GABJ

Genetics and Biodiversity Journal

Journal homepage: http://ojs.univ-tlemcen.dz/index.php/GABJ

OPEN ACCESS

Original Research Paper

Biometric assessment of White Fulani cattle in a semi intensive production system in Northern Cameroon using principal components analysis

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Article history; Received: May 7, 2019; Revised: July 20, 2019***;*** Accepted: July 24, 2019

Abstract

In order to appraise the population genetic diversity of a Cameroon native beef cattle breed, eighty-eight adult individuals(70 females and 18 males) of the White Fulani cattle breed in North Cameroon were characterized by metric tools involving 12 simple measurements (the height at the withers, the tail length, the face length, the width of the face, the ears'length, the horns'length, the top line which is the occipito-ischial length, the scapulo-ischial length, the bump circumference, the canon bone perimeter, the thoracic perimeter and the weight) and five combined measures, Body length Index (IBL)(oblique one), the Hearth Girth index (IHG), the index of the barrel bone, the index of compactness or massiveness (MI), and the thoracic auricular index (IAT).Sexual dimorphism was exhibit in White Fulani cattle breed for 50 % of the traits measured (Tail length, ear length, bump perimeter, cannon bone circumference, ,heart girth,body weight). For example, the body weight varied from 350.51a±26.61 in cows to 390.56b±51.33 in bulls. The principal components analysis revealed that, as far as body measurements are concerned, three factors accounting for 73.45 % of total variance should be considered for selection purposes. The MI should also be taken into account in such an exercise in White Fulani cattle breed in the North region of Cameroon.

Keywords: Measurements, White fulani, Biodiversity, Phenotype, Cameroon.

Introduction

Currently, about 180 breeds of cattle have been recognized in sub-Saharan Africa; 150 breeds of indigenous cattle and recently introduced exotic and commercial composites (Rege, 1999; Rege et al., 2007).In Cameroon, there is a high genetic diversity of cattle breeds. In fact, both Bosindicus (large majority) and Bos taurus are reared and exploited (Messine et al., 1999).Almost 98 % of those cattle breeds are phenotypically humped cattle or zebu cattle (Bosindicus). Most cattle production is carried out in the three northern regions namely, the Adamawa region, the North region and the Far-North region (Messine et al., 1999).The very high importance of zebu cattle is mainly mediated by the action of the nomadic stockbreeders such as the Fulani which used to raise the White Fulani cattle breed. This later is also called Bunajiby the Haousa tribe or Yakanajiby Fulani tribe in North Nigeria; Aku, Akou, Danedji or Foulbein Foulbe tribe of Cameroon.It is a white coat animal with black ears, eyes, muzzle, hooves, and the tips of horns and tail (Ibeagha and Erhart, 2006).The White Fulani are the most numerous of several West African cattle breeds and have socioeconomic importance and wide distribution in those countries (Tawah and Rege,1994).In Cameroon for example , they represent approximately 33 % of the 7.5 million of the national herd and are mainly found in the North region(INS,2017).They are found within the belt between the Sahara and the rain forest from the west of the river Senegal to the east of Lake Chad including western Senegal, Niger, Nigeria, Chad and Cameroon (Adebayo, 1995).This breed is commonly used for meat, milk and draughtt and its dung used as manure (Kanai et al.,2013). The White Fulani cattle breed can produce 1.52 l/day in an extensive production system (Cissé,2000) to 3.14 l/day (Marichatou et al.,2005)in an intensive production system. Unfortunately, there is a big flow of genes between local breeds like White Fulani and Gudali (NgonoEma et al., 2014).For conservation and management purposes it is crucial to characterize individual breeds, particularly those like White Fulani, which are less documented. In this specific breed, some morphological variations have been observed by Tawah and Rege (1994). Nowadays, variation in morphological traits is considered as the root of the characterization of livestock (Delgado et al., 2001).Morphometric measurements could provide useful information on the suitability of animals for selection (Yakubu et al., 2009).

