Review Article

Phenotypic characteristics and Gene Frequency of the Banyo Gudali zebu (*Bos indicus*) variety in the high Guinean Savannah zone of Cameroon

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Abstract

This study is aimed at evaluating the phenptypic and genetic diversity of local cattle breeds in Cameroon. To this end, biometric data were collected randomly in six (6) localities of the Mayo-Banyo Division, on a sample of 321 adult Banyo Gudali zebu cattle (234 cows and 87 bulls) aged between 6 and 16 years and having a body condition score varying from 2 to 4. Results reveal a variability of the coat color i.e., 19,00% white coat and its derivatives (speckled, stoat, grey, truiture); 9.99% black coat and its derivatives (black list and black piebald); 18.06% piebald (4.67% black piebald and 13.39 red piebald); 52.94% red and its derivatives (red piebald and red list). The single-colored coats are less represented (38.94%) compared to double-colored coats (61.06%). The frequency of alleles S^+, D, ED, Aa, E^+, s, A^+, e and P are respectively 0.315; 0.201; 0.140; 0.267; 0.859; 0.685; 0.733; 0.386 and 1.000. There is a predominance of white-black horns (50.2%) over grey horns (42.4%). This population is characterized by long hairs, straight-edged ears oriented laterally and with humps occupying a cervico-thoracic position. The facial and back profiles are straight. The neck has a horizontal curved profile, the rump with a low set tail. Crescent shaped horns predominate (73,5%) followed by the horns in low lyre (15,9%) with the other shapes (stump, lateral pointed tip, crown and asymmetrical deformed right or left) being the least represented. The raised horns (92.5%) are predominant. Erect and moderate humps (86.6%) are dominant over drooping ones (13.4%).

Key words: Gudali, phenotypic characteristic, gene frequency, Morpho-biometry, Cameroon

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Resumé

Ce travail vise à évaluer la diversité phénotypique et génétique de la race Banyo Gudali bovine~~s~~ locale~~s~~ du Cameroun. A cet effet, des données morpho-biométriques ont été collectées dans six (6) localités du Département de Mayo-Banyo, de façon aléatoire, sur un échantillon de 321 zébus Gudali adultes (234 vaches et 87 taureaux) âgés de 6 à 16 ans dont la note d'état corporelle varie de 2 à 4. Les principaux résultats montrent une variabilité de la couleur de la robe, soit 19,00% de robe blanche et ses dérivés (moucheture, herminure, grise, truiture) ; 9,99% de noir et ses dérivés (noir liste et noir pie) ; 18,06% de robe pie (4,67% pie noir et 13,39 pie rouge) ; 52,94% de robe rouge et ses dérivés (rouge pie et rouge liste). Les robes monochromes étant moins représentées (38,94%) que les robes dichromes (61,06%). La fréquence des allèles S^+, D, E^D, A^a, E^+, s, A^+, e et P est respectivement 0,315 ; 0,201 ; 0,140; 0,267; 0,859; 0,685; 0,733; 0,386 et 1,000. Une prédominance des cornes blanches-noires (50,2%) suivi des cornes grises (42,4%). Il s'agit d'une population à poils long avec des oreilles à bord droit orientées latéralement et dont la bosse occupe une position cervico-thoracique. Le profil facial est rectiligne tout comme celui du dos. L'encolure a un profil horizontal incurvé, la croupe inclinée à queue attachée bas. Les cornes en forme croissante sont majoritairement représentées (73,5%) suivi des cornes en lyre basse (15,9%), les autres formes (moignon, extrémité pointée latéral, couronne et asymétrique déformé droit ou gauche) étant très peu représentées. Les cornes relevées (92,5%) sont prédominantes. Les bosses dressées et modérées (86,6%) sont dominantes sur celles tombantes (13,4%).

