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Phenotypical Characterization of Senegalese Local Cattle Breeds Using Multivariate Analysis

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Abstract: In order to discriminate local Senegalese cattle breeds, a survey was conducted in three agroecological areas of Senegal (South of "Bassin Arachidier", Senegal River Valley, Middle and Upper Casamance). One hundred and twenty six cattle have been described by visual assessment criteria and 75 cows based on dairy performances. These parameters were analyzed by discriminant factor and multiple correspondence factor analysis. The cows were distinguished at best by their format, coat colour and average milk production. They were distributed in 4 genetic types with percentage of cows well classified in order: N'Dama (100%), Djakore (100%), Maure (95%) and Gobra (94.12%). The typology by classification has permitted to divide them in three genotypes identifying in two phenotype groups. The first phenotype is characterized by the presence of thoracic hump and a unique coat colour. Their average daily milk production varied between 2 and 4 L even >4 L. The second phenotype is identified by the absence of hump and a compound coat colour. Their average milk production is <2 L day^{-1}. The first phenotype associating a large size with a good milk production should be most suitable for dairy production in these agroecological areas of Senegal.

Key words: Cattle, phenotypical characterization, multivariate analysis, milk production, Senegal

INTRODUCTION

Livestock plays an important socio-economic role in Senegal and the national annual milk production is estimated at 180 million L. However, this production is still below the government expectation which is approximately 400 million L per year.

In order to achieve food self-sufficiency many programmes had been developed for the improvement of dairy production through bovine artificial insemination in the region "Bassin Arachidier" and the pastoral zone, the Niayes' area and Upper Casamance region. The artificial insemination campaigns implemented throughout the country in the view of improving local dairy potential resulted in uncontrolled genetic crossings between local and exotic cattle breeds, generating more crossbreds. Presently, these crossbreds resulting from the artificial insemination are widespread throughout the country so much that the genetic structure of local cattle breeds appears very confused. Furthermore, the livestock breeders in the transition area between the zebu Gobra and taurine N'Dama had a trend to crossbreed intensely their small sized taurine cattle with by zebu cattle with bigger size. According to the producer, big sized cattle are more suitable for meat production and draught power. This uncontrolled crossbreeding promoted introgression of trypanosomosis sensitive genes in zebu cattle in the genetic pool of local trypanotolerant taurine breeds. Consequently, the loss of such biological specificity in a breeding area heavily infested by tsetse flies affects livestock productivity. Especially, if the implicated effectives are weak, uncontrolled spread of exotic and local genes can dilute in terms the germplasm of these indigenous breeds which will affect not only their conformation but also the biodiversity conservation of local bovine species.

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In this context, the characterization of local bovine breeds on phenotypical and zootechnical levels is essential for valorizing these populations in their respective production systems. The zootechnical parameters of reproduction and production are essential to any strategy for improving the productivity (Sokouri *et al*., 2010). Hence, improving the productivity of local cattle breeds requires first a zootechnical characterization to identify reproductive and productive performances (Sokouri *et al*., 2010). Thus, this study aimed to perform a phenotypical description of Senegalese local cattle breeds in order to highlight discriminating characters and to determine their typology according to their phenotypical traits and zootechnical performances.

MATERIALS AND METHODS

Study sites: The study was conducted from October to December 2013, between the end of the rainy season and the beginning of the dry season in three agropastoral zones of Senegal (Kaolack, Saint-Louis and Kolda) which represent the wide areas of distribution of the different local cattle breeds and situated respectively in the agroecological areas of South of Region of "Bassin Arachidier", Senegal River Valley and Middle and Upper Casamance (Fig. 1).

The region of the "Bassin Arachidier" is situated in the center of Senegal also known as the region of the Kaolack is located between 14°08'35"N and 16°05'45"W. The climate is characterized by high temperatures in April to July (35-40°C). The rainy season is short and goes from July to October. Annual rainfalls are ranged in average between 800 and 900 mm. The extensive and semi-intensive breeding consist of cattle, sheep, goats, horses, pigs and poultry. The phenotypical investigation was carried out on Djakore, Gobra and zebu Maure breeds in the following villages: Ndiebel, Koutal Wolof, Ndiaffate, Sibassor, Kabatoki and Wardiakhal.