In Cameroon, despite of some achievements on characterization of White Fulani cattle breed specially using morphometric tools which highlighted a sexual dimorphism (Tawah and Rege, 1994), there is still a need to investigate on their phenotypic diversity by the means of body linear measurements treated as multivariate. In fact, compare to univariate statistical analyses that are common in morphometric characterization of animals, multifactorial discriminant analyses have been found to be more suitable in assessing variation within a population (Dossa et al. 2007). Therefore, the aim of the current research was to assess the variation on biometric traits among White Fulani cattle of Cameroon. Consequences for management and conservation of White Fulani cattle breeds are discussed.

Material and Methods:

The present investigation was carried out in Garoua in the North region of Cameroon, precisely in the semi intensive production system of the Laboratoire National Veterinaire. The area falls within the soudano-sahelianagroecologicalzone and is located within latitude9°15'39.8"Nand longitude 13°26'56.2"E.The climate is a typical hot and dry tropical climate with a dry season of seven to nine months and a monomodal rainy season with annual rainfall ranging from 1200 to 400 mm / year.The vegetation is of savanna type.

A total of 70 adults females (5 to 6 years old) and 18 males (4 to 5 years old) from 152 adults animals, reared through a semi extensive system of management, were measured using simple random sampling method. The animals were carefully screened to avoid measuring related animals, crossbreds, unhealthy and pregnant ones. Age of the individuals was ascertained by examining dentition and direct inquiries to the shepherd.

Twelve (12) biometric traits were measured on each animal considering the AU-IBAR (2015) guidelines.The parts measured and illustrated in fig.1 below were, height at withers (HW), vertical distance from ground to the point of withers measured vertically from the ridge between the shoulder bones to the fore hoof; heart girth (HG), measured as body circumference just behind the forelegs; top line (ToL), measured from distance between the horn site to tail drop; face length (FL), distance from between the horn site to the lower lip; ear length (EL) distance from the point of attachment to the tip of the ear; face width (FW), measured as the distance between the two horn sites; cannon bone circumference (CB), smallest circumference of the cannon bone of foreleg; tail length (TL), measured from the tail drop to the tip of the tail; scapulo-ischiallength (SIL),measured from the tip of the rump to the tip of the shoulder, horn length,the external horn length (EHL), measured as the external length from the base of the horn to the tip of the horn, bump perimeter (BP),measured as the circumference of the bump at its base and the body weight (BW).

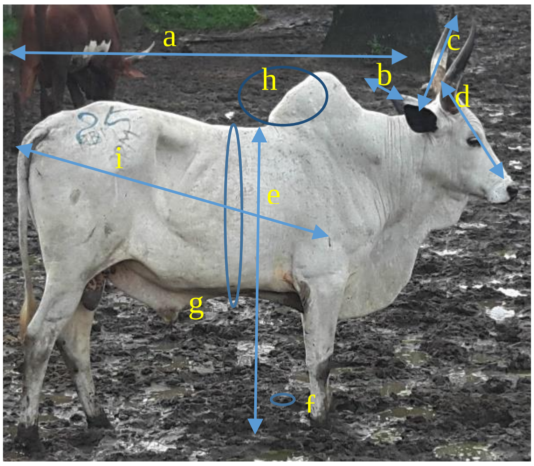

Figure 1: Morphometric measurements of White Fulani cattle breedused in the current study

a :top line ;b :ear length ;c :external horn length ;d :face length ;e :withers height; f :cannon bone circumference ;g :heart girth ;h : bump circumference ;i :scapulo-ischiallength.

Body measurements were carried out using a graduated measuring stick (in cm) and a barymetric tape measure with an accuracy of the order of 20 % of their true weight (Tebug and *al.,2016*).Animals were put on a flat floor and managed by the respective shepherd. Gender of the cattle was also taken into consideration. Measurements were taken early in the morning prior to grazing to avoid the effect of feeding and watering on the body' size and conformation.