Mots clés : Gudali, caractéristique phénotypique, fréquence génique, Morpho-biométrie, Cameroun

1. INTRODUCTION

The cattle population of Cameroon is estimated at a little over 5,040,000 heads for an annual production estimated at over 110,000 tons of meat. This production represents more than 54% of all meat products consumed per capita per year (MINEPIA, 2011). The latter is constituted mainly of zebus (99%), with the taurine species (1%) being very poorly represented. Zebus arrived in the Northern part of Cameroon from Bornu (in Nigeria) approximately 200 years ago (Paguem *et al.,* 2020). Today, they exist in two breeds: the Gudali zebu (34%) and the M'bororo zebu (66%) (Manjeli and Tchoumboué, 1990). The Gudali zebu which exists in three varieties; the Ngaoundéré, Tignère and Banyo varieties (Lhoste, 1969) are mostly found in the Adamawa region of Cameoon, where they are reared mainly by herders of the Fulani ethnic group. It is estimated that between 400,000 and 600,000 people derive most of their livelihood from cattle breeding (Hamadou, 2009).

This breed represents a very important animal genetic resource for these farmers because of their immense capacity to adapt to a wide variety of climates and ecosystems (FAO, 2007) with a carcass yield ranging from 46 to 52% (Lhoste, 1966). Despite the interest and importance of this breed, very little studies (Lhoste, 1969; Tawah and Rege, 1994; Doba, 2016) have been carried out in view of its phenotypic characterization. The latter constitutes nevertheless a trademark for breeders (Boujenane, 2011; Kabbara, 2008) and equally serves as an indicator of the primarity of the breed (Loukou, 2008). In line with the strategic priority N° 1 of the Global Plan of Action for the management of animal genetic resources, the Ministry of ~~of~~ Livestock, Fisheries and Animal Industries recommends the characterization of native genetic resources as well as the monitoring of associated trends and risks. It is in this context that this study was effected in view of a better valorization of these animal genetic resources.

2. MATERIALS AND METHODS

2.1 Period and area of study

The study was conducted between May and June 2020 in the Mayo-Banyo Division of the Adamawa Region (Figure 1), and more precisely in the Banyo Sub-division. This is because as the name suggests, the Banyo Sub-division is known for its abundance of the Banyo Gudali zebu variety which constitutes a little more than ¾ of the division's cattle population. The prevailing climate is of the Sudano-Guinean type, characterized by a long rainy season of 7 months (April to October) and a short dry season of five months (November to March). Rainfall is abundant (1,500 to 1,800 mm) but unevenly distributed (MINEPAT, 2012). The relief is rugged with an altitude varying between 800m and 1800m.

2.2 Sampling technique

Data were randomly collected in seven (07) different localities of the Mayo-Banyo Division, on a sample of 321 adult Banyo Gudali zebu cattle (234 cows and 87 bulls) aged between 6 to 16 years having a body condition score ranging from 2 to 4. The age of the animals was estimated by a combination of dental chronometry and horn ring count as well as by interviewing the herdsman.

2.3 Data collection

Phenotypic data was obtained by simple visual and direct daylight observations, and in accordance with AU-IBAR (2015), FAO (2007) and Souyoudi (2017) guidelines. These include: coloration of dander (coat, horns, hooves, muzzle and eyelid), shape and orientation of the horns, position and shape of the hump, facial, neck and dorsal profile. In the present study, gene frequencies at four coat coloration loci namely extension (E), agouti (A), spotting (S) and dun dilution (D) were studied. At the Extension locus, there are three alleles: E^D

