	N	M±SD	N	CV (%)	p - value	Sex
BW (kg)	1.25 ± 0.52	64	1.06 ± 0.29	116	1.13 ± 0.40	180	34.96	3×10^{-6}	***
CC (cm)	27.45 ± 4.10	64	25.04 ± 3.00	116	25.90 ± 3.61	180	13.93	5×10^{-6}	***
BL (cm)	42.13 ± 4.20	64	38.72 ± 3.25	116	39.93 ± 3.96	180	9.92	3×10^{-8}	***
SL (mm)	87.19 ± 11.89	64	70.63 ± 12.21	116	76.51 ± 14.45	180	18.88	2×10^{-16}	***
SC (mm)	12.71 ± 2.37	64	11.14 ± 1.47	116	11.70 ± 1.98	180	16.96	1×10^{-9}	***
WS (cm)	43.11 ± 4.55	64	39.07 ± 4.27	116	40.50 ± 4.77	180	11.79	5×10^{-8}	***
CH (cm)	3.46 ± 1.14	64	1.67 ± 0.60	116	2.30 ± 1.19	180	51.80	2×10^{-16}	***
WL (cm)	3.04 ± 0.83	64	1.69 ± 0.43	116	2.17 ± 0.88	180	40.61	2×10^{-16}	***

N = number; M±SD**:** mean ± standard deviation; CV: Coefficient of variation; BW: Body weight; CC: Chest circumference; BL: Body length; SL: Shank length, SC: Shank circumference; WS: Wingspan; CH: Comb height; WL: Wattle length; ***: $p < 0.001$

3.3 Correlation between morphobiometric traits

Table 8 shows the correlation between the various morphobiometric parameters of the local peri-urban chicken of Lubumbashi. There was a significant (p<0.001) and strong correlation (r = 0.86) between live body weight and shank circumference on the one hand, and between live body weight and chest circumference on the other hand (r = 0.80). In addition, length of the wattle was significantly (p<0.01) and strongly (r = 0.83) correlated with the height of combs.

4. Discussion

Considerable variation in plumage colours was seen within the study population. Phenotype variation usually characterises local chicken and indicates the presence of several morphological mutations that result from domestication and random breeding. The wide variety of plumage colours is thus the result of multiple uncontrolled crosses for several decades between populations having different plumage colours, which gave rise to other combinations existing in small proportions (Akouango et al. 2004). A total of 27 plumage colours were observed in the populations of local chicken reared on the outskirts of Lubumbashi with a predominance of black colour (15%). This result is consistent with those reported by Moula et al. (2009) in Algeria and Chabi (2008) in Benin. Indeed, the black colour of the plumage is the first and most dominant mutation in the plumage of the original chicken which is golden. Dark colours could be at the origin of the camouflage phenomenon developed by chicken to avoid predation by rapacious birds and other carnivorous animals that was one of the causes of their mortality (Fayeye et al. 2006).

From the point of view of morphology and distribution of feathers on the body, the local peri-urban chicken of Lubumbashi were characterised by smooth (normal) plumage and normal distribution of feathers although other phenotypes existed with small proportions (frizzled, head crested, naked-neck, and feathered shank). The crested phenotype was better represented especially in females (23.28%). Chicken with this phenotype are often preferred for their good reproductive performance (Keambou et al. 2007). The frequency of naked-necks (1.67%) found in this study was lower than the 6%

Table 8. Correlation between morphobiometric traits

Features	CC	BL	SL	SC	WS	CH	WL	BW
CC	1							
BL	0.72**	1						
SL	0.41	0.60**	1					
SC	0.70**	0.73**	0.67*	1				
WS	0.65**	0.73**	0.63*	0.74**	1			
CH	0.52	0.47	0.55	0.51	0.47	1		
WL	0.57	0.58**	0.62*	0.65*	0.59	0.83**	1	
BW	0.80***	0.74**	0.48	0.86***	0.68**	0.45	0.59	1

M±SD**:** mean ± standard deviation; CV: Coefficient of variation; BW: Body weight; CC: Chest circumference; BL: Body length; SL: Shank length, SC: Shank circumference; WS: Wingspan; CH: Comb height; WL: Wattle length; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

observed in Nigeria (Gueye 1998), 4.3% in northern Cameroon (Haoua 2010), 3.6% in Botswana (Badubi et al. 2006), and 2% in Ethiopia (Nigussie et al. 2010). These low proportions of mutants could be explained by the fact that some local chicken producers do not prefer chicken with mutant traits (Fayeye et al. 2006; Aklilu 2007). However, it should be noted that the presence of the naked-neck type in poultry is a definite advantage in tropical environments. Indeed, birds carrying this gene produce fewer feathers, which not only has an advantage in warm climates but also leads to a better feed efficiency (Hako et al. 2009).