The region of Saint-Louis is situated between 16°02'00"N and 16°30'00"W. The area is located in the most northern part of Senegal. Entrenched in the Sahelian Zone and is affected by a subtropical climate. The average annual temperature is around 25°C and the average annual rainfall is about 346 mm. Owing to the fact that the area hosts the large part of the Sylvopasroral Zone, the pastoral breeding was developed with a huge mobilization of livestock namely cattle and small ruminants. The phenotypical survey on Gobra and Maure zebu cattle was carried out in localities of Taba Darou Salam, Ndiouguette, Peulh Djeuss, Medina Maka and Diama Peulh.

The region of Kolda is located between 13°01'60"N and 14°52'00"W and covers two entities: the Middle and Upper Casamance. Characterized by a Sudan-Guinean climate, the area records on average rainfalls of 700-1300 mm, lower temperatures that fluctuate between 25-30°C

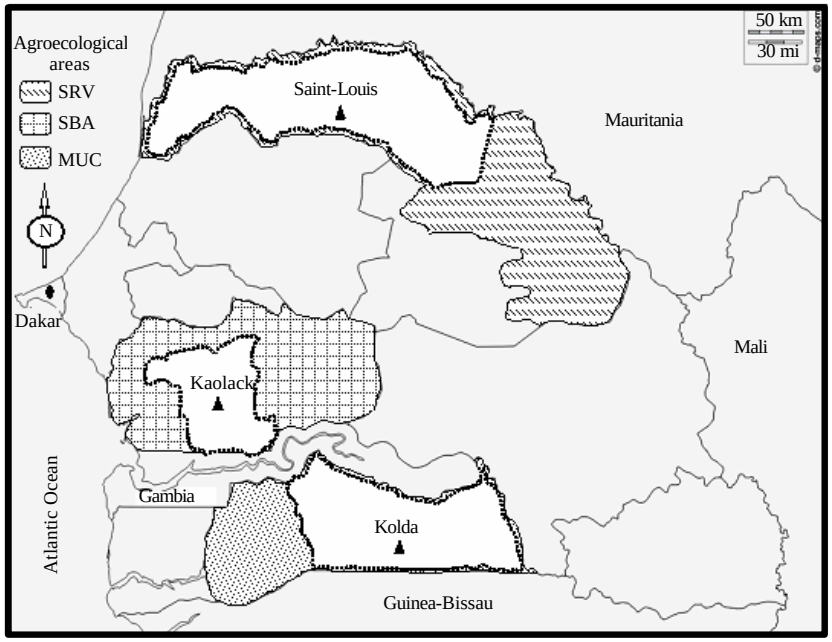

Fig. 1: Localization of study sites in argoecological areas of the Senegal River Valley (SRV), the South of "Bassin Arachidier" (SBA) and the Middle and Upper Casamance (MUC)

Table 1: Distribution of cattle breeds according to study sites and agroecological areas

Study sites and agroecological areas	Saint-Louis (SRV)		Kaolack (SBA)		Kolda (MUC)		
Cattle breeds	M	F	M	F	M	F	Overall
Gobra zebu	5	10	5	14	-	-	34
Maure zebu	8	20	1	2	-	-	31
Djakore	-	-	4	23	-	-	27
N'Dama	-	-	-	-	15	19	34
Overall	43		49		34		126

Agroecological areas: SRV = Senegal River Valley; SBA = South of "Bassin Arachidier"; MUC = Middle and Upper Casamance. Sex: M = Male; F = Female

and higher ones ranging between 30-40°C. Livestock breeding, the second major activity in this region, represents a daily survival income for most rural populations. The cattle breeds consists mainly N'Dama and Djakore which are rustic trypanotolerant cattle. The phenotypical investigation was done on N'Dama cattle in the localities of Gadapara, "Cite Regionale, Marawata Baya, Veliyadembel and the Zootechnical Research Center of Kolda (ZRC of Kolda).

Sampling and data collection: In each geographical area, at least 5 localities were considered in order to have a representative sample. The selection of breeding stocks included in this study was done mainly depending on the availability of breeders to provide information that was requested in the structured survey questionnaires and on the breeding type (traditional, modern or breeding center). Therefore, 30 stockbreeders and 4 herdsmen of Zootechnical Research Center (ZRC) of Kolda including 15 breeders in the region of Kaolack, 10 in the region of Saint-Louis and 5 of the region Kolda. For each locality, a maximum of 8 herds were visited. In the ZRC of Kolda, 4 reproduction flocks were sampled.