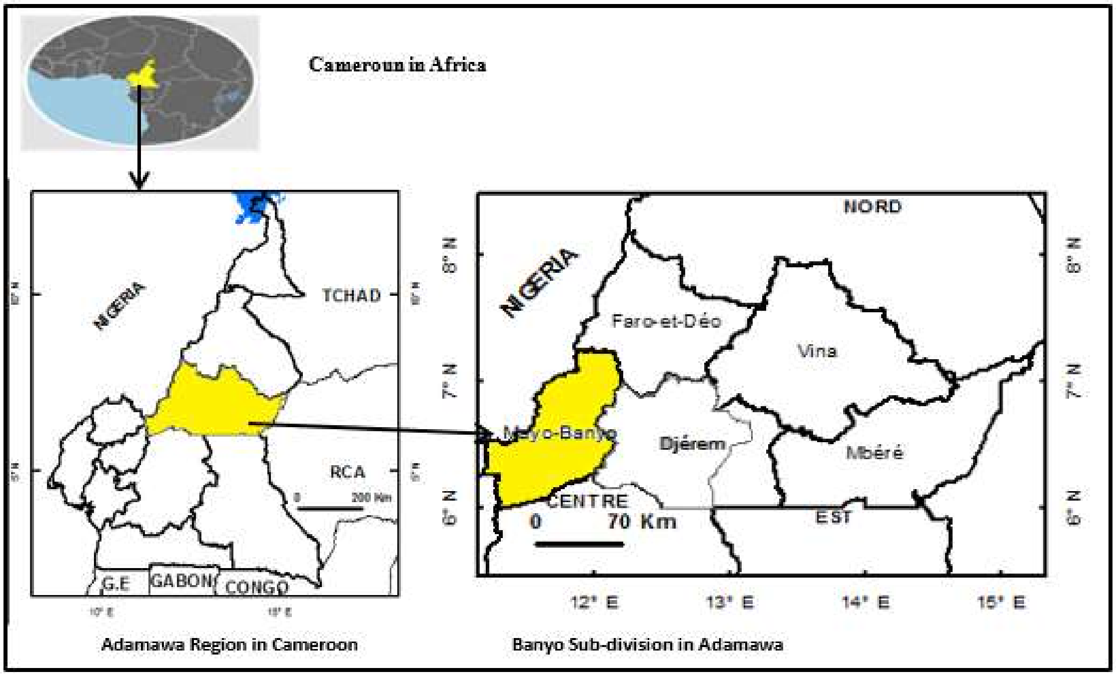

Figure 1 : Study zone
Banyo Municipality (2015)

which generates a black phenotype with dominant inheritance; E^+ which is the wild allele responsible for the black pigmentation, and e which is the recessive red allele. Indeed, animals e/e are red, individuals E^D/E^+ are typically black, individuals E^+/e tend to red and individuals E^+/E^+ can vary in color between red and black (Kabbara, 2008; Boujenane, 2011). At locus A (agouti), we note the existence of a recessive black allele (a) and a wild allele (A^+) which allows the combined expression of red and black pigments of the wild coat. The allele (a) in homozygous form, has no effect on color in the presence of genotypes e/e or E^D/- for the locus (E) (Kabbara, 2008). At the White-spotting locus, we find the recessive allele (s) which is responsible for white-spotting and the wild allele (S^+) which when expressed, the animal is unspotted (Kabbara, 2008). The D allele of the "Dilute" gene is epistatic to alleles of the "Extension" gene and induces the expression of a white coat color (Kabbara, 2008).

Photo. Some Banyo Gudali varieties

2.4 Statistical analysis

Descriptive statistics (mean, standard deviation, frequency) as well as the Chi-square tests were performed by SPSS version 20 software. The phenotypic and gene (allelic) frequencies were calculated according to the formula proposed by Minvielle (2010).

Phenotypic frequency = (total individuals with the concerned phenotype) / (total number of individuals)

Gene frequencies = (total alleles concerned) / (total number of individuals)

3. RESULTS

3.1 Colour of coat, muzzle, eyelid and hooves

The description of the coat color in the 321 adult animals revealed a great variability. A total of 19.00% of animas had the coat and or its derivatives (i.e., speckled, stoat, grey, tuiture); 9.99% had a black coat or its derivatives (black list and black piebald); 18.06% were piebald (4.67% black piebald and 13.39 red piebald) while 52.94% had a red coat or its derivatives (red piebald and red list). Double-colored coats are predominant (53.9%) compared to single coat (46.1%). Among the single-colored coats, we note the presence of white subjects though rare as well as that of dark-red animals. Whether it is the muzzle, the eyelids or hooves, two color variants have been noted: black and light. In most cases, the colors of the muzzle, eyelid and hooves are uniform. The number and percentage of coat pattern, muzzle, eyelid and hoof colors are summarized in Table 1.