Shank and skin had multiple colours in the study area, but white colour predominated in both cases. White shank (44.44%) and white skin (56.67%) were the most represented. Indeed, skin and shank colouring depend on the combination of pigments in the dermis and epidermis, which is particularly associated with the presence or absence of melanin in the skin. The presence or absence of pigments is due to the W+ and w alleles. The W+ allele is dominant and gives a white skin and shank (wild type). However, when the recessive allele w is expressed, it gives a yellow coloration because it allows the homozygous state to deposit xanthophyll pigments in the beak, skin, and shank (Coquerelle 2000). The results of this study are consistent with those of Yapi-Gnaore et al. (2010) who also found the predominance of white colour for both shank and skin. The low presence of yellow shank and skin colouration, characteristic features of commercial strains (Fotsa et al. 2010), could indicate that phenomenon of introgression is not yet occurring in the local peri-urban chicken's population of Lubumbashi. Also, the low proportion of green shank (5.56%) observed in this study is not surprising, as this trait has an adverse effect on the viability of adult chicken (Desta et al. 2013).

The single comb as well as the red colour of combs, earlobes, and wattles dominated in the local chicken reared on the outskirts of Lubumbashi. Comparable results were reported by Keambou et al. (2007) in western Cameroon, Badubi et al. (2006) in Botswana, Wani (2008) in Sudan, and FAO (2005) in Bangladesh. According to Navara et al. (2012), males with red combs have better sperm quality (a sign of fertility). However, in females, it was the pink colour that predominated in the combs, wattles, and earlobes. The pink comb of females could be the result of an autosomal recessive mutation that decreases the vascularization of the comb and wattles (Richard et al. 1969). Regarding comb shape, a contradiction was observed with the results of Nigussie et al. (2010) who observed that the pea comb is most common in the population of local chicken in the areas of Farta, Mandura, Horro, Konso, and Sheka in Ethiopia. Indeed, the pea comb has an important effect on breeding in tropical conditions. The P gene that determines this type of comb reduces the proportion of keel feathers and improves the growth of young chicken (Horst 1989).

In terms of eye colouring, the orange-red colour (wild type) was the most represented (73.3%) in this study. The same result was reported by Keambou et al. (2007) and Yapi-Gnaore et al. (2010). The orange-red colour of the eyes is the result of an absence of pigments in the iris, which reveals the red colour of the blood in the vessels present in it. Other colours result from the presence of different melanic pigments (Crawford 1990).

The only shape of the beak recorded within the population studied was the curved shape. Bembide et al. (2013) and Keambou et al. (2007) described two forms – the curved shape, which is the most common and the straight shape. On the other hand, four colours of the beak were found, the hornish colour, white, black, and yellow. Hornish colour was most commonly observed (51.2%) in the three study sites. Similar results were reported by Keambou et al. (2007) with a percentage of 47.4% compared to 21.6% for black and 24.7% for yellow. However, Moula et al. (2011) found that hornish colour is less common than yellow colour and Bembide et al. (2013) mentioned that hornish colour is the rarest with a proportion of 11.6%.