For a better consideration of body proportions, ten combined measures were firstly determined as previously described by Putra and Ilham (2019):

Body length Index (BLI) = scapulo-ischiallength(SIL) / height at withers (HW);

Dactyl Thorax Index (DTI) = circumference of the cannon bone / chest circumference,

Index of compactness or massiveness (MI) = live weight (BW) / height at the withers,

Ear length Index(ELI) = (LO/HG)

Cephalic index (CpI)=(FW×100)/FL

Proportionality (Pr)=(HW/SIL)×100

Thoracic development (TD)=HG/HW

Area index (AI)=WH×SIL

Relative cannon thickness index (RCTI)=(CB/HW)×100

Prior to the multivariate analysis, the suitability of the data for Factor Analysis was checked by generating the determinant of the correlation matrix. This later presented a value of 0.0000036 which is lower than the minimal value accepted 0.00001 (Cerny and Kaiser, 1977). The SIL was then removed from the multivariate analysis as it was highly correlated (r=0.826) to the Body length. A new value of 0.000048 was then found allowing us to proceed to the multifactorial analysis.

Statistical analyses

Descriptive statistics including mean, standard deviation, coefficients of variation and biometric indices were carried out using SPSS 20.The overall reliability of the Principal Component analysis was established by

Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity. The KMO should be greater than 0.50 for a satisfactory factor analysis to be done. For the rotation of the factor matrix, the varimax criterion of the orthogonal rotation method was used. Finally, the number of components to extract was determine through the cumulative proportion of variance criterion (Kaiser, 1960) and the scree plot. PCA analysis were carried out in R 3.5.2 and SPSS 20.

Results

Descriptive statistics of morphological traits of White Fulani cattle are presented in Table 1.In average, the three main longitudinal traits varied from 131.90±4.91 cm for HW to 146.50±9.82 cm for SIL and 177.16±12.75 cm for ToL. Except for tail length and ToL, all the means body traits were higher in bulls compare to those computed for cows in White Fulani. Those differences were found to be significant in six cases (TL, EL, BP, CB, HG, BW), showing a clear sexual dimorphism. Among all those biometric measurements, the highest variability was shown by EHL, followed by FW and BP. Relatively low coefficients of variation were exhibit by HW, HG and FL. The coefficients of correlation between biometric traits under study are given in Table 2. The correlation coefficients ranged from -0.298 (cannon bone circumference and tail length) to 0.981 (heart girth and body weight). BW was highly correlated to HG (r=0.981), followed by SIL(r=0.639) and HW(r=0.637).

Table 1: Means (in cm)±SD ,coefficients of variation in percentage (%) (in brackets) and contribution to the factors identified by PCA for 12 body measurements assessed in local White Fulani cattle of Cameroon

Traits	Females	Males	Total	Factor 1$^{\alpha}$	Factor 2$^{\beta}$	Factor 3$^{\gamma}$
N	70	18	88			
TL	88.31^{a}±6.80 (7.70)	81.33^{b}±9.06 (11.14)	86.89±7.79 (8.97)	*0.000*	***0.767***	*0.000*
FL	47.14±3.23 (6.85)	49.22±2.34 (4.75)	47.57±3.17 (6.66)	**0.695**	-0.383	*0.000*
FW	18.13±2.59 (14.29)	19.44±1.54 (7.92)	18.40±2.47 (13.42)	***0.602***	**-0.612**	*0.000*
EL	22.61^{a}±1.84 (8.14)	24.83^{b}±2.31 (9.30)	23.07±2.13 (9.23)	**0.629**	-0.358	*0.000*
EHL	44.61±9.34 (20.94)	45.83±8.99 (19.62)	44.86±9.24 (20.60)	*0.257*	*0.328*	**0.844**
ToL	177.76±11.88 (6.68)	174.83±15.88 (9.08)	177.16±12.75 (7.17)	***0.715***	0.531	0.000
SIL	146.043±11.88 (8.13)	148.28±11.89 (8.02)	146.50±9.82 (6.70)	*0.000*	*0.000*	*0.000*
HW	131.37±4.73 (3.60)	133.94±5.21 (3.89)	131.90±4.91 (3.72)	***0.767***	**0.541**	*0.000*
BP	67.43^{a}±6.97 (10.34)	72.89^{b}±7.65 (10.50)	68.55±7.41 (10.81)	***0.724***	**0.443**	*0.000*
CB	18.07^{a}±1.64 (9.08)	21.00^{b}±1.33 (6.33)	18.67±1.98 (10.61)	***0.658***	*0.000*	-0.448
HG	163.92^{a}±5.42 (3.31)	173.56^{b}±11.78 (6.79)	165.90±8.11 (4.88)	***0.712***	***-0.544***	*0.000*
BW	350.51^{a}±26.61 (7.59)	390.56^{b}±51.33 (13.14)	358.70±36.61 (10.21)	***0.821***	*0.000*	*0.000*