However, to have the least possible related animals insures the representativeness of sample, a maximum of 8 animals was sampled by herd and 4 by each reproduction flock. Therefore, the animals of different inventoried phenotypic types were composed of male subjects aged at least 24 months and females at least 36 months. A total of 126 subjects were selected, including 88 females (Table 1).

The considered phenotypic descriptors are those defined in the checklist of guidelines for phenotypic characterization of animal genetic resources document's FAO (2012) with the purpose of the phenotypical characterization of bovine breeds. In addition for each animal, the age determined by dental feature, the Body Condition Scores (BCS) assessed according to Vall and Balaya, the utilization of animals in their production environment, the productive and reproductive performances were recorded. The history of each sampled animal as the place of birth, the origin was equally noted.

Statistical analysis: The collected data were recorded on Excel 2007 spreadsheet and were analyzed using XLSTAT version 2010.3.01 and R Version 3.1.0 (Bloomfield, 2014). Records of 126 animals were used to perform the descriptive statistics, the test of independence of χ^2 to determine the correlation between factors and qualitative variables at the significance level of 5% and the multiple comparisons of means by multivariate Analysis of Variance (ANOVA) according to the test of Tukey-Kramer at the significant threshold of 5%.

Data relative to phenotypic descriptors and zootechnical performances of 75 lactating cows were afterward submitted to Discriminant Factor Analysis (DFA) to identify characters that best discriminate the different breeds. A typology of cows by Multiple Correspondence Factor Analysis (MCFA) was performed also to distinguish different phenotypic groups.

RESULTS

Distribution of cattle breeds by age class and sex: Table 2 presents the repartition of animals by age group according to breeds and sex. The animals of different bovine breeds are distributed into seven age groups with a wide homogenous dispersion of females. Considering, the total population, about 33.3% of animals had an age ranging between 72 and 95 months. In females, the majority was aged between 72 and 95 months, except those of Djakore breed. However in males, the most part was aged between 24 and 47 months, except those of Gobra breed.

Amongst the phenotypes, the N'Dama taurine had the oldest animals with 15.8% of females aged between 168 and 192 months and 6.7% of males aged between 144 and 167 months.

Table 3 shows the mean age of cattle by phenotypic type and sex of animal. Amongst the males, the mean age varied as of 55.7±34.5 months at the N'Dama cattle to 36±17 months at Djakore cattle. In females, it varied from 102.3±45.1 months at the N'Dama population to 79.5±23.4 months at the Gobra zebu population. Thus, we could observe that the oldest animals as well as in females than in males are those of the N'Dama breed.

Table 2: Distribution of cattle breeds by age class and sex

Age class (months)	Females (%) Djakore	Gobra	Maure	N'Dama	Total females	Males (%) Djakore	Gobra	Maure	N'Dama	Total males	Overall
24-47	-	4.2	-	-	1.1	75	40	77.8	60.0	60.5	19.0
48-71	39.1	25.0	18.2	5.3	22.7	25	50	22.2	20.0	28.9	24.6
72-95	30.4	45.8	50.0	57.9	45.5	-	10	-	6.7	5.3	33.3
96-119	17.4	12.5	18.2	5.3	13.6	-	-	-	-	-	9.5
120-143	8.7	12.5	9.1	10.5	10.2	-	-	-	6.7	2.6	7.9
144-167	4.3	-	4.5	5.3	3.4	-	-	-	6.7	2.6	3.2
168-192	-	-	-	15.8	3.4	-	-	-	-	-	2.4

Table 3: Mean age of animals by cattle breeds in accordance with the sex

Cattle breeds	Age (months)±SD Females	Males
Djakore	80.9±25.6	36.0±17.0
Gobra	79.5±23.4	49.2±15.4
Maure	86.7±23.4	40.0±8.50
N'Dama	102.3±45.1	55.7±34.6

The analysis of variance showed that age varied very significantly with the sex of animal ($p<0.0001$). In consequence, the sex had a very considerable effect on age. However, the factor breed and the interaction breed x sex did not have influence on age.

Also, analysis of age difference between males and females categories by test of Tukey was highly significant ($p<0.0001$), allowing thus to identify two groups of animals, A (females) and B (males) with estimated mean of age in respectively, 87.4 and 45.2 months.

