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Phenotypic variability and typology of cavy (Cavia porcellus) production in the Democratic Republic of Congo (DRC)

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Abstract

Domestic cavies (*Cavia porcellus* L.) are one of the mini livestock used in Sub-Saharan Africa to improve food and nutrition security, and also income generation. In DRC, these animals are part of 'rehabilitation kits' for humanitarian organizations and because they are included in the agricultural portfolio of development agencies that seek to address the challenges of widespread hunger and malnutrition in destabilized eastern regions. This study was carried out to assess the phenotypic diversity of cavies reared in DRC as well as their typology and identify the major parameters that could be used for breeding purposes. A total of 1,250 animals were characterized based on qualitative (coat color pattern, eyes color, satin of the coat and coat color variegation, the head shape and ears orientation) and quantitative traits (animal weight, animal length, head length, body length, heart girth, and the animal height). Main results indicated a body weight ranging from 300 to 1,203g at maturity and a total animal length from 20 to 38.5 cm. Three main coat colors patterns were identified (white, brown and black) from which derived several combinations, the most common combination being white-brown-black (43.09%) or the brown-white (23.98%). Three clusters were identified from the typology results, and differed essentially by the animal length, body length, body weight and head length, coat color pattern, eyes color, coat color variegation, head profile and the animal origin. These results indicate a first step in the decision making and orientation of the genetic improvement in this promising species.

Keywords: Biodiversity, Cavia porcellus, diversity, domestic cavy, morphometrics, phenotype.

Introduction

Domestic cavies (*Cavia porcellus*) are one of the mini livestock used in Sub-Saharan to alleviate hunger, poverty and malnutrition. Introduced in Africa probably during the western colonial times (Blench, 2000), cavies have several attributes. A part of being widely known as pet, fancy and laboratory animal (Wagner, 1976; Hardouin et al., 1991), they are used for meat production like in South America where they originated (Chauca de Zaldívar, 1995; Avilés et al., 2014). Furthermore, keeping purposes include income generation, manure production and they are also used in traditional medicine to treat anemia (Ngou Ngoupayou et al., 1995; Maass et al., 2014; Simtowe et al., 2017).

Cavies are considered as promising livestock as they require small capital and produce high quality meat compared to other livestock (NRC, 1991; Lammers et al., 2009). Their meat contains low fat, and more protein and minerals as compared to meat of other livestock species (Kouakou et al., 2013). They get mature earlier and they are prolific (Dikko et al., 2009; Lammers et al., 2009) with less competition to human as their diet is mainly made up of crop residues, kitchen wastes and forages (Bacigale et al.,

2014; Kouakou et al., 2015 and Faihun et al., 2017). They are easily reared with other species such as rabbits (Lammers et al., 2009), and they require less care if kept in relatively clean environment (NRC, 1991; Lammers et al., 2009).

The Cavy husbandry is currently having great interest since the last decades with the objective of increasing and diversifying the products of animal origin (Hardouin et al., 1991; Niba et al., 2012). This species occupies a special place in animal production in Latin America (Hardouin et al., 1991; Morales, 1994) and Sub-Saharan Africa (Ngou Ngoupayou et al., 1995, Fransolet et al., 1994). Nowadays in Sub-Saharan Africa, cavies are raised in Benin, Cameroon, Côte d'Ivoire, Democratic Republic of Congo (DRC), Ghana, Guinea (Conakry), Mali, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo (NRC, 1991; Ngou Ngoupayou et al., 1995). In many countries of the Great Lakes region, cavies' keepers are predominantly higher than those of rabbits or pigs (Metre, 2012; Maass et al., 2012). They are well suited to family farming systems where they would constitute with the rabbit the major source of animal proteins for home consumption, other species serving as source of income for the household (Lammers et al., 2009; Metre, 2012; Maas et al., 2013).

In eastern DRC, cavies are currently kept by eight out of ten households, with numbers ranging from 6 to 30 (Mass et al., 2010; Metre, 2012). This is similar to previous observation by Schoepf and Schoepf (1987), who reported about one third of surveyed households in DRC. Previously consumed exclusively by children, it has become a source of protein for all categories since the 1990s (Metre, 2011). In urban areas, however, consumption remains limited due to the accessibility and consideration of cavies as an animal of poors (Maass et al., 2010; Maas et al., 2013; Maass et al., 2014). In sub-Saharan Africa, despite the socio-economic benefits of cavy husbandry at household level, the flocks dynamics remains poorly documented, for domestic cavies are not included in national census exceptTanzania (NBS, 2012). Cavy population of DRC is estimated to be more than 2 millions, contributing significantly to nutrition security, especially for animal protein, and income generation of more than a hundreds of thousands of poor rural and urban households (Maass et al., 2013). The largest cavy populations are kept in the Kivu provinces, where they are part of 'rehabilitation kits' of humanitarian NGOs and because they are included in the agricultural portfolio of development agencies who seek to address the challenges of widespread hunger and malnutrition in the area (Maass et al., 2013).

This study proposed to evaluate the phenotypic diversity of cavy reared in DRC as well as their typology and identify discriminants parameters that could be used for breeding purposes.