TL=Tail length; FL=Face Length; FW=Face width; EL=Ear length; EHL=External Horn Length; ToL=Top Line; SIL=Scapulo-Ischial Length; HW=Height at Withers; BP=BumpPerimeter;CB=Cannon Bone circumference;HG=Heart Girth;BW=Body Weight
Results and samplesize(N)are given per gender.
Eigenvectors computed for the three factors identified using principal component analysis are also given.
Eigenvectors higher than |0.480| are in bold
Eigenvalue=4.58; proportion of the total variance explained=41.63 %
Eigenvalue=2.43; proportion of the total variance explained=22.07 %
Eigenvalue=1.07; proportion of the total variance explained=9.75 %
^{a,b} Different letters in a row implies a significant difference ($p<0.05$) on a body trait according to the gender

Table 2 : Correlation among different morphometric traits in local White Fulani cattle of Cameroon

	TL	FL	FW	EL	EHL	ToL	SIL	HW	BP	CB	HG	BW
TL	1											
FL	-0,045	1										
FW	-0,224*	0,774**	1									
EL	-0,082	0,438**	0,504**	1								
EHL	0,336**	0,091	0,003	0,108	1							
ToL	0,456**	0,263*	0,111	0,241*	0,270*	1						
SIL	0,435**	0,317**	0,131	0,268*	0,233*	0,879**	1					
HW	0,385**	0,342**	0,124	0,241*	0,146	0,634**	0,826**	1				
BP	0,065	0,375**	0,400**	0,359**	-0,089	0,441**	0,418**	0,398**	1			
CB	-0,298**	0,587**	0,650**	0,614**	0,096	0,218*	0,204	0,262*	0,554**	1		
HG	0,033	0,470**	0,420**	0,494**	0,286**	0,520**	0,595**	0,590**	0,389**	0,645**	1	
BW	0,087	0,479**	0,414**	0,495**	0,282**	0,537**	0,639**	0,637**	0,431**	0,609**	0,981**	1

*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level

PCA allowed to identify three factors with an Eigenvalue>1(Kaiser, 1960).This was confirmed by the scree plot as shown in Fig. 1. Those three factors were representative of the total information with 73.75 % of the cumulative Eigenvalues.

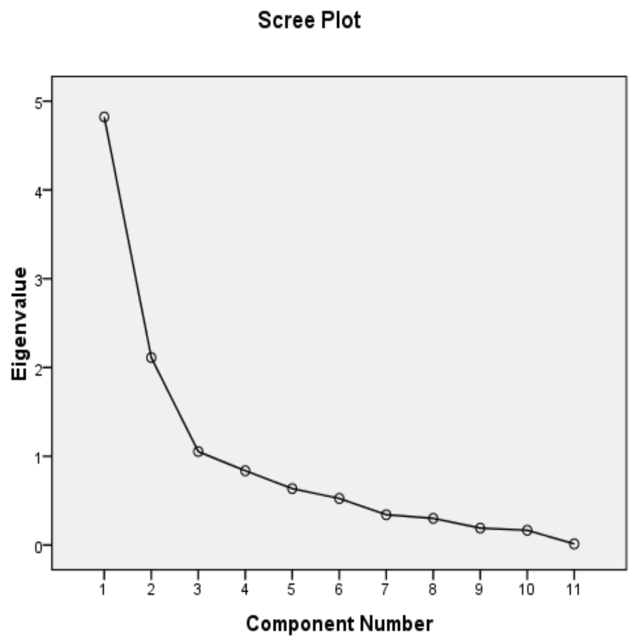

Figure 1: Scree plot showing component number with Eigenvalues for body measurements of White Fulani cattle breed of Cameroon