Distribution of animals' phenotypic traits by cattle breeds: Phenotypic observations noted in animals allowed distinguishing 19 descriptors with their modalities at variable frequencies among bovine breeds. The results in Table 4 showed that:

- The straight profile of head is the most distinguished with particularly >70% of observations in all breeds
- The rounded shape of eyes is observed at more than 55% of different cattle breeds. However in the Gobra breed, 50% of animals had rounded eyes and the 50% remaining possessed polygonal eyes
- The straight-edge shape and lateral orientation of ears prevailed in breeds
- The lyre-shape of horns on upwards orientation was the most frequent with 73.5% of Gobra and 63% of Djakore and on forwards with 45.2% of Maure zebu and 61.8% of N'Dama breed
- The most dominant colour of horns in animals was the brown. Nevertheless, for 51.6% of Maure cattle had black horns
- The dewlap is thinly developed for 51.6% of Maure zebu and 64.7% of N'Dama. The dewlap was fairly developed for 73.5 and 70.4% of Gobra and Djakore cattle, respectively

Table 4: Frequencies (%) of phenotypic traits by cattle breeds

Phenotypic traits and modalities	Cattle breeds Gobra zebu	Maure zebu	Djakore	N'Dama	p-values of χ^2
Head profile (%)					
Straight	97.1	83.9	70.4	70.6	p<0.05
Convex	2.9	16.1	29.6	29.4	
Eyes shape (%)					
Rounded	50.0	61.3	55.6	73.5	p>0.05
Polygonal	50.0	38.7	44.4	26.5	
Ears shape (%)					
Rounded	23.5	41.9	29.6	44.1	p>0.05
Straight-edge	76.5	58.1	70.4	55.9	
Ears orientation (%)					
Lateral	85.3	100.0	85.2	97.1	p>0.05
Drooping	14.7	0.0	14.8	2.9	
Horns presence (%)					
Absent	0.0	0.0	0.0	2.9	p>0.05
Present	100.0	100.0	100.0	97.1	
Horns orientation (%)					
Laterally	5.9	25.8	3.7	2.9	p<0.05
Upward	73.5	25.8	63.0	29.4	
Downward	0.0	3.2	0.0	0.0	
Forward	20.6	45.2	33.3	61.8	
Backward	0.0	0.0	0.0	2.9	
Absent	0.0	0.0	0.0	2.9	
Horns shape (%)					
Straight	8.8	32.3	3.7	2.9	p<0.05
Lyre-shape	91.2	67.7	92.6	94.1	
Polled	0.0	0.0	3.7	0.0	
Absent	0.0	0.0	0.0	2.9	
Horns colour (%)					
Black	29.4	51.6	48.1	20.6	p>0.05
Brown	58.8	45.2	51.9	64.7	
White (not pigmented)	11.8	3.2	0.0	11.8	
Absent	0.0	0.0	0.0	2.9	
Dewlap size (%)					
Small	8.8	51.6	11.1	64.7	p<0.05
Medium	73.5	48.4	70.4	29.4	
Large	17.6	0.0	18.5	5.9	
Hump position (%)					
Thoracic	100.0	100.0	92.6	0.0	p<0.05
Absent	0.0	0.0	7.4	100.0	
Hump size (%)					
Absent	0.0	0.0	7.4	100.0	p<0.05
Small	26.5	64.5	63.0	0.0	
Medium	67.6	35.5	29.6	0.0	
Large	5.9	0.0	0.0	0.0	
Hump shape (%)					
Absent	0.0	0.0	7.4	100.0	p<0.05
Erect	88.2	100.0	92.6	0.0	
Drooping (backward)	11.8	0.0	0.0	0.0	
Tail lenght (%)					
Medium	8.8	19.4	33.3	32.4	p>0.05
Long	91.2	80.6	66.7	67.6	