Table 1: Coat pattern, muzzle and hoof colors by sex, breeding system, locality and coat

Sources of variation	Muzzle / eyelid		Total	Hoof		Total	Coat color pattern		Total
	Clear	Black		Clear	Black		Dichrome	Monochrome	
	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)
Sex	**ns**			**ns**			**ns**		
Cow	100(72.5)	134(73.2)	234(72.9)	84(69.4)	150(75.0)	234(72.9)	124(71.7)	110(74.3)	234(72.9)
Bull	38(27.5)	49(26.8)	87(27.1)	37(30.6)	50(25.0)	87(27.1)	49(28.3)	38(25.7)	87(27.1)
Breeding system		**ns**		**ns**			**ns**		
Controlled	23(16.7)	29(15.8)	52(16.2)	23(19.0)	29(14.5)	52(16.2)	30(17.3)	22(14.9)	52(16.2)
Non controlled	115(83.3)	154(84.2)	269(83.8)	98(81.0)	171(85.5)	269(83.8)	143(82.7)	126(85.1)	269(83.8)
Localities	*******			******			**ns**		
Bunji	9^{a}(6.5)	41^{b}(22.4)	50(15.6)	9^{a}(7.4)	41^{b}(20.5)	50(15.6)	20(11.6)	30(20.3)	50(15.6)
Banyo Centre	48^{a}(34.8)	68^{a}(37.2)	116(36.1)	44^{a}(36.4)	72a(36.0)	116(36.1)	68(39.3)	48(32.4)	116(36.1)
Leswouroun	9^{a}(6.5)	0^{b}(0.0)	9(2.8)	3^{a}(2.5)	6^{a}(3.0)	9(2.8)	6(3.5)	3(2.0)	9(2.8)
Tiqué	34^{a}(24.6)	33^{a}(18.0)	67(20.9)	27^{a}(22.3)	40^{a}(20.0)	67(20.9)	36(20.8)	31(20.9)	67(20.9)
Fronctière Banyo-Tibati	12^{a}(8.7)	22^{a}(12.0)	34(10.6)	12^{a}(9.9)	22^{a}(11.0)	34(10.6)	17(9.8)	17(11.5)	34(10.6)
Mayo Djinga	26^{a}(18.8)	19^{b}(10.4)	45(14.0)	26^{a}(21.5)	19^{b}(9.5)	45(14.0)	26(15.0)	19(12.8)	45(14.0)
Coat color	***				***		***		
White	5^{a}(3.6)	20^{b}(10.9)	25(7.8)	5^{a}(4.1)	20^{a}(10.0)	25(7.8)	12^{a}(6.9)	13^{a}(8.8)	25(7.8)
Black	1^{a}(0.7)	22^{b}(12.0)	23(7.2)	1^{a}(0.8)	22^{b}(11.0)	23(7.2)	5^{a}(2.9)	18^{b}(12.2)	23(7.2)
Pie	69^{a}(50.0)	70^{b}(38.3)	139(43.3)	63^{a}(52.1)	76^{b}(38.0)	139(43.3)	127^{a}(73.4)	12^{b}(8.1)	139(43.3)
Red	63^{a}(45.7)	71^{a}(38.8)	134(41.7)	52^{a}(43.0)	82^{a}(41.0)	134(41.7)	29^{a}(16.8)	105^{b}(70.9)	134(41.7)
Overall average	**138(43.0)**	**183(57.0)**	**321(100)**	**121(37.7)**	**200(62.3)**	**321(100)**	**173(53.9)**	**148(46.1)**	**321(100)**

* * ($p < 0.01$), *** ($p < 0.001$), **ns:** not significant, **a, b**: numbers with the same letter in the same column are statistically comparable, **n:** sample size

3.2 Phenotypic and gene frequencies of staining loci

The main results (Table 2) show a large fluctuation of the gene frequencies with a predominance of the E^{+}, s and A^{+} alleles. The technique of data collection as well as other exogenous factors (introgression, selection, etc.) could be at the origin of this fluctuation in gene frequencies.

