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RESEARCH ARTICLE
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Phenotypic Characterization of Ndama Cattle Breed from the Kolda Region (Senegal) based on Qualitative Parameters

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ABSTRACT

The objective of this study aims to better understand the phenotypic characteristics of Ndama taurus cattle from the Kolda region in order to have sufficient data and contribute to the phenotypic characterization of these animals. In total 238 Ndama breed cattle raised in an extensive pastoral system were the subject of a phenotypic characterization study of qualitative traits in the department of Kolda and Medina Yoro Fulha in the Kolda region. The observations were carried out directly on the animals and made it possible to record 18 qualitative parameters. The results revealed variability in qualitative traits within the overall population. The typology revealed by Multiple Correspondence Analysis (MCA) made it possible to identify 2 groups of cattle which are distinguished by the color of the muzzle and eyelids. No discrimination based on area was obtained. This study revealed the great variability of the morphological characters of Ndama breed. However, despite this great diversity, it seems impossible to classify the Ndama of the Kolda region into genetic type based on qualitative traits. Thus, the great variability observed at the level of qualitative traits is carried by the individuals making the cattle of the Kolda region a composite group.

Keywords: Phenotypic characters, Ndama, Cattle, Variability

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INTRODUCTION

The Ndama is a cross-border breed of cattle found in all trypano-endemic countries in West and Central Africa and even in Angola (Kanh et al., 2019). It is a breed bred for meat and whose milk production is mediocre, if not negligible (Okouyi et al., 2014). This breed originated in Fouta Djallon in Guinea, where most of the animals have fawn-colored coats (Coulomb, 1978; Gueye et al., 1981). Along with Gobra zebus and Djakorés, it is one of the three dominant breeds in Senegal (Sow et al., 2021). This taurus cattle is bred mainly in the south of Senegal because of its trypanotolerance. Although this wetland is a major livestock production area, it is infested with tsetse fly. Breeding trypano sensitive breeds is impossible without continuous medical prophylaxis (Badji et al., 2020; Ezanno et al., 2020). This breed fulfills important socio-economic and socio-cultural functions in the lives of livestock farmers in southern Senegal (Kanh et al., 2018). However, increased pressure (bush fires, abusive deforestation) on natural resources and the extension of crop fields due to population growth are encouraging the incursion of trypanosensitive Zebu and their cross-breeding with the Ndama breed. This poses a potential threat to the breed's genetic purity (Kanh et al., 2018). This situation has led to fears of a drastic reduction in the number of Ndama cattle and the loss of phenotypic and biological characteristics as a result of crossbreeding with Sahelian breeds (Kanh et al., 2019). In addition, breeders prefer the fawn color because it has long been associated with trypanotolerance (Gueye et al., 1981). This preference leads to a selection of this coat color to the detriment of others. To gain a better understanding of these cattle, many studies have been carried out on the Ndama in West Africa. Also, in Senegal, the genetic diversity of the subpopulations or ecotypes of this taurine in the Southern zone is increasingly being studied (Ndiaye et al., 2014; Ndiaye et al., 2015; Badji et al., 2020). The aim of this study is to phenotypically characterize Ndama cattle in the Kolda region. It thus contributes to a better understanding of the genetic material existing in the rural environment.

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MATERIALS & METHODS

Study Area

Located in the south of Senegal, Fouladou corresponds to the administrative region of Kolda, also known as Upper Casamance. It comprises 3 departments: Kolda, Vélingara and Médina Yoro Fulah (Fig. 1). It covers an area of 13.721km^2, or 7% of the national territory. It is bordered to the east by the Tambacounda region, to the south by Guinea-Bissau, to the west by the Sédhiou region and to the north by the Gambia. It is home to several classified forests, including Dabo, Bakor, Pata and Guimara.

Material

The biological material consisted of Ndama cattle. In total, there were 238 animals from 53 herds (Table 1). These herds are divided between the departments of Medina Yoro Fulha with four communes, and the departments of Kolda with five communes. The animals are all managed as extensive pastoralists.

Table 1: Number and origin of herds and cattle used in the study

Department	Commune	Number of Herd	Workforce
	Medina Yoro Fulha	2	20
Medina Yoro Fulha	Niaming	1	10
	Fafacouroun	1	10
	Bignarabe	9	49
	Kolda	2	6
	Medina el Hadj	11	36
Kolda	Saré Bidji	11	28
	Dioulacolon	8	41
	Guire Yéro Bocar	8	38
Total		53	238

Sampling Methods

A total of 18 qualitative traits were recorded. The qualitative data were obtained simply by observing the individuals. These included coat characteristics such as: the type of hair, the general appearance of the coat, the presence and intensity of black spots, variegations, brindle marks, mule stripes, frontal spots, the color of the bun and speckles, and on the other hand the particularities, namely the presence or absence of pigment on the eyelids, the muzzle, the shapes of the horns, the color of the horns, the color of the hooves, the appearance of the dewlap of the head and the carriage of the ears.

Comparisons were made between two zones. The first consists of sites in the department of Medina Yoro Foulah and the commune of Saré Bidji. This area was called Kolda Nord for the purposes of this study. The second is located between the Casamance River and the border with Guinea-Bissau. It covers the communes of Medina El Hadj, Dioulacolon and Guiré Yero Bocar. This second zone has been named Kolda Sud. This division is not justified by the impossibility of crossing the river, but rather by the inaccessibility of the river by the majority of breeders because of the crops grown along its banks.

Data Analysis Methods

The data were entered using Excel 2010. Qualitative data were coded and analyzed to produce descriptive statistics. Qualitative variables were expressed as a percentage frequency. A Multiple Correspondence Analysis (MCA) was carried out to check the segregation of individuals in a factorial design according to the categorical variables using the factomineR, ggplot2 and Ade4 packages. This analysis was carried out by transforming the data matrix made up of the parameters studied, eliminating the *hclust* objects beforehand. The optimum number of groups was determined using the fastcluster package.

RESULTS

Quality Parameters

All the animals sampled in this study have a straight profile and straight ears. The horns are bicolored and the dewlap is moderately developed. Individuals with pigmented snouts represented 60.92% of the cattle population in the study, compared with 30.58% of animals with no pigmentation. The majority of Ndama cattle in the Kolda region have pigmented eyelids and

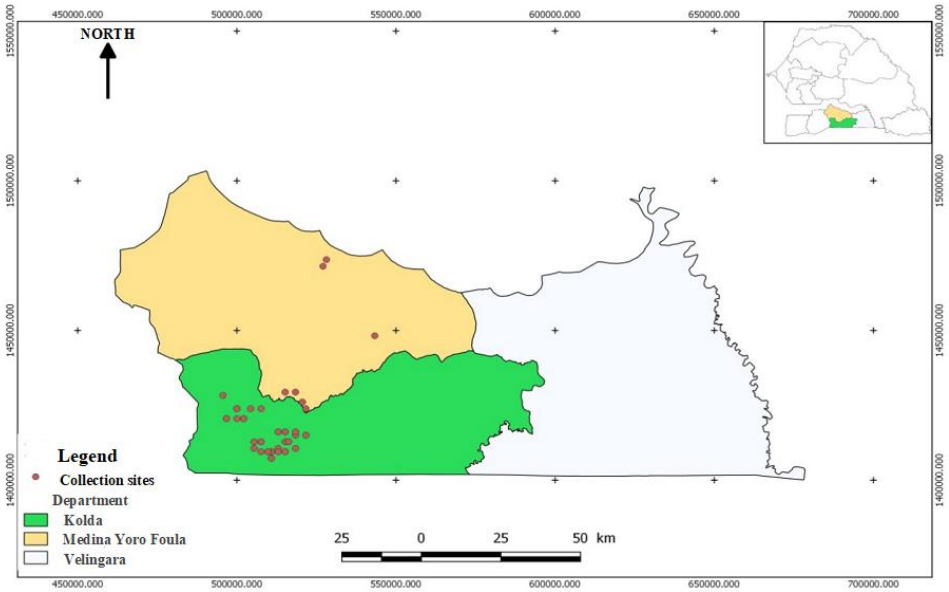

Fig. 1: Presentation of the study area

hooves, with frequencies of 60.50% for eyelids and 78.15% for hooves. Only 3.78% of animals had a frontal patch compared with 96.22%. The shape of the horns differs from one area to another. In the northern zone, lyre-shaped horns dominated, being worn by 42.74% of the animals sampled (Fig. 2). In contrast, in the southern zone, cup-shaped horns are dominant. They were found in 50.48% of cases. In the population as a whole, the most common horn shapes were cup-shaped (43.70%), lyre-shaped (35.71%) and crescent-shaped (15.55%) (Table 2).

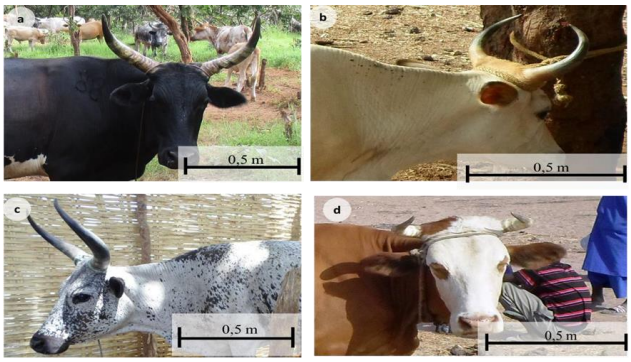

Fig. 2: Horn shapes observed in the Ndama Taurus cattle. (a): cupped horn, (b): crescent horn, (c): lyre horn, (d): crown horn.

Table 2: Characteristics of hoof colour, Horns, mucous membranes and horn morphology of Ndama cattle in the Kolda region

Parameters	Location		Total population (N=238)
	Kolda South	Kolda North	
Head profile (straight)	100 (n=121)	100 (n=117)	100 (n=238)
Wearing the ears (right)	100 (n=121)	100 (n=117)	100 (n=238)
Muzzle color			
Pigmented	69.42 (n=84)	52.14 (n=61)	60.92 (n=145)
Non-pigmented	30.58 (n=37)	47.86 (n=56)	39.08 (n=93)
Eyelid color			
Pigmented	69.42 (n=84)	51.28 (n=60)	60.50 (n=144)
Non-pigmented	30.58 (n=37)	48.72 (n=57)	39.50 (n=94)
Shoe color			
Pigmented	78.51 (n=95)	77.78 (n=91)	78.15 (n=186)
Non-pigmented	21.49 (n=26)	22.22 (n=26)	21.85 (n=52)
Forehead spot			
Yes	3.31 (n=4)	4.27 (n=5)	3.78 (n=9)
No	96.69 (n=117)	95.73 (n=112)	96.22 (n=229)
Horns			
Rear	0.83 (n=1)	0 (n=0)	0.42 (n=1)
Cut	50.40 (n=61)	36.75 (n=43)	43.70 (n=104)
Crown	5.78 (n=7)	1.71 (n=2)	3.79 (n=9)
Crescent	14.05 (n=17)	17.09 (n=20)	15.55 (n=37)
Lyre	28.93 (n=35)	42.74 (n=50)	35.71 (n=85)
Wheel	0 (n=0)	1.71 (n=2)	0.84 (n=2)
Fanon (medium)	100 (n=121)	100 (n=117)	100 (n=238)
Horn color (two-tone)	100 (n=121)	100 (n=117)	100 (n=238)

The values outside the brackets represent the frequencies (%). The values inside the brackets represent the number of individuals characterized.

Ndama cattle in the Kolda region all have short hair. The uniform coat is dominant, occurring in 73.53% of animals in the total population, 69.42% in the southern zone of Kolda and 77.78% in the southern and northern zone. The spotted coat was found in 23.53% of animals in the total population, with frequencies of 27.27% and 19.66% in the southern and northern zones respectively. Piebald coats were observed in 2.94% of the animals sampled in the total population, with 3.31% of individuals in the southern zone showing piebald coats and 2.56% of individuals in the northern zone. In terms of uniform coat, the most widespread coat was wheaten fawn, which was observed in 31.93% of the animals in the total population. The population in the southern zone had 25.62% of individuals with this coat color, while in the northern zone 38.46% of individuals had this coat. This was followed by the white coat found on 20.17% of the animals in the study. Charcoal was observed in 26.89% of all animals sampled (Fig. 3). In the southern zone, these features were found on 33.06% of cattle, compared with 66.94% of animals without them. In the northern zone, around 20.54% of the animals had anthrax compared with 79.49% that did not. Brindle markings, speckles and mule stripes were observed in the population with low frequency (Table 3).

Fig. 3: Coat variants in the Ndama taurus cattle in the farms surveyed. (a): uniform coat, (b): charcoal coat, (c): spotted coat, (d): piebald coat.

Table 3: Characteristics of hoof colour, horns, mucous membranes and horn morphology of Ndama cattle in the Kolda region

Parameters	Location		Total population (N=238)
	Kolda South	Kolda North	
Type of hair			
Short	100 (n=121)	100 (n=117)	100 (n=238)
Long	0 (n=0)	0 (n=0)	0 (n=0)
General appearance coat			
Uniform	69.42 (n=84)	77.78 (n=91)	73.53 (n=175)
Mottled	27.27 (n=33)	19.66 (n=23)	23.53 (n=56)
Magpie	3.31 (n=4)	2.56 (n=3)	2.94 (n=7)
Coat color			
White	21.49 (n=26)	18.80 (n=22)	20.17 (n=48)
Wheaten fawn	25.62 (n=31)	38.46 (n=45)	31.93 (n=76)
Redhead fawn	18.18 (n=22)	11.11 (n=13)	14.71 (n=35)
Red fawn	2.48 (n=3)	3.42 (n=4)	2.94 (n=7)
Grey	8.26 (n=10)	3.42 (n=4)	5.88 (n=14)
Black	13.22 (n=16)	7.69 (n=9)	10.50 (n=25)
Magpie	3.31 (n=4)	2.56 (n=3)	2.94 (n=7)
Sand	7.44 (n=9)	14.53 (n=17)	10.92 (n=26)
Coal			
No	66.94 (n=81)	79.49 (n=93)	73.11 (n=174)
Strongly	2.48 (n=3)	5.98 (n=7)	4.20 (n=10)
Medium	4.13 (n=5)	0.85 (n=1)	2.52 (n=6)
Slightly	26.45 (n=32)	1.67 (n=16)	20.17 (n=48)
Variegated			
No	80.16 (n=97)	89.74 (n=105)	84.87 (n=202)
Irregular	19.01 (n=23)	10.26 (n=12)	14.71 (n=35)
Lateral staining	0.83 (n=1)	0 (n=0)	0.42 (n=1)
Bringeures			
Yes	1.65 (n=2)	0.85 (n=1)	1.26 (n=3)
No	98.35 (n=119)	99.15 (n=116)	98.74 (n=235)
Mullet ray			
Yes	4.96 (n=6)	2.56 (n=3)	3.78 (n=9)
No	95.04 (n=115)	97.44 (n=114)	96.22 (n=229)
Bun color			
Yes	2.48 (n=3)	10.26 (n=5)	3.36 (n=8)
No	97.52 (n=118)	89.74 (n=112)	96.64 (n=230)
Flycatcher			
Yes	9.09 (n=11)	10.26 (n=12)	9.67 (n=23)
No	90.91 (n=110)	89.74 (n=105)	90.33 (n=215)

The values outside the brackets represent the frequencies (%). The values inside the brackets represent the number of individuals characterized.

Multiple Component Analysis

The MCA carried out on the sample gives us a cumulative variance of 33.58% of the total variance on

the first five axes. Axis 1 has an eigenvalue of 0.24, representing 10.86% of the total variance. Axis 2 has an eigenvalue of 0.14, representing 6.51% of the total variance. Axes 3, 4 and 5 have eigenvalues of 0.13, 0.13 and 0.11 respectively. These values represent 5.69%, 5.66% and 4.86% of the total variance respectively (Table 4).

Table 4: Eigenvalues and inertia percentages for the first five axes

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5
Eigenvalue	0.24	0.14	0.13	0.13	0.11
Percentage of Inertia	10.86	6.51	5.69	5.66	4.86
Cumulative percentage of Inertia	10.86	17.37	23.06	28.72	33.58

The contribution of the variables to the formation of the first five axes is summarized in Fig. 4. On Axis 1, the three most contributing variables are eyelid color (ColPau), muzzle color (ColMu) and skin color (ColPeau). The second axis is essentially made up of the skin color variable (ColSkin), followed by the horn shape variable (FrmCrn) and then the general appearance of the coat (AspGR). Axis 3 is essentially made up of two variables: skin colour (ColPeau) and the presence of charcoal (Charb). These two variables are followed by the general appearance of the coat (aspGR). Axis 4 is essentially made up of the skin color variable (ColPeau), to which is added the shape of the horns (FrmCrn) and the presence of charcoal (Charb). The fifth axis is also essentially made up of the skin colour variable (ColSkin). To this variable is added the presence of mule stripes.

The discrimination of the different classes was carried out with a partitioning algorithm using the method of relative loss of inertia plus removed criteria. Fig. 5 shows the jumps in inertia obtained from the transformation of the matrix of qualitative variables into *hclust* class objects. Analysis of this figure reveals the optimum number of groups, which is two groups high. The individuals in our sample are represented as points in two factorial planes of the multiple component analysis. The first is made up of factorial Axis 1 and factorial Axis 2. The two colors observed represent the two groups obtained from the partitioning method. The red individuals represent group 1 and the blue individuals represent group 2 (Fig. 6).

The representation of individuals in the first factorial plane shows the discrimination of the study population into two distinct groups. Group 1 consists of 159 individuals, 103 of which come from the department of Kolda and 56 from the department of Medina Yoro Fulha. Within this group, 87.42% of the animals had pigmented eyelids compared to 12.58% without. Animals with pigmented snouts accounted for 88.05% of this group, and those without pigmented snouts accounted for 11.95 %. Group 2 is made up of 58.23% from the department of Kolda and 41.77% from the department of Medina Yoro Fulha. Within this group, 6.33% of the animals had pigmented eyelids compared with 93.67% who did not. Animals with pigmented snouts accounted for 6.33% of this group and those without pigmented snouts for 93.67% (Table 5).

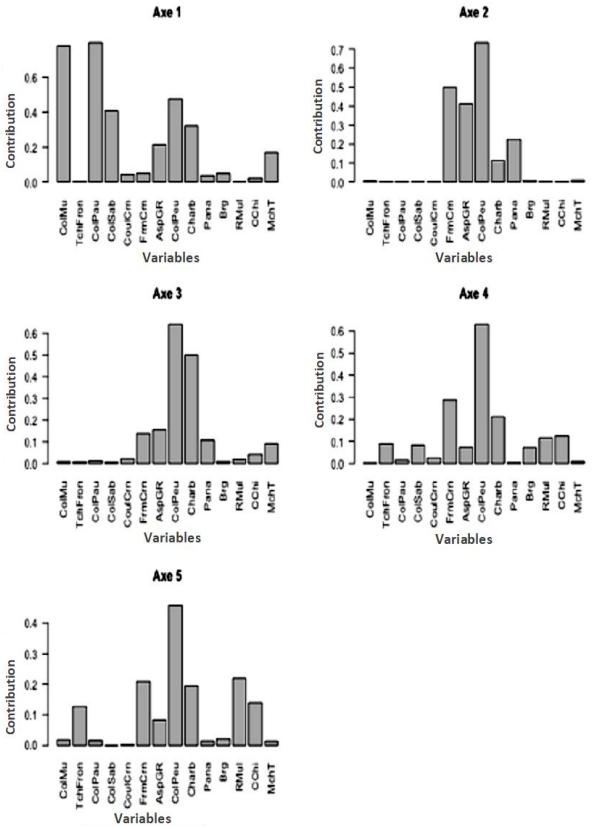

Fig. 4: Contribution of variables to the formation of the first five axes of the MCA; the x-axis presents the different qualitative variables used in the construction of the MCA and the y-axis presents the different contributions to the construction of these axes

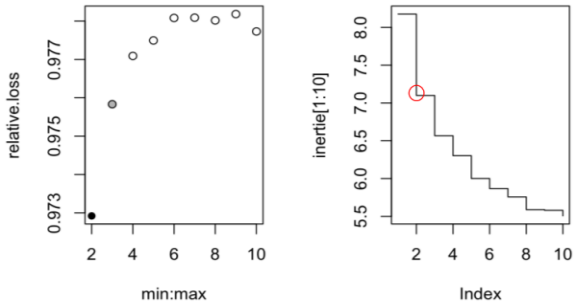

Fig. 5: Determining the optimum number of groups using the relative inertia loss method

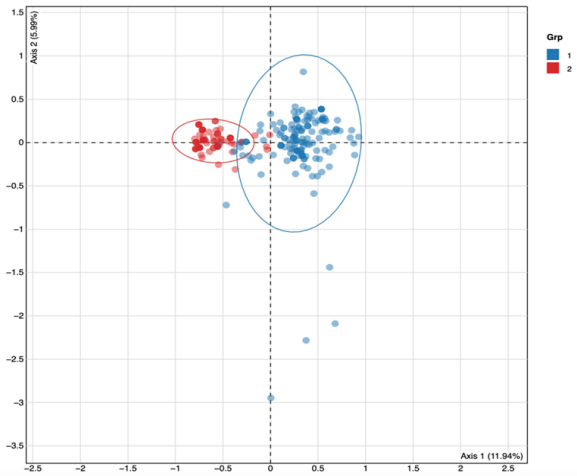

Fig. 6: Presentation of the different groups obtained after partitioning using the ACM method; Axis 1 of the analysis of multiple correspondence carries 11.94% of the total variability against 5.99% for axis 2.

Table 5: Composition of the different groups in relation to the departments and the main discriminating factors

	Groupe 1 (n=159)	Groupe 2 (n=79)
Department		
Kolda	64.77 (n= 103)	58.23 (n=46)
Medina Yoro Fulha	35.23 (n=56)	41.77 (n=33)
Eyelid colour		
Pigmented	87.42 (n=139)	6.33 (n= 5)
No Pigmentation	12.58 (n= 20)	93.67 (n=74)
Muzzle colour		
Pigmented	88.05 (n=140)	6.33 (n=5)
No Pigmentation	11.95 (n=19)	93.67 (n=74)

The values outside the brackets represent the frequencies (%). The values inside the brackets represent the number of individuals.

DISCUSSION

The Ndama cattle herd in the Kolda region has a straight head profile and straight ears. In the study area, there are both pigmented and unpigmented hooves and mucous membranes, with a higher proportion of animals with pigmentation on these parts of the body in the southern zone than in the northern zone. These results are in line with those obtained by Yapi-Gnaore et al. (1996) stipulating the existence in the Ndama population of Côte d'Ivoire, of individuals with pigmented and non-pigmented mucous membranes. Frontal spots are rare. The dominant form of horning in the north, as in the study area, is the lyre, typical of Gobra zebus, with a prevalence of 42.74%. In terms of horn shape, cup-shaped horns are dominant in the south, followed by lyre-shaped horns and crescent-shaped horns. The frequencies of the different horn shapes in Ndama cattle, 43.70% for the cup shape and 35.71% for the Lyre shape are different from those obtained by Ndiaye et al. (2014) for lyre-shaped horns, which are 91.2, 67.7, 92.6 and 94.1% in Gobra zebu, Maure zebu, Djakoré half-breeds and Ndama taurus cattle, respectively. Although the results for the southern zone in our study are similar to those for the Sédhiou region in terms of predominance, they are different from those for the northern zone. They are also different from those of Yapi-Gnaore et al. (1996) and N'goran et al. (2018) which show a predominance of the lyre shape among the Ndama of Côte d'Ivoire.

Uniform coats are the most common, with a percentage of 73.53%. All shades of fawn were the most common, followed by white and then black. These results differ from those of Yapi-Gnaore (1996) and N'goran et al. (2018). Although these authors show a predominance of the fawn coat and these shades, the proportions obtained for the other coat colors are different. In addition, the absence of the white coat among the Ndama of Côte d'Ivoire is noteworthy, as it represents more than 20.17% of the coats among the Ndama of Kolda.

The white coat is typical of Gobra zebus. According to Santoze and Gicheha (2019), these animals generally have a white coat, with some colored spots and stripes. Also, Sambe et al. (2019) attests to the predominance of this coat described in 81.82% of individuals to the detriment of fawn and sandy coats. This color is also found in Djakoré cattle. The latter are stabilized cross-breeds between Ndama taurus cattle and Gobra zebus. According to some authors, their coat colors can vary between white and gray (Sow et al., 2021; Sambe et al., 2019). The proportion of white coats in this population indicates that zebu blood has been introgressed. In this respect MacHugh et al. (1997) after molecular characterization studies, assert that the Ndama cattle of Casamance present a higher introgression of zebu genes than the Ndama populations of Guinea.

Our study also showed that the Ndama in the Kolda region have coat colors typical of Lagune (*Bos taurus*) and Muturu (*Bos taurus*) cattle breed, namely black and piebald-black (Karnuah et al., 2018; Aka et al., 2022). The black color of the coat found in these cattle could be due to the absorption of old local breeds by the Ndama population, as explained by Kanh et al. (2019). This author say that vestiges of the Gambian Dwarf breed could still be found south of the River Gambia, but these populations were absorbed by the Ndama breed, mainly because of the latter's economic superiority. According to Ahozonlin et al. (2022) and Aka et al. (2022), Guinea Bissau and the Gambia, as well as our study area, were formerly populated by the Manjaca cattle and the Gambian Dwarf. these cattle would be assimilated to the lagoon cattle found in Ivory Coast and Benin.

Furthermore, the Ndama breed's coat differs from that of the lagoon cattle. Kapsiki, Baoulé and Borgou, in which piebald-black and black coats predominate, followed by red (fawn), spotted and truited coats (Dineur and Thys, 1998; Adanléhoussi et al., 2003). Panachure, brindle stripes, mullet stripes and colored bunches are very rare features in Ndama cattle, while black overlay is relatively common, at 26.89%. These results are similar to those of Baldé (2017) in the Kolda and Sédhiou regions, where charcoal and charcoal variegated coats represented 16.48 and 27.50% respectively, but are lower than in the Kédougou region (50.90%).

This study revealed an equiprobable distribution of pigmented and non-pigmented mucosa in Ndama cattle in the Kolda region. These results are similar to those of Badji et al. (2020) in the farming environment. However, they differ from the results obtained by these same authors at the Regional Zootechnical Center in this region. In this Center, the authors observed a predominance of unpigmented or pink mucosa. These observations by these authors are probably due to the selection effect carried out at this center. The predominance of pink mucosa is also generally observed in zebus such as the Gobra with a frequency of 75% of pink mucosa (Planchenault et al., 1984). On the other hand, in short-horned taurus cattle such as Baoulés cattle and lagoon cattle in south-west Côte d'Ivoire, pigmented mucosa predominates to the detriment of pink mucosa (Soro et al., 2015).

The discrimination of the different classes enabled us to subdivide the Ndama of the Kolda region into two groups. The MCA also enabled us to assess the projection of individuals and the discriminant variables of the two groups obtained. These variables are essentially those relating to the color of the mucous membranes, the color of the muzzle and the color of the eyelids. There is variability in the other parameters. However, the configuration of this variability does not make it possible to discriminate between individuals. This shows that for

these other parameters the variability is carried by the individuals and not the groups. We could therefore assume discrimination of the population based on the coloration of the mucous membranes, based on the observations of Kanh et al. (2019). According to Tidori et al. (1975) and Hadzi (1996) this trait would be a phenotypic trait inherited from the absorption of ancient local breeds by the Ndama populations. This explains why there is no total discrimination on the factorial level of the ACM.

Conclusion

The diversity of phenotypic traits was highlighted in the bovine population studied. There is great diversity in the traits studied. This population has a wide range of coat colors, the most dominant of which is fawn with all its shades, followed by white. The most common horn shape is the cup followed by the lyre. Thus, two different groups have been distinguished, differentiated solely by the color of the mucous membranes. However, despite this great diversity, it seems impossible to classify the Ndama of the Kolda region into genetic types based on qualitative traits. Thus, the great variability observed in qualitative traits is carried by the individuals making the cattle of the Kolda region a composite group.

Conflict of Interest: There is no conflict of interest.

Author's Contribution: KHMK: Documentary research, data collection, statistical analysis and writing of the article. BS: writing of the article, YJMPK: writing of the article. DPS: general supervision of the writing of the article corrections and amendments.

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