Material and methods

Sampling zone

The sampling zone consists of four different provinces of DRC located on both sides of the equator, extending between 5° 20' northern and 13° 50' southern and between 12° 15' and 31° 15'eastern. The natural environment is made up of variety of agro-pastoral potentials and offer an ecosystem conducive to the promotion and sustainable development of plants and animals production. There are four climatic zones: (i) the equatorial zone at the center, with a warm and humid climate, temperatures varying between 20°c and 32°C, heavy precipitation exceeding 2,000 mm per annum, regularly distributed throughout the year; (ii) the tropical zones, with two very marked seasons as one moves away from the Equator. These are: (a) the rainy season, characterized by precipitation ranging from 800 to 1,500 mm per annum and fluctuating temperatures between 25° and 33°c; (b) the dry season, which can last from 1 - 3 months in the North and from 1 to 6 months (of dry season), in the South, with temperatures ranging from 17° to 25°C. (iii) the monsoon climate transition zone, separating humid equatorial and tropical climates, and (iv) the relatively temperate zone in the eastern part of the country with special rainfall conditions (mean 60 mm per month), with temperatures varying between 8°C and 18°C due to the elevation of the relief (FAO, 2010).

Data collection

Only mature cavies (more than 6 months old) from the study area were considered for data collection at

household level in this study. In total, 1,250 non-pregnant individuals were selected based on region and sex. Quantitative data was collected using a digital scale and a ribbon. Qualitative characteristics were recorded based on visual observations under the day light. Apart from the animal sex, collected data were related to the morphology (coat color patterns, eyes color, the satin of the coat and the coat color variegation, the head shape and ears orientation) and morphometric measurements (animal weight, animal height, animal length, head length, body length, heart girth.). Individual body measurements were taken on a fasted animal and recorded on a pre-established comparison sheet. Indications for measurements were as follows:

- Animal Length (AL): distance from the upper mandible to the vestigial tail,
- The Body length (BL): is the distance from the blow to the vestigial tail,
- The heart girth (HG): circumference at the chest taken behind the forelegs,
- Head Length (HL): distance from upper mandible to the blow,
- Animal Height (AH): height at withers of the animal

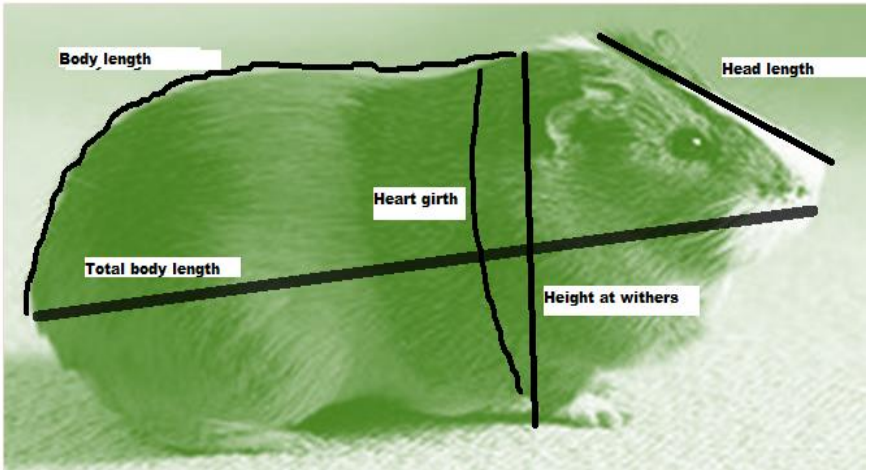

Photo 1 shows schematically the different measurements taken.

Data analysis

The data were analyzed using descriptive statistics (mean, standard deviation, variance, maximum, minimum and coefficient of variation for quantitative variables and relative frequencies for categorical variables). Two-way analysis of variance was performed to compare the means of quantitative traits of cavies by sex and province of origin.

The ANOVA model used for these analyses was:

$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + E_{ijk}$

Where Y_{ijk}: body weight and body measurements of k^{th} individual from i^{th} province and j^{th} sex.

μ: general mean of the population. A_i : effect of the i^{th} province.

B_j:effect of the j^{th}sex.

$(AB)_{ij}$: effect of the interaction of j^{th}sex and i^{th} province and E_{ijk}: residual error from k^{th} individual of the i^{th} province and j^{th} sex.

The alpha significance level considered for this analysis was 0.05. In case of differences between mean, multiple pairwise comparison of means was performed using the Tukey HSD test always at alpha equal to 0.05. For cavy typology, multiple component analysis was performed with categorical variables and principal component analysis with quantitative variables. After each of these two analyses, a

classification was carried out (hierarchical ascending classification followed by a partitioning of k-means for the consolidation of the obtained classes). All these analyses were carried out with R software,version 3.4.4 (R Core Team, 2017) using the FactoMineR (Lê et al., 2008) and facto extra (Kassambara and Mundt, 2017) packages for the multidimensional analyses and ggplot2 (Wickham, 2016) for the graphical representation of the results.