In the current study, factor 1 explained 41.63 % of the variance for body measurements while factor2 and factor 3 gathered 22.07 % and 9.75 % of the variability respectively. As shown in fig. 2, all the traits are positively correlated to Factor 1. It had comparatively higher loading for HG, HW and BP. Less representative, factor 2 tended to discriminate between length measurements (positive correlation) and width or circumference measurements (negative correlation). A reliable analysis of the third factor could not be achieved as there is a commonly used rule that there would be at least three variables per factor (SAS, 1998). In the present study, there were only two variables.Pundir et al. (2011) reported that 7.44% of variation was explained by the third factor in Kankrej cows in India.

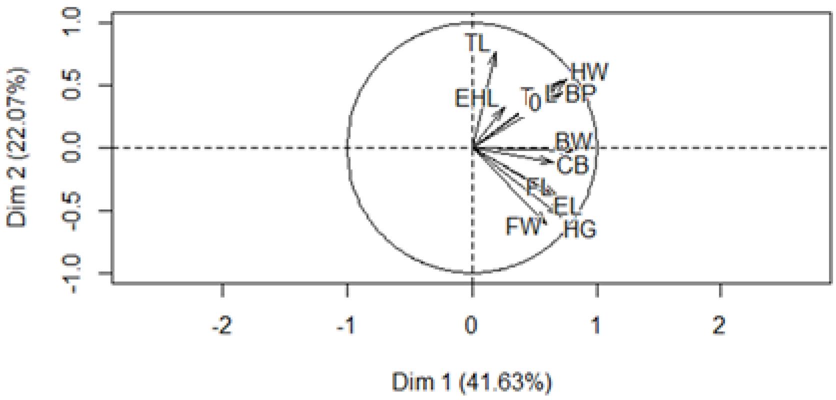

Figure 2 : PCA of 11 body traits in White Fulani Cattle breed of Cameroon.

Factor1 lies on the x axis and factor2 on the y axis. Abbreviations on the graph mean the following:CB : Cannon Bone Circumference ; HG : Hearth girth ;BW :Body weight ;BP :Bump perimeter ;FW :Face width ;EL :Ear length ;HW :Height at withers ;BL :body length ;EL :Ear Length ;TL :Tail length ;EHL :External Horn Length

According to the results presented in Table 3 below, in White Fulani cattle breed, bulls showed a significantly higher thoracic development and relative cannon bone thickness compare to cows. Furthermore, they are much more massive, hence more suitable for meat production.

Table 3: Descriptive statistics of nine body indices assessed in White Fulani Cattle breed of Cameroon

Parameter		BLI	DTI	MI	ELI	CpI	Pr	TD	AI	RCTI
Females	**Mean**	1.11	0.11[a]	2.67[a]	0.17[a]	38.35	90.16	1.25[a]	19219.79	13.77[a]
	SD	0.46	0.01	0.17	0.02	3.82	3.89	0.04	1834.289	1.29
	CV(%)	41.44	9.09	6.37	11.76	9.96	4.31	3.2	9.54	9.37
Males	**Mean**	1.11	0.12[b]	2.91[b]	0.19[b]	39.47	90.61	1.30[b]	19917.00	15.69[b]
	SD	0.48	0.01	0.29	0.01	1.98	3.84	0.06	2409.70	0.95
	CV(%)	43.24	8.33	9.97	5.26	5.02	4.24	4.62	12.10	6.06
Total	**Mean**	1.11	0.11	2.72	0.18	38.58	90.25	1.26	19362.40	14.16
	SD	0.47	0.01	0.22	0.02	3.54	3.86	0.05	1970.56	1.45
	CV(%)	42.34	9.09	8.08	11.11	9.18	4.28	3.97	10.18	10.24