Table 2: Phenotypic, Genetic and gene Frequencies of genotypes

Phenotype	N	(%)	Genotype				Alleles	Frequency
White	13	0.040		$S^+/-$		DD	S^+	0.315
							D	0.201
Black	23	0.071	$E^D/-$	$S^+/-$	A^a/A^a		E^D	0.140
							A^a	0.267
Pie	151	0.470	$E^+/-$	s/s			E^+	0.859
							s	0.685
Dark red	86	0.267	$E^+/-$		$A^+/-$		A^+	0.733
Light red	48	0.149	e/e				e	0.386
Hornless	00	0.000			P/p		P	0.000
Horned	321	1.000			p/p		p	1.000

E = extension, S= spotting, A= agouti, D = Dilute, P = polled locus

3.3 Horn coloration according to sex, breeding system, locality and coat

The Chi-square test shows that the color of the horn is associated with the sex of the animal, the breeding system and the locality as presented in the Table 3. There is a strong predominance of horns half white at the base and half black at the top (50.2%), followed by gray horns (42.4%). These are associated with the pie and red coat color. The black and white horns are the least represented within the population (i.e., 6.5% and 0.9% respectively). A similar trend is observed with the other factors; sex, breeding system and locality.

Table 3: Horn coloration according to sex, breeding system, locality and coat

Sources of variation	**Horn coloration**				**Total**
	White-black	White	Grise	Black	
Sex	***				
	n (%)	n (%)	n (%)	n (%)	n (%)
Cow	108^{a}(67.1)	$3^{a.b}$(100.0)	114^{b}(83.8)	9^{a}(42.9)	234(72.9)
Bull	53^{a}(32.9)	$0^{a.b}$(0.0)	22^{b}(16.2)	12^{a}(57.1)	87(27.1)
Breeding System			**		
Controlled	37^{a}(23.0)	$0^{a.b}$(0.0)	12^{b}(8.8)	$3^{a.b}$(14.3)	52(16.2)
Non controlled	124^{a}(77.0)	$3^{a.b}$(100.0)	124^{b}(91.2)	$18^{a.b}$(85.7)	269(83.8)
Localities			***		
Banyo Bunji	32^{a}(19.9)	0^{a}(0.0)	15^{a}(11.0)	3^{a}(14.3)	50(15.6)
Banyo Centre	79^{a}(49.1)	3^{a}(100.0)	20^{b}(14.7)	14^{a}(66.7)	116(36.1)
Leswouroun	0^{a}(0.0)	$0^{a.b}$(0.0)	6^{b}(4.4)	3^{b}(14.3)	9(2.8)
Banyo Tiqué	34^{a}(21.1)	0^{a}(0.0)	32^{a}(23.5)	1^{a}(4.8)	67(20.9)
Banyo-Tibati	6^{a}(3.7)	$0^{a.b}$(0.0)	28^{b}(20.6)	$0^{a.b}$(0.0)	34(10.6)
Mayo Djinga	10^{a}(6.2)	$0^{a.b}$(0.0)	35^{b}(25.7)	$0^{a.b}$(0.0)	45(14.0)
Coat color		***			
White	6^{a} (3.7)	$0^{a.b}$ (0.0)	16^{b} (11.8)	$0^{a.b}$ (0.0)	22 (6.9)
Black	12^{a} (7.5)	0^{a} (0.0)	11^{a} (8.1)	3^{a} (14.3)	26 (8.1)
Pie	$74^{a.b}$ (46.0)	$1^{a.b}$ (33.3)	51^{b} (37.5)	13^{a} (61.9)	139 (43.3)
Red	69^{a} (42.9)	2^{a} (66.7)	58^{a} (42.6)	5^{a} (23.8)	134 (41.7)
Overall average	**161(50.2)**	**3(0.9)**	**136(42.4)**	**21(6.5)**	**321(100.0)**

* * (p < 0.0 1), *** (p <0.0 01), **ns:** not significant, **n:** sample size

a, b: figures with the same letter in the same row are statistic ally comparable

3.4 Hump position and the presence of horns

Regardless of the different sources of variation, the hump in the subjects occupied a cervico-thoracic position (100%). Furthermore, all 321 (i.e., 100%) had horns.