Results

Phaneroptic and morphology characterization of DR cavy population

Table 1. Phaneroptic and morphology of cavy reared in DRC (%)

Characteristic	modality	Katanga	Kinshasa	North Kivu	South Kivu	Mean
Sex	female	68.67	79.17	76.35	66.86	69.46
	male	31.33	20.83	23.65	33.14	30.54
Coat color pattern	dichromic	46.99	37.50	30.74	37.74	36.69
	monochromic	16.87	4.17	16.55	14.74	15.11
	trichromic	36.14	58.33	52.70	47.52	48.20
Coat color pattern types	white	3.61	0.00	10.14	12.62	11.19
	white-brown	19.28	20.83	21.96	25.24	23.98
	white-brown-gray	7.23	12.50	2.03	4.95	4.56
	white-brown-black	28.92	45.83	50.00	41.98	43.09
	white grey	2.41	4.17	2.70	1.06	1.60
	white black	9.64	4.17	4.39	8.61	7.59
	white-black-gray	0.00	0.00	0.00	0.59	0.40
	brown	13.25	0.00	1.35	0.94	1.84
	gray-brown	8.43	8.33	0.00	0.00	0.72
	brown-black	7.23	0.00	2.36	2.71	2.88
	black	0.00	4.17	5.07	1.30	2.16
Eyes color	black	100.00	95.83	86.15	88.21	88.65
	red	0.00	4.17	13.85	11.79	11.35
Ears orientation	erect	45.78	62.50	60.81	69.93	66.03
	dropping	54.22	37.50	39.19	30.07	33.97
Coat color variegation	absence	34.94	45.83	56.42	64.50	60.27
	presence	65.06	54.17	43.58	35.50	39.73
Satin of the coat	absence	43.37	70.83	81.42	69.93	70.90
	presence	56.63	29.17	18.58	30.07	29.10
Head Profile	ellongated	25.30	45.83	96.28	83.84	82.17
	rounded	74.70	54.17	3.72	16.16	17.83

The table 1 presents the phaneroptic and morphology characteristics of cavies according to their origin.

It appears globally from table 1 that in DRC, cavy population, there exist 3 main coat colors patterns: the white, brown and black from which derive several combinations of coat color patterns observed in cavies. These cavies have predominantlytrichromic coat color pattern (48.20%) or dichromic (36.69%), the most common combination being white-brown-black (43.09%) for the trichromic or the brown-white (23.98%) for the dichromic. Most of cavies have black eyes (88.65%) while those with red eyes (11.35%) also have a white colored pattern and are associated with albinism in this species. Only 33.97% of cavies have drooping ears and this trait is more associated with improved cavies. The coat color variegation and satin of the coat are present in 39.73% and 29.10% of the population respectively, while the head is mostly elongated (82.17%).

Descriptive analysis of the morphological characteristics of cavies reared in DRC

The average, standard deviations, minima, maxima and coefficients of variation of body measurements of cavies from the studied population are presented in table 2. From the table 2, it can be observed that the average weight of an adult cavy from DRC is 577.19 g and varies between 300 and 1203 g, with 25.63% of variation. The animal length ranges from 20 to 38.5 cm (28.6 cm average), against 11 to 30 cm of body length. However, on average, the head length, the animal height as well as the heart girth

are respectively 7.98 cm, 10.98 cm and 17.07 cm. Only body weight had the highest variation compared to the rest of measurements.

Table 2. Body Measurements in cavies from the DRC

Characteristics	Mean	Standard deviation	Variance	CV	Min	Max	Number of observations
PV	577.19	147.91	21876.91	25.63	300	1203.0	1250
LAl	28.63	2.65	7.03	9.26	20	38.5	1249
LC	20.65	2.58	6.65	12.49	11	30	1249
LT	7.98	1.18	1.40	14.79	5	19	1249
PT	17.07	1.88	3.53	11.01	10	25	1249
HG	10.98	1.39	1.93	12.66	14	19.5	1249

LW (animal weight), TAL (Total animal length), BL (body length), HL (head length), HG (heart girth), AL (animal height). PV (animal weight), LAl (animal length), LC (body length), LT (head length), PT (heart girth), HG (animal height).

Influence of sex and province of origin on cavy body measurements variations

Table 3: Effect of sex and province of origin on body measurements of cavies raised in DRC