BLI=Body length Index; DTI=Dactyl Thorax Index; MI=Index of compactness or massiveness; ELI= Ear length Index; CpI=Cephalic index; Pr=Proportionality; TD=Thoracic development;AI=Area index; RCTI=Relative cannon thickness index

[a,b]Different superscript in a column indicates a significant difference ($p<0.05$) of the index according to the gender

The total variance explained by different components and rotated component matrix of different body indices of White Fulani in this study were presented in Table 3 and Table 4 respectively. The Kaiser-Meyor-Olkin (KMO) measure of sampling adequacy of body indices was 0.66. The overall significance of the correlations tested with Bertlett's test of Sphericity for the body indices (chi-square was 192.93, $P<0.01$) was significant and provided enough support for the validity of the factor analysis of data. There were two components extracted from different body indices with eigen values greater than 1.00.Those factors accounted for 72.65% of total variance (Table 3). The first (PC1) and second (PC2) components explained 41.20 % and 31.45 % of total variance respectively.

Table 4: Repartition of total variance according to body indices in the present study

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
BLI	2,47	41,20	41,20	2,47	41,20	41,20	2,40	39,94	39,94
ELI	1,89	31,45	72,65	1,89	31,45	72,65	1,96	32,71	72,65
MI	0,56	9,37	82,01						
CpI	0,55	9,12	91,14						
AI	0,28	4,72	95,85						
RCTI	0,25	4,15	100,00						

As described in Table 4, the body indices that closely related the most to factor 1 were ELI, MI and CpI. Moreover, MI was positively and strongly related to both factors.

Table 4: Rotated component matrix of different factors for body indices in the present study

	Principal Components	
	1	**2**
BLI	-0,002	0,897
ELI	0,788	-,042
MI	0,627	0,550
CpI	0,768	-0,005
AI	-0,086	0,923
RCTI	0,887	-0,036

Discussion

In a study on morphostructural indices of White Fulani cattle in Nigeria, Yakubu et al(2009) found smaller values for HW (111.84±0.98) and ToL (175.29±2.25) compare to the results presented in the current study.This can probably be explained by the age (2.5-3.6 years old) of their animals. In Sudan, Alsiddig et al. (2010) also found smaller values of HW in Baggara cattle with its main sub-types Nyalawi and Mesairi.The zebu Peul sires described by Traoré et al. (2016) were shorter (height at withers and scapulo-ischiallength of 120.6 ± 1.8 and 130.9±2.6 respectively), and less ‘rounded’ (heart girth of 149.2 ± 3.1 cm) with shorter horn length (31.4±1.7).However, the results founded in the current study are in accordance with Tawah and Rege (1994) who stated that White Fulani are fairly medium to large size.The positive and significant correlation among different biometric traits suggested high predictability among the various traits.Concerning the variability of the traits,Fantazi et al. (2017) also found a relatively high variability in horn length of Algerian goats breeds. A different picture was presented by yakubu et al. (2009) with TL and HG showing the highest variability.The low variability in HW and HG indicates that the White Fulani of North Cameroon were almost similar in their body conformation.

In a study of 14 morphostructural traits of White Fulani cattle in Nigeria,Yakubu et al. (2009) extracted two factors in the age group of 1.5 to 2.4 years representative of 85.37% of total variation after using PCA. This is lower than the three factors extracted in the current study.However , similar to the present findings,inPalanpur district of Gujarat, India , Pundir et al. (2011) extracted three factors from 18 different biometric traits in Kankrej cows which accounted for 66.02 % of total variation.

In alignment to the present study, Sadek et al. (2006), Karacaroen et al. (2008), Yakuba et al. (2009), Pundir et al. (2011), reported that the first factor explained highest variation. In the same vein, Tolenkhomba et al.