Table 4: Continue

Phenotypic traits and modalities	Cattle breeds: Gobra zebu	Maure zebu	Djakore	N'Dama	p-values of χ^2
Eyelids colour (%)					
Pigmented	91.2	90.3	96.3	58.8	p<0.05
Not pigmented (black)	8.8	9.7	3.7	41.2	
Muzzle colour (%)					
Pigmented	91.2	77.4	85.2	52.9	p<0.05
Not pigmented (black)	8.8	22.6	14.8	47.1	
Hoofs colour (%)					
Pigmented	88.2	80.6	92.6	76.5	p>0.05
Not pigmented (black)	11.8	19.4	7.4	23.5	
Body skin colour (%)					
Pigmented	100.0	96.8	100.0	91.2	p>0.05
Not pigmented (black)	0.0	3.2	0.0	8.8	
Body coat appearance (%)					
Uniform	88.2	61.3	81.5	64.7	p<0.05
Patchy	2.9	22.6	3.7	5.9	
Spotted	8.8	16.1	14.8	29.4	
Body coat colour (%) (Unique)					
White	73.5	6.5	66.7	11.8	p<0.05
Brown	8.8	9.7	11.1	2.9	
Dark brown	0.0	32.3	3.7	0.0	
Fawn	0.0	3.2	0.0	17.6	
Black	0.0	0.0	0.0	5.9	
Pale orange	2.9	9.7	0.0	26.5	
Grey	2.9	0.0	0.0	0.0	
Red	0.0	3.2	0.0	0.0	
Dirty white	0.0	3.2	0.0	0.0	
Compound					
White-brown	0.0	9.7	7.4	8.8	
Brown-white	2.9	9.7	7.4	2.9	
Black-white	0.0	3.2	0.0	2.9	
White-black	2.9	0.0	0.0	14.7	
Black-brown	0.0	3.2	0.0	0.0	
Brown-black	5.9	0.0	0.0	5.9	
Grey-white	0.0	3.2	0.0	0.0	
Dark brown-white	0.0	3.2	0.0	0.0	
White-red	0.0	0.0	3.7	0.0	

[1]Medium (about the hocks), long (below the hocks)

- The thoracic hump was present in all cattle breeds, except for those of N'Dama breed which is taurine cattle. The hump was small size and erected shape in the majority of Maure zebu and Djakore breeds and was very developed in Gobra zebu. It was even predominant in some Gobra subjects
- Long tail is the most widespread among the sampled animals
- Eyelids, muzzle, hoofs and coat, remained pigmented in the most part of sampled animals
- The uniform appearance of body coat was the most prevalent. In Gobra zebu, the body coat colour that is the most prevalent was the white with 73.5%, followed by the brown (8.8%). The most prevalent colour of body coat among Maure zebu was dark brown with 32.3% followed by pale orange and light brown (9.7%). In Djakore breed, the most predominant coat colour was white (66.7%) followed by brownish (11.1%). The dominant colour of coat in N'Dama cattle was pale orange with 26.5% of individuals followed by fawn or and reddish brown (17.6%)

There was a strong association between the factor breed and the following phenotypic traits ($p<0.05$): head profile, horns orientation, horns shape, dewlap size, hump position, hump size, hump shape, eyelids colour, muzzle colour, appearance and colour of body coat.

Phenotypic structure of Senegalese local cattle breeds

Discriminating characters of cows: The discriminant factorial analysis has indicated that the two first axes (F_1 and F_2) explained 95.36% of the total phenotypic variation (Fig. 2). Over the 25 qualitative recorded traits, only 11 of them had permit to best distinguish the cattle breeds (Table 5). They were the average Milk production per day (MILK), the Horns Orientation (HORN), the Horns Shape (HORNSH), the Dewlap Size (DWSIZ), the Hump Position (HUMPP), the Hump Size (HUMPSZ), the Hump Shape (HUMPSH), the Eyelids Colour (EYELID), the Muzzle colour (MUZZLE), the Body Coat Appearance (BCOATA) and the Body Coat Colour (BCOAT).

Considering the F_1 axe that describing 74.48% of the total phenotypic variation, the hump position character has the highest contribution of 0.959, followed by the hump shape (0.894) and the hump size (0.519) (Table 5). The F_2 axe which described 20.89% of the variability was essentially defined by the body coat colour with a contribution of 0.488 followed by the body coat appearance (0.355) (Table 5). Regarding the coefficients given for discriminating variables, F_1 was defined like as the axe of format of animal and dairy performance and F_2 as the axe of colour.

According to the best contribution of the character hump position, the F_1 axe with a high variability separated the cows into two populations (Fig. 2). The first one was formed by the N'Dama breed and the second formed by the Maure, Gobra and Djakore breeds. However, the F_2 axe with a best contribution of body coat colour, distinguish the Maure breed to the Gobra and Djakore breeds which constituted together one population (Fig. 2).

Classification of cows: The factorial discriminant analysis has revealed that the genetic types which have been predicted on different traditional, modern herds were well classified on average in 97.28% of cases in accordance with the phenotypic descriptors. The well-classified cows are observed on the first diagonal. The N'Dama and Djakore breeds constituted the most homogeneous populations with 100% of animals' correctly classified (Table 6). Regarding the