Province	**Sex**	**LW (g)**	**TAL (cm)**	**BL (cm)**	**HL (cm)**	**HG (cm)**	**AH (cm)**
South Kivu	F	619.35± 0.10^{a}	28.94±0.10^{c}	20.75±0.10^{b}	8.28±0.10^{a}	17.57±0.10^{ab}	11.30±0.46^{a}
	M	479.12± 0.14^{b}	27.84±0.14^{b}	19.76±0.14^{a}	8.05±0.14^{b}	16.70±0.14^{b}	10.63±0.10^{b}
	Mean	550.79± 4.80^{B}	28.40±0.09^{B}	20.27±0.08^{B}	8.16±0.03^{A}	17.15±0.06^{A}	10.96±0.04^{B}
Katanga	F	622.75± 0.31^{a}	30.78±0.313^{bc}	24.12±0.31^{b}	6.66±0.31^{a}	17.49±0.31^{ab}	11.61±0.29^{a}
	M	553.53± 0.45^{ab}	30.01±0.45^{ab}	23.38±0.45^{a}	6.63±0.45^{b}	16.96±0.45^{ab}	11.38±0.31^{a}
	Mean	588.14±15.54^{A}	30.40±0.29^{A}	23.75±0.27^{A}	6.64±0.12^{C}	17.22±0.21^{A}	11.49±0.15^{A}
North Kivu	F	602.81± 0.16^{a}	28.45±0.16^{bc}	20.43±0.16^{ab}	7.81±0.17^{ab}	16.63±0.16^{ab}	10.70±0.16^{b}
	M	531.85± 0.29^{b}	27.31±0.29^{bc}	19.65±0.29^{ab}	7.58±0.29^{ab}	15.92±0.29^{ab}	10.46±0.14^{b}
	Mean	580.04± 9.17^{A}	28.13±0.17^{B}	20.22±0.16^{B}	7.77±0.07^{B}	16.35±0.12^{B}	10.58±0.09^{C}
Kinshasa	F	541.63± 0.52^{ab}	29.39±0.52^{a}	22.07±0.52^{a}	7.31±0.52^{b}	16.07±0.52^{a}b	10.86±0.53^{ab}
	M	522.60± 0.91^{b}	29.40±0.91^{a}	22.40±0.91^{a}	7.00±0.91^{b}	16.80±0.91^{a}	10.60±0.91^{b}
	Mean	532.11±33.02^{AB}	29.39±0.61^{AB}	22.23±0.58^{A}	7.15±0.26^{BC}	16.43±0.44^{AB}	10.73±0.32^{BC}
General Mean	F	600.50± 9.08$_{A}$	29.46±0.17$_{A}$	21.90±0.16$_{A}$	7.53±0.07$_{A}$	16.97±0.12$_{A}$	11.12±0.09$_{A}$
	M	525.04±16.65$_{B}$	28.70±0.31$_{B}$	21.34±0.29$_{B}$	7.33±0.13$_{B}$	16.61±0.22$_{B}$	10.76±0.16$_{B}$
	Mean	562.77±12.86	29.10±0.24	21.62±0.22	7.43±0.10	16.79±0.17	10.94±0.13
p-value		0.0001	0.0001	0.0001	0.0001	0.0007	0.0001

*a,b,**c** means in the same column with same letters are statistically comparable (p>0.05). A, B means in same column with same letters are statistically comparable (p>0.05). LW (Live weight), TAL (Total animal length), BL (body length), HL (head length), HG (heart girth), AH (animal height), F (Female) and M (Male), μ ± SE : mean ± Standard Error.*

From table 3 it appears that adult mean live weight of cavy is 562.77 g and generally females are heavier (600.50 g) than males (525.04 g), with significant variation on live weight between provinces for either female or male. Investigations are needed to understand the reason of such variation. Total animal length average 29.1 cm, female having longer total animal length (29.46 cm) than male (28.70 cm). Mean body length is 21.62 cm, again with female (21.90 cm) being longer than male (21.34 cm). Cavy head length was on average 7.43 cm with female (7.53 cm) longer than male (7.33 cm). Cavies from South Kivu (8.16 cm) had the longer head while the shortest head was observed in Katanga (6.64). The heart girth was high for females (16.97 cm) compared to males (16.61 cm), with average of 16.79 cm. Cavies with high heart girth were observed in Katanga and South Kivu provinces (17.22 cm) while the low value was recorded in North Kivu (16.35cm).

The height (height at withers of the cavy) average 10.94 cm with female (11.12 cm) having higher height than male (10.76 cm). The lower value was observed in South Kivu (10.96 cm), while cavies from Katanga had the high value (11.49).

The explanation of these variations observed on body measurements between sex and province of origin needs to be investigated.

Body weight distribution of cavies reared in DRC

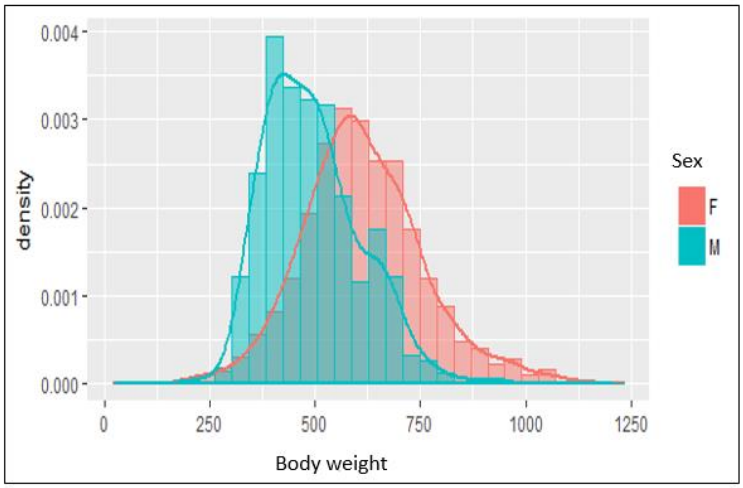

Figure 1. Cavy body weight distribution according to sex.