(2012) precised that the first extracted factor determine the main source of variability, i.e. general size, in White Fulani. This factor could be considered in selection programs to acquire highly coordinated bodies in White Fulani with fewer measurements. In comparison to the three factors found with an eigen value greater than 1 in the current study, Yakubu et al. (2009) extracted two factors in the age group of 1.5 to 2.4 years representative of 85.37% of total variation, and four factors in the age group of 2.5 to 3.6 years accounting for 86.47% of the total variation by studying the 14 morphostructural traits of White Fulani cattle in Nigeria. In Palanpur district of Gujarat, India, Pundir et al. (2011) extracted three factors from 18 different biometric traits in Kankrej cows, which accounted for 66.02 % of total variation.

Biometric indices were also very useful to analyze. In fact, Putra and Ilham (2019) described three category of goats according to their BLI : breviline (BI<0.85), medioligne (0.86 <BI<0.88) and longiligne (BI>0.88).They also classify their animals according to the DTI and found four classes : light animals (DTI<0.105), intermediary (0.106<DTI<0.108), light meat animals (0.109<DTI<0.11) and heavy meat animals (0.111<DTI<0.115).From these two classifications, the present study demonstrated that White Fulani were longiligne animals with bulls being heavy meat animals and cows light meat animals. Furthermore, PCA of biometric indices showed that MI should be considered in any selection program of White Fulani cattle breed in North Cameroon.

Conclusion

The multivariate analysis technique was used for the reduction of morphometric traits and biometric indices of White Fulani cattle in a semi intensive production system in North Cameroon.Three factors were obtained with the biometric traits which contributed to 73.45 % of total variance. The first factor appeared to be exploitable in breeding and selection programs to acquire coordinated animal bodies using fewer measurements. Meanwhile, the PCA of the biometric indices revealed that two factors representing 72.65 % of the total variation should be considered. Mass Index should be highly taken into account in a selection involving White Fulani in North Cameroon as it was the only indice to positively contribute to both factors. However, biotechnology and genomics tools have also to be used to identify and achieve the characterization not only of White Fulani cattle breed but of all the local indigenous cattle breeds in Cameroon.

Acknowledgment

We thank the helps of herders during sampling. Special thanks to DrAbdoulkadiriSouley,Chief executive officer of the LANAVET in Garoua, Dr Rodrigues Mpoueme and Dr Gomsu Charles Dada.

Author Contributions

DrNgonoEma and DrMeutchieye designed and implemented the study. The manuscript was written by DrNgonoEma and revised by DrMeutchieye.All this work was done under the general supervision of Professor ManjeliYacouba.

Conflict of Interest

All authors declare that there is no conflict of interest.

References

Adebayo AG. 1995: “Of Man and Cattle: A Reconsideration of the Tradition of Origin of Pastoral Fulani of Nigeria”History of Africa 18 (1991), pp 1-21.

Alsiddig MA. Babiker SA. Galal MY. Mohammed AM. 2010. Phenotypic characterization of Sudan Zebu cattle (Baggara type). Research. Journal of. Animal and Veterinary Sciences, 5: 10–17.

Bouba M.2005. Évolution et situation actuelle de l’élevage au Cameroun. Rapport de synthèse, MINEPIA-Cameroun, 42 p.

Cerny CA. Kaiser HF. 1977. A study of a measure of sampling adequacy for factor-analytic correlation matrices. Multivariate Behavioral Research, 12(1), 43-47.

Cissé S. 2000. Stratégie nationale en matière de diversité biologique. Tome 1: situation générale de la diversité biologique au Mali, p.122.

Delgado JV. Barba C. Camacho M.E. Sereno FTPS. Martinez A. Vega-Pla J.L. 2001. Livestock characterisation in Spain. Animal Genetic Research. Information. 29: 7–18.

Dossa LH. Wollny C. Gauly M. 2007. Spatial variation in goat populations from Benin as revealed by multivariate analysis of morphological traits. Small Ruminant Research, 73: 150–159.

Ibeagha-Awemu EM. Erhardt G. 2006. An evaluation of genetic diversity indices of the Red Bororo and White Fulani cattle breeds with different molecular markers and their implications for current and future improvement options," TropicalAnimal. Health Production, 38(5):431-441.