3.6 Horn shapes according to sex, breeding system, locality and coat color

The different horn shapes distributed according to the factors of variation are presented in Table 5. Results reveal that most animals (73.5%) had crescent-shaped horns, while 15.9% had low lyre horns. The other shapes (i.e., stump, lateral pointed tip, crown and asymmetrical deformed right or left) were least represented. Asymmetric deformed right or left horns are very rare (1.2%) meanwhile the other shapes result from violent falls.

3.7 Horn orientations according to sex, breeding system, locality and coat color

This population shows a high diversity in horn orientation (Table 4). The latter is marked by the predominance of animals with horns (92.5%). These are horns that are in the same plane as the frontal line and can take either of the shapes described above. The horizontal horns in the horizontal plane through the bun come in second place (3.4%). Lateral pointed horns as well as asymmetrical horns are rare (2.8% and 1.2% respectively).

Table 4: Horn coloration according to sex, breeding system and locality

Sources of variation	Horn orientations				
	Asymetric	Horizontal	Lateral	Raised	Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Sex	ns				
Cow	3(75.0)	8(72.7)	6(66.7)	217(73.1)	234(72.9)
Bull	1(25.0)	3(27.3)	3(33.3)	80(26.9)	87(27.1)
Breeding system			***		
Controlled	2^{ab}(50.0)	8^{b}(72.7)	1^{a}(11.1)	41^{a}(13.8)	52(16.2)
Non controlled	2^{ab}(50.0)	3^{b}(27.3)	8^{a}(88.9)	256^{a}(86.2)	269(83.8)
Localities	***				
Banyo Bunji	1^{a}(25.0)	0^{a}(0.0)	2^{a}(22.2)	47^{a}(15.8)	50(15.6)
Banyo Centre	2^{ab}(50.0)	8^{b}(72.7)	1^{a}(11.1)	105^{b}(35.4)	116(36.1)
Leswouroun	0^{abc}(0.0)	0^{c}(0.0)	5^{b}(55.6)	4^{ac}(1.3)	9(2.8)
Banyo Tiqué	0^{a}(0.0)	0^{a}(0.0)	1^{a}(11.1)	66^{a}(22.2)	67(20.9)
Banyo-Tibati	0^{a}(0.0)	3^{a}(27.3)	0^{a}(0.0)	31^{a}(10.4)	34(10.6)
Mayo Djinga	1^{a}(25.0)	0^{a}(0.0)	0^{a}(0.0)	44^{a}(14.8)	45(14.0)
Coat color		**ns**			
White	0 (0.0)	1 (9.1)	0 (0.0)	24 (8.1)	25 (7.8)
Black	0 (0.0)	2 (18.2)	0 (0.0)	21 (7.1)	23 (7.2)
Pie	1 (25.0)	5 (45.5)	5 (55.6)	128(43.1)	139(43.3)
Red	3 (75.0)	3 (27.3)	4 (44.4)	124(41.8)	134(41.7)
Overall average	4(1.2)	11(3.4)	9(2.8)	297(92.5)	321(100)

* * * (p <0.001), **ns:** not significant, **n:** sample size, **(%):** percentage

a, b, c: figures with the same letter in the same column are statistically comparable