Result from figure 1 shows a normal distribution of the body weight in females cavies although in male cavies, body weight's distribution seems to be symmetric in female population whereas it seems to be slightly asymmetric in male population. Indeed distribution curve of weight of males tends towards the minimum. That asymmetry highlights a negative selection in male unlike females. However, regardless of sex, there still existence of some individuals with more than 700g for male and 800g for females that indicates an opportunity for selection and improvement. For males, 25% of highly prolific individuals have more than 562.75g while the same proportion of better performing females have more than 700g.

Phenotypic correlation between cavy measurements

Phenotypic correlations between different body measurements in cavies are presented by sex in table 4.It appears that in general, positive correlations were observed between weight and body measurements except between body length (BL) and head length (HL) for the two sexes. Moreover, correlations varied from low (0.081) between HG and BL to high (0.847) between TAL and BL.

Cavies with a rounded head profile are those with shorter head length and the longer body length, the opposite is observed for cavies with elongated head profile. This character can thus be taken into consideration in cavy breeding program as it influences carcass yield.

Discriminant characteristics in cavy population

Figure 2 presents the results of a principal component analysis and the distribution of studied cavies considering their province of origin (a) and sex (b).

Principal component analysis (PCA) was used for cavies by considering animal origin (Katanga, Kinshasa, North Kivu and South Kivu) and sex (Female and Male). Different variables used for this analysis were: animal weight, animal length, body length, head length, heart girth and animal height. As shown in Figure 2a cavies from these different provinces share a certain number of characteristics but some of them are distinct. The first axis separates cavies with large values for quantitative traits from those with small values whereas the second axis separates the cavies with large head length with those with large body length.

Table 4. Phenotypic correlation between cavy measurements

Variables	PV	LAl	LC	LT	PT	HG
PV		**0.62**	**0.53**	**0.28**	**0.56**	**0.49**
LAl	**0.66**		**0.85**	**0.24**	**0.25**	**0.45**
LC	**0.54**	**0.82**		**-0.14**	**0.12**	**0.35**
LT	**0.38**	**0.27**	**-0.17**		**0.36**	**0.20**
PT	**0.60**	**0.26**	**0.08**	**0.40**		**0.24**
HG	**0.39**	**0.37**	**0.24**	**0.30**	**0.35**	

Correlations above the diagonal are for males and those below are for females. LW (animal weight), TAL (Total animal length), BL (body length), HL (head length), HG (heart girth), AL (animal height). PV (animal weight), LAl (animal length), LC (body length), LT (head length), PT (heart girth), HG (animal height).

The results of this analysis (Figure 2a and Figure 2b) indicate that the two axes explain up to 70.73% of the variability observed in the studied cavy population. The first axis, which retains 48.3% of the total inertia, is represented by the following variables: the total length of the animal, the body length and the body weight. For the second axis, it retains 22.4% of the total inertia and is represented by the head length of the animal. The body weight and the animal length are the two variables that make it possible to better distinguish the cavies. It should also be noted that there seems to be very slight difference between cavies from different provinces in terms of quantitative traits (all groups have very close centers of gravity as it can be seen on the Figure 2a). It can also be seen in Figure 2b that females appear to have the highest quantitative trait values while males appear to be smaller.

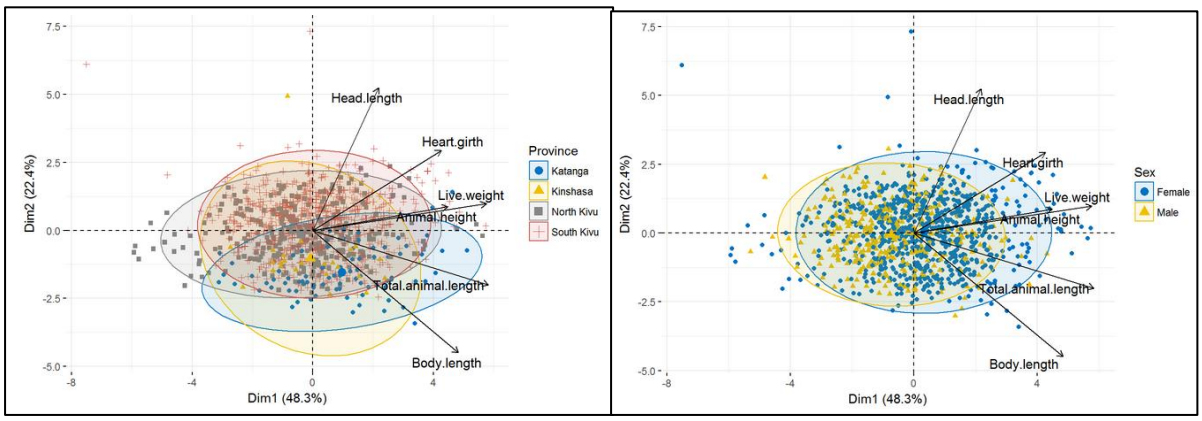

Figure 2. Principal component analysis of cavies considering their origin (a) and sex (b).