This study shows that in the local poultry population studied, sexual morpho-ponderal dimorphism is very pronounced in favour of males. Indeed, cocks were heavier and had more imposing morphology than hens. These results are corroborated by reports of Gueye et al. (1998), Msoffe et al. (2002), Bonou (2006), Gnikpo (2006), and Keambou et al. (2007). The average live body weight was 1.25 ± 0.52 kg for cocks and 1.06 ± 0.29 kg for hens. These values are lower than those reported by Moula et al. (2012a) in the Kabylia region of Algeria (males - 1.43 ± 0.18 kg; females - 1.14 ± 0.18 kg), Getu et al. (2014) in Ethiopia (males - 1.63 ± 0.30 kg; females - 1.37 ± 0.20 kg), Guni et al. (2013) in Tanzania (males - 2.10 ± 0.29 kg females - 1.53 ± 0.16 kg), and Jesuyon and Salako (2013) in Nigeria (males - 2.40 ± 0.14 kg; females - 1.50 ± 0.14 kg). However, these results are higher than those reported by Moula et al. (2012b) in the province of Bas-Congo of the DRC where the average weight of males was 1.03 ± 0.72 kg compared to 0.90 ± 0.20 kg for females. The morpho-ponderal variations observed in local African chicken can be attributed, on one hand, to differences in animal behaviour and management, uncontrolled crosses with exotic strains, and the availability of food and supplements (Abdelqader et al. 2008), and on the other hand to the climatic characteristics of each region (Bulgarella et al. 2007).

The mean value of chest circumference of the characterised chicken was 25.90 ± 3.61 cm. It is lower than that reported by Yapi-Gnaore et al. (2010) in Côte d'Ivoire (30.40 ± 3.60 cm), Bembide et al. (2013) in Central African Republic (36.82 ± 3.10 cm), and Keambou et al. (2007) in Cameroon (39.10 ± 2.88 cm). The local peri-urban chicken of Lubumbashi are therefore smaller in size compared to other African poultry populations. Nevertheless, referring to the results reported by Moula et al. (2012b), the local peri-urban chicken of Lubumbashi have the same size as that of Bas-

Congo in the DRC and also have the advantage of having a longer body (39.93 ± 3.96 cm vs 31.30 ± 0.41 cm). In addition, the local peri-urban chicken of Lubumbashi had longer shank than the local chicken of Algeria (76.51 ± 14.45 mm vs 67.54 ± 14.50 mm) (Mahammi et al. 2014).

Analysis of body measurements revealed strong correlations between different morphobiometric traits. These observations are similar to those reported by Mahammi et al. (2014); Moula et al. (2012a); Fosta et al. (2010); Batimsoga and Lombo (2009), and Keambou et al. (2007). Thus, the live body weight shows a strong correlation with the circumference of the shank (r = 0.86) and the chest (r = 0.80). The positive correlation between body weight and other body measurements suggests that selection of one of these body parameters would lead to indirect improvement in body weight (Apuno et al. 2011). Gueye et al. (1998) found a correlation of 0.74 between body weight and chest circumference and suggested that the equation for predicting body weight from the chest circumference could be a simple method for measuring body weight in rural areas. A strong correlation was also observed between comb height and wattle length. Indeed, differences in wattle length are likely to reflect climate adaptation, as wattle is an important heat exchange area that plays a role in thermoregulation. help avoid such infections.

5. Conclusions

The phenotypic inventory carried out on the local peri-urban poultry populations of Lubumbashi, in addition to supplying the necessary information for the knowledge of these populations, has made it possible to highlight the great diversity of existing phenotypic characteristics, diversity due to the lack of directional selection, and the diversity of environmental conditions in which these poultry live. Indeed, despite their low productivity and high exposure to the harsh environments in which they are held, Congolese chicken play a particularly important socio-economic role. This study showed that the overall morphobiometric measurements of the local peri-urban chicken of Lubumbashi are low compared to the exotic strains, but that they are within the reported averages for local chicken in low-income countries. Furthermore, morphobiometric characterisation showed a pronounced natural sexual dimorphism in local poultry populations in favour of the male for all quantitative traits. This confirms what is reported in the existing literature on the species *Gallus gallus domesticus*.

Ultimately, the study of the phenotypic diversity of other local poultry populations in the country should be carried out to supplement the information on the overall diversity of this species at the national level and to study the effect of different climatic conditions on the frequency of certain phenotypes of interest. In addition, molecular analysis using microsatellite markers will help better assess this diversity at the genome level and to compare it with the results obtained in other populations with the same markers. Conservation of poultry genetic resources therefore requires a rapid response of the political authorities through the release of special budgets for the conservation of genetic resources threatened, the scientific community through research on the evaluation and characterisation of local breeds, and breeders through the creation of local associations to keep the genetic diversity of each breed, and the improvement and sharing of know-how.

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