Table 5: Horn shapes according to sex, breeding system, locality and coat

Sources of variation	**Horn shapes**						**Total**
	Asymetric distorted	Crown	Crescent	Low lyre	Stump	Lateral pointed	
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Sex				**ns**			
Cow	3(75.0)	5(83.3)	174(73.7)	39(76.5)	9(60.0)	4(44.4)	234(72.9)
Bull	1(25.0)	1(16.7)	62(26.3)	12(23.5)	6(40.0)	5(55.6)	87(27.1)
Breeding system				*			
Controlled	2^{a}(50.0)	3^{a}(50.0)	31^{b}(13.1)	11^{ab}(21.6)	2^{ab}(13.3)	3^{ab}(33.3)	52(16.2)
Non controlled	2^{a}(50.0)	3^{a}(50.0)	205^{b}(86.9)	40$^{a.b}$(78.4)	13ab(86.7)	6^{ab}(66.7)	269(83.8)
Localities				***			
Banyo Bunji	1$^{a. b. c}$(25.0)	0$^{a. b. c}$(0.0)	31^{c}(13.1)	17^{b} (33.3)	1$^{a. c}$ (6.7)	0$^{a. c}$ (0.0)	50(15.6)
Banyo Centre	2(50.0)	3(50.0)	75(31.8)	(45.1)23	5(33.3)	8(88.9)	116(36.1)
Leswouroun	0$^{a. b. c. d}$(0.0)	0$^{a. b. c. d}$(0.0)	4$^{c. d}$(1.7)	0$^{b. d}$(0.0)	5_{a}(33.3)	0$^{a. b. c. d}$(0.0)	9(2.8)
Banyo Tiqué	(0.0)0$^{a. b}$	(0.0)0$^{a. b}$	61^{b} (25.8)	(7.8)4^{a}	(6.7)1$^{a. b}$	(11.1)1$^{a. b}$	(20.9)67
Fronctière Banyo-Tibati	0$^{a. b}$ (0.0)	3^{b} (50.0)	24^{a} (10.2)	7^{a} (13.7)	0^{a} (0.0)	0^{a} (0.0)	34 (10.6)
Mayo Djinga	1^{a} (25.0)	0$^{a. b}$ (0.0)	41^{a} (17.4)	0^{b} (0.0)	3^{a} 20.0)	0$^{a. b}$ (0.0)	45 (14.0)
Coat color				**ns**			
White	0(0.0)	1(16.7)	23(9.7)	1(2.0)	0(0.0)	0(0.0)	25(7.8)
Black	0(0.0)	1(16.7)	14(5.9)	7(13.7)	1(6.7)	0(0.0)	23(7.2)
Pie	1(25.0)	3(50.0)	104(44.1)	23(45.1)	6(40.0)	2(22.2)	139(43.3)
Red	3$^{. b}$(75.0)	1^{b}(16.7)	95^{b}(40.3)	20^{b}(39.2)	8^{b}(53.3)	7(77.8)	134(41.7)
Overall average	4(1.2)	6(1.9)	236(73.5)	51(15.9)	15(4.7)	9(2.8)	321(100.0)

* (p <0.05), *** (p <0.001), **ns:** not significant, **n:** sample size

a, b, c, d: figures with the same letter in the same row are statistically comparable

3.8 Facial, Neck, Backline and Rump Profiles

Results (Table 6) show that all animals have a straight facial profile as well as a straight back profile, independent of the factors of variation. The neck is horizontally curved. The rump is sloping (the rump line slopes backwards) with a low set tail.

Table 6: Numbers and frequencies of the different profiles of interest

facial Profile				**Total**
	Convexilinear	Rectilinear	Concavilinear	
Total (%)	00	321(100)	00	321
Neckline profile				
	Straight	Curved	Wheeled	
Total (%)	00	321(100)	00	321
Profile of the back line				
	Hollowed	Straight	Goes down to the rump	
Total (%)	00	321(100)	00	321
Profile of the croup				
	Raised	Inclined	Straight	
Total (%)	00	321(100)	00	321

3.9 Hump shapes according to sex, breeding system, locality and coat color

The population has two hump shapes; erect and drooping (Table 7) with erect humps being dominant (86.6%) in the population. Among the animals with erect humps, 81.7% are cows and 18.3% are bulls. On the other hand, out of the 13.4% of animals with drooping humps, 83.7% are bulls while 16.3% are cows. This would indicate that although both forms of hump are present in both sexes, moderate upright humps are predominant in bulls while drooping humps are much more prevalent in males.