Typology of cavy reared in DRC

The factorial map of the qualitative characteristics of cavy are presented in figure 3 (a and b). These results suggest that the main qualitative traits that describe the better the different types of cavies are: coat color pattern, eyes color, the coat color variegation and the head profile. The discriminant and factorial multiple component analysis allowed to highlight 3 classes on the basis of the qualitative characteristics of cavies from DRC.

Class 1 is dominated by cavies with a trichromic coat color pattern that is either, white-black-brown, white-brown-gray or white-black-gray. Cavies belonging to this class have black eyes (52%), coat color variegation (58%), their heads are elongated and they are mainly from Walungu and Uvira (South Kivu).

Class 2, however, contains many more cavies whose coat color are monochromic, either white, brown or black. Their eyes are often red or black and they don't have coat color variegation. They are mainly from Rutchuru in North Kivu.

For class 3, cavies of this class have a dichromic coat color pattern (brown-white, gray-white, black-white or black-brown). Their eyes are black, with a rounded head profile while the coat color variegation is absent. They are much more from Lubumbashi in the Katanga province.

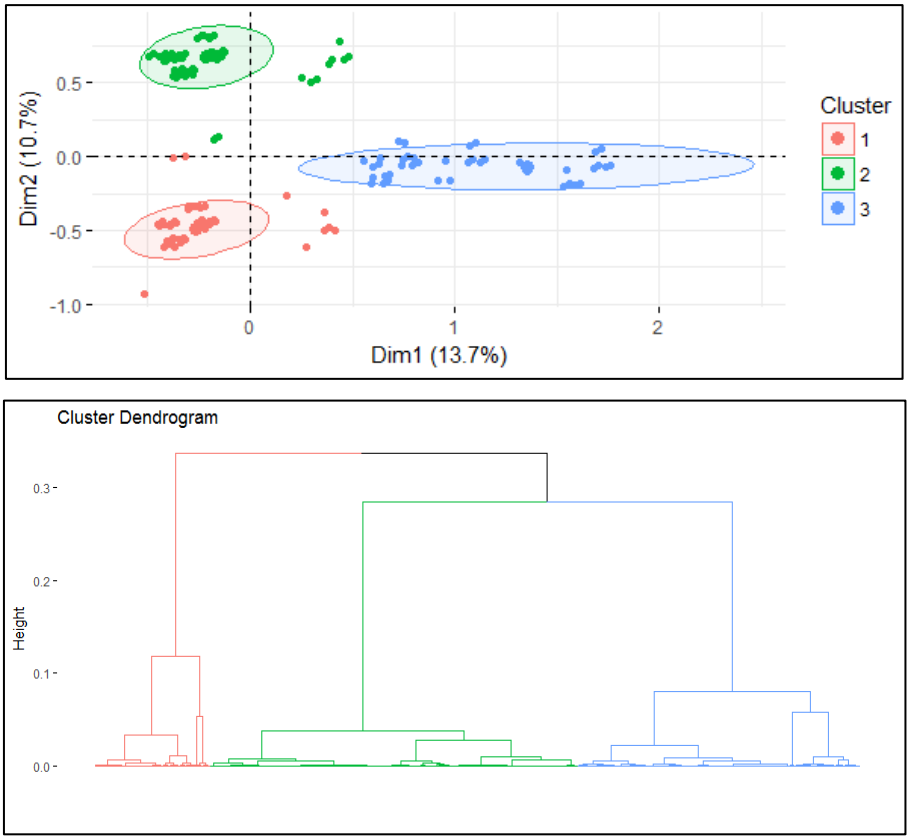

Figure 3. Factorial map and cluster of cavies considering the qualitative characteristics (a and b).

Ascendant hierarchical classification of cavies from DRC

The fourth figure presents the results of the ascendant hierarchical classification of DRC cavies based on morphological measurements. The ascendant hierarchical classification allowed to divide the 1,250 sampled cavies from the four provinces into three (3) distinct groups as shown in Figure 4. The average characteristics of comparison between the three formed classes are presented in table 5. The different characteristics of the three classes (table 5) are as follow:

Class 1: is composed by small sized cavies, which are characterized by on average 26 cm of total animal length, while their body length is 18.6 cm against 7.36 cm of head length. Their body weight is on average 426g, while their heart girth and height are respectively 15.4 and 9.8 cm.

Class 2: this class has cavies whose body weight average is 568.3g. Their total as well as body lengths are respectively 28.3 and 20.3 cm. They are 8.1 cm in head length while the height is 10.5 cm and 17.2 cm of the heart girth.

Class 3: cavies belonging to this class are heavier compared to those from the two other classes. They weigh on average 733.8g at the adult stage; have a total length of 31.4 cm and a body length of 231 cm. Their head length, heart girth and height are respectively 8.2, 18.2 and 11.9 cm.

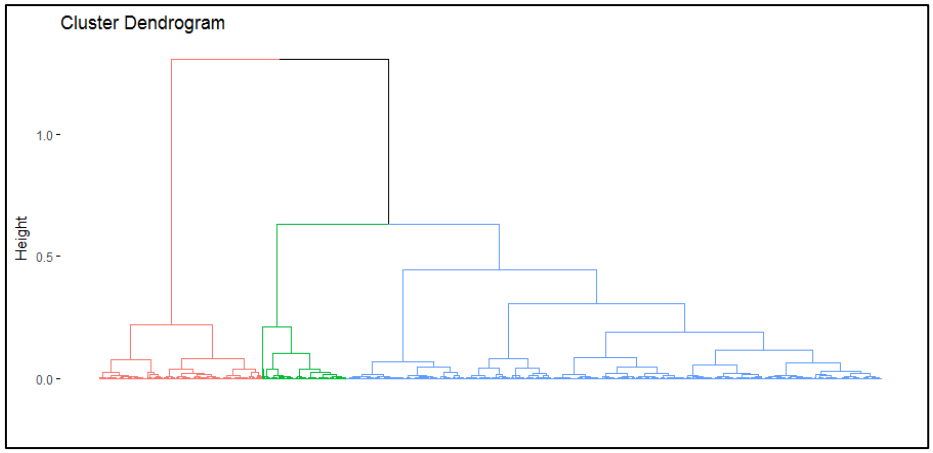

Figure 4. Typology cluster of cavies from DRC

Table 5. Morphometric characteristics of three classes of cavy identified by the ascendant hierarchical classification.

Characteristics	Class 1 (μ ± SE)	Class 2 (μ ± SE)	Class 3 (μ ± SE)
LW (g)	426.0±3.34^{c}	568.3±3.43^{b}	733.8±3.86^{a}
TAL (cm)	26.0±0.10^{c}	28.3±0.11^{b}	31.4±0.12^{a}
BL (cm)	18.6±0.11^{c}	20.3±0.11^{b}	23.1±0.12^{a}
HL (cm)	7.4±0.05^{c}	8.1±0.05^{b}	8.2±0.06^{a}
HG (cm)	15.4±0.07^{c}	17.2±0.07^{b}	18.2±0.08^{a}
AH (cm)	9.8±0.05^{c}	10.5±0.06^{b}	11.9±0.06^{a}
p-value	<0.0001	<0.0001	<0.0001

a,b,c means with same letters in the same row are statistically comparable (p>0.05.
LW (animal weight), TAL (Total animal length), BL (body length), HL (head length), HG (heart girth), AL (animal height). μ ± SE : mean ± Standard Error

Individual's variation analysis

Figure 5 shows the distribution of individuals according to the three classes taking into consideration their discrimination characteristics. The results in Figure 5 indicate that the three classes, although distinct, share a number of features. Class two, represented in green, has average performance and is between class one (represented in red) and class three (shown in blue). Individuals in class one have the worst performances while individuals in class three are the best performers.

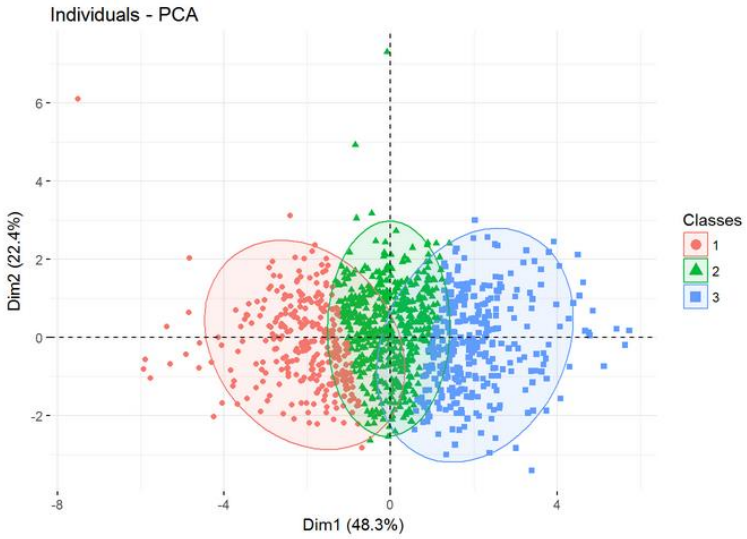

Figure 5. Distribution of cavies in the three identified classes

Discussion

In general, the cavy population has preserved significant genetic and phenotypic variability (Chauca, 1997). The main coat color patterns identified in DRC cavy population are white, brown and black. These colorpatterns are among what is reported in cavy population (Ayagirwe et al., 2015). In this work, the trichromic color pattern was the most dominant, unlike the observation of Ayagirwe et al. (2015) who observed more dichromic pattern in cavies from Cameroon. The studied cavies might belong to type 1 called 'Inglés' (i.e. 'English') with short and smooth hairs. Animals with long and or curly hair, even forming rosettes, as known from South America (Chauca de Zaldívar (1995) have not been reported in Africa. Coat colors are found with or without satin (lightening or shiny hair). High diversity of coat color pattern has been observed in DRC cavy population as reported elsewhere by Fotso et al. (1995) and Ayagirwe et al. (2015) in Cameroon and Kouakou et al. (2015) in Côte d'Ivoire. The same observations have been made by Harman and Case (1941), Festing (1976) and Warren et al. (2008). The existence of different coat color pattern in one individual has been highlighted to be linked to the effect and interaction of several genes, like the Extension (E) locus, the Agouti (A) locus, the Brown (B) locus, the Color (Albino) locus, the Roan (Ro) locus, and the locus responsible for white traces in the coat (S) (Festing, 1976; Warren et al., 2008). The coat color pattern is recognized to be influenced by up to 12 loci (Festing, 1976), however, the different combination of coat color may result in the mating system as well as gene interaction.

In DRC, cavies were red colored eyes (11.35%) or black as reported in literature (Ayagirwe et al., 2018). The majority of cavies reared in DRC have elongated head profile (82.17%) and erected ears (66.03%). In Cameroon, Ayagirwe et al. (2015) reported 53% of cavies with elongated head profile and 56.19% erected ears.

A body weight ranging from 300 to 1,203g was obtained for cavies from DRC. This range of variation is slightly greater than the observations made by Ayagirwe et al. (2015) in Cameroonian cavy population (267 to 1,161g). This performance variation in cavies had already been reported by Manjeli et al. (1995). The farm management system variations, as well as a variability of environmental conditions alongside genetic diversity, are all reasons that may explain this variability (Ayagiwe et al., 2015). Several genetic diversity assessment studies for cavy populations in sub-Saharan Africa (Kouakou et al., 2015a, Poutougnigni et al., 2015, Wikondi et al., 2015, Ayagirwe et al., 2017) and South America (Burgos-Paz et al., 2011, Aviles et al., 2015) have demonstrated the existence of great genetic variability. In this study, cavy weighted on average 577.29g; Metre (2012) reported 540 g in South Kivu for 24 weeks old cavies. In Ivory Coast however, cavy body weight varied from 563 to 594g (Kouakou et al., 2013). Umba et al. (2017a) recorded 486-581g for F1 to F3 of Congolese genotypes and 416-483 g for F1 to F3 from crosses between Congolese and Belgian genotypes. Depending of the age, 403 and 526g respectively for cavies at 15th and 23th weeks in Cameroon were recorded (Fotso et al., 1995). In Africa the live weight of cavies generally varies between 352 and 1200 g (Ayagirwe et al., 2018). The recorded body weight mean is comparable to the documented weight for cavies reared under traditional systems in South America (459g), but remain low compared to improved breed (1,091g at 13^{th} week; Chauca de Zaldívar, 1995). Theses improved breeds in Peru were selected for a birth weight of about 150g with high daily body weight gain such as they can reach at two months about 800g (Chauca de Zaldívar, 1995, Noguera et al., 2008). For laboratory cavies reared under similar conditions, Hudson (2003) recorded an average weight of 900 to 1,200 g for males and 700 to 900 g for females.

The weight distribution was symmetrical and asymmetrical respectively in females and males in the DRC cavy population. Indeed, this asymmetry observed is linked to a negative selection for male. Males are the most targeted when slaughtering or selling cavies, because they do not more intervene more in the herd renewal. Unfortunately, the larger males are also the most eliminated as more meat or cash are expected. This negative selection has been noticed by several researchers (Numbela and Valencia, 2003). In Cameroon, cavy husbandry is influenced by the market (Ayagirwe, 2014). During the period of high demand, farmers sell most of their animals, unfortunately, the animals sold are generally the most vigorous especially males.

The total length of cavy in this study ranged from 20 to 38.5 cm (mean of 28.6 cm) with 7.98 cm head length. This finding is similar to what is reported by several researchers for cavies in Africa (animal length of 20 and 35 cm; Metre, 2012, Ayagirwe et al., 2015, Umba et al., 2017b). In Cameroon, Ayagirwe et al. (2015) reported 8.7cm and 24.73cm respectively for the head and animal length, whereas Faradja (2012) reported 5.34cm and 25.56cm in South Kivu.

From DRC cavy typology, three classes have been observed discriminated both with quantitative variables (animal length, body length, body weight and head length) and qualitative variables (coat color pattern, eyes color, coat color variegation, head profile and the animal origin). Based on phaneroptic features and body measurements in cavy, Ayagirwe et al. (2015) noted that the main components differentiating cavy groups in Cameroon were body weight, coat color variegation, satin of the coat, and the head profile. These phenotypic characteristics vary among populations, regions and countries (Manjeli et al., 1995). They depend both on the breed and the reproduction management system.

Conclusion

Cavy population in DRC is very diversified. Three groups of cavies were obtained after the typology classification. These cavies differ essentially from the animal length, body length, body weight and head length, coat color pattern, eyes color, coat color variegation, head profile and the animal origin. The three classes obtained have different performances ranging from less to more performers. These results indicate a first step in the decision making and orientation of the genetic improvement in this livestock species. Molecular analysis should be considered in order to elucidate the determinisms of the observed phenotypic differences either they are genetically based or they are from environment influence.

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Author's Contributions

Ayagirwe made conception of the work and supervised data collection and manuscript write-up;**Mugumaarhahama and Baenyi** conducted data collection and analysis and produced the first draft**, Meutchieye and Manjeli** revised and improved the paper contents.

Ethics

Authors declare that there are no ethical issues that may arise after the publication of this manuscript.

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