INS. 2017. "Elevage et Pêche" In Annuaire statistique du Cameroun, pp 208-219.

Kaiser HF. 1960. The application of electronic computers to factor analysis. Educational and Psychological Measurement, 20, 141-151.

Kanai ET. Wamagi IT. Zagi I. 2013. Phenotypic Characterization of White Fulani and Bunaji x Fresian Breeds of Cattle from National Animal production research Institute (NAPRI) Cattle Hard from Nigeria. World Journal of Agricultural Science1 (6) 215-219.

KaracaroenB. Kadarmindeen HN. 2008. Principal component and clustering analysis of functional traits in swiss dairy cattle. Turkish Journal of Veterinary and Animal Sciences 32:163-171

Fantazi K. Marco T. Benedetta A. Hossem S. Lo Presti V. Maria L. Gaouar SBS. Maria V. 2017. Characterization of morphological traits in Algerian indigenous goats by multivariate analysis. Genetics and biodiversity journal (GABJ), *1*(2), 20-30.

Marichatou H. Gouro AS. Kanwe AB. 2005. Production laitière de la race Gudali et croissance des jeunes purs et croisés, en zone périurbaine de Bobo-Dioulasso (Burkina Faso). Cahiers de l'Agriculture, 14(3): 291-296

Messine O. Tanya VN. Mbah DA. Tawah CL. 1999. Ressouces génétiques animales du Cameroun passé, présent, avenir : le cas des ruminants.Animal Genetic ResearchInformation,16,51-69.

NgonoEma PJ. Manjeli Y. Meutchieyié F. Keambou C. Wanjala B. Desta AF. Ommeh S. Skilton R. Djikeng A.2014. Genetic diversity of four Cameroonian indigenous cattle using microsatellite markers. Journal of Livestock. Science, 5:9–17.

Pundir RK. Singh PK. Singh KP. Dangi P. S. 2011. Factor analysis of biometric traits of Kankrej cows to explain body conformation. Asian-Australasian Journal of Animal Sciences 24(4):449-456

Putra WPB. Ilham F.2019. Principal component analysis of body measurements and body indices and their correlation with body weight in Katjang does of Indonesia. Journal of Dairy, Veterinary and Animal Research.; 8(3):124–134. DOI: 10.15406/jdvar.2019.08.00254

R Core Team 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rege JEO 1999. The state of African cattle genetic resources I. Classification framework and identification of threatened and extinct breeds. Animal Genetic Research Information, 25: 1–25.

Rege JEO. Hanotte O. Mamo Y. Asrat B. Dessie T. 2007. Domestic Animal Genetic Resources Information System (DAGRIS). International Livestock Research Institute, Addis Ababa, Ethiopia.

Sadek MH. AZ. Al-Aboud A. Ashmawy A. 2006. Factor analysis of body measurements in Arabian horses. Journal of Animal Breeding and Genetics 123:369-377.

SAS, 1998. SAS/STAT User's Guide, release 6.03 edn. SAS Institute Inc., Cary, NC,

SPSS 20, IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp

Tebug SF. Missohou A. Sabi SS. Juga J. Poole EJ. Tapio M. Marshall K. 2016.Using body measurements to estimate live weight of dairy cattle in low-input systems in Senegal. Journal of Applied Animal Research.

Tawah CL. Rege JEO. 1994. White Fulani cattle of West and Central Africa. . Animal Genetic Research Information, No. 17, FAO,Rome, Italy.

Traoré A. Koudandé DO. Fernández I. SoudréA. Álvarez I. Diarra S. DiarraF. Kaboré A. Sanou M.TambouraHH.GoyacheF.2016. Multivariate characterization of morphological traits in West African cattle sires. Archives Animal Breeding 59, 337-344. https://doi.org/10.5194/aab-59-337-2016

YakubuA. Ogah DM. Idahor KO. 2009. Principal component analysis of the morphostructural indices of White Fulani cattle. Trakia Journal of. Science, 7: 67–73