Table 7: Hump shapes by sex, breeding system, locality and coat

Sources of variation	Upright form	Drooping form	Total
	n (%)	n (%)	n (%)
Sex		***	
Cow	227[a] (81.7)	7[b](16.3)	234(72.9)
Bull	51[a](18.3)	36[b](83.7)	87(27.1)
Breeding system		ns	
Controlled	49(17.6)	3(7.0)	52(16.2)
Non controlled	229(82.4)	40(93.0)	269(83.8)
Localities		*	
Banyo Bunji	48[a](17.3)	2[b](4.7)	50(15.6)
Banyo Centre	94[a](33.8)	22[b](51.2)	116(36.1)
Banyo Leswouroun	8[a](2.9)	1[a](2.3)	9(2.8)
Banyo Tiqué	55[a](19.8)	12[a](27.9)	67(20.9)
Fronctière Banyo-Tibati	30[a](10.8)	4[a](9.3)	34(10.6)
Mayo Djinga	43[a](15.5)	2[a](4.7)	45(14.0)
Coat color		**ns**	
White	21 (7.6)	4(9.3)	25 (7.8)
Black	20(7.2)	3(7.0)	23 (7.2)
Pie	120 (43.2)	19(44.2)	139 (43.3)
Red	117(42.1)	17(39.5)	134 (41.7)
Overall average	278(86.6)	43(13.4)	321(100.0)

* (p <0.05), *** (p <0.001), **ns:** not significant, n: sample size

a, b: figures with the same letter in the same column are statistically comparable

4. DISCUSSION

The main results revealed a polymorphism in coat color. Similar observations were reported for the Namchi breed by Thys and Wandi (1070), for the Banyo Gudali variety by Lhoste (1969) in Cameroon. In Ivory Coast and Niger, Coulumb (1976) and Yahaya *et al.* (2019) also reported similar results for the N'Dama breed and the Djelli zebu respectively. In terms of coat color, the population is divided into two main groups i.e., the single-colored and double-colored animals. This result is in harmony with those reported by Tawah and Rege (1994) and Lhoste (1969). There is also a predominance of the E+ and A+ alleles. Similar findings were obtained on the Jutland Breed, Nordland cattle and Western Red polled cattle by Kantanen *et al,* (2000). Mbah (2020) suggests that fluctuation in genotype and gene frequencies is driven by natural and artificial forces. Regardless of the different sources of variation, the hump occupied a cervicothoracic position (100%) in all study animals. The same observation was made by Yahaya *et al.* (2019) on the Djelli zebu in Niger. All animals (100%) had horns with variability in shape and orientation. Yahaya *et al.* (2019), Lhoste (1969) and Coulomb

(1976) also made the same observation. Horn shape is associated with breeding system and locality. This would probably be due to the selection practiced by the breeders. This result is in agreement with those of Yahaya *et al.* (2019) obtained on the Djalli zebu of Niger. Moreover, there is great diversity in the shape of the horn. This would imply interbreeding also with local breeds (Bokolo, White and Red Fulani) as well as with exotic breeds (Holstein, Simmental, Charolaise, etc.) as revealed by the work of Paguem *et al.* (2020). Boma *et al.* (2018) equally reported a similar observation. Crescent-shaped (73.5%) and low lyre-shaped (15.9%) horns are predominant in within the population. This finding is in harmony with those of the results obtained by Lhoste (1969) on the Banyo Gudali variety. Contrastingly, Yahaya *et al.* (2019) reported a predominance of cup-shaped horns within the Djalli zebu population o Niger.

CONCLUSION

Ultimately, the main results from this study on the phenotypic variability of Banyo Gudali zebu cattle showed colour and gene polymorphism within the studied population, suggesting a non-standardized, primary and or traditional population. This character of primarity of the population offers us the possibility of genetic improvement through selection for food security. However, it is desirable that such a study be carried out on other varieties (Ngaoundéré and Tignère) in order to better study their genetic distance and the possibilities of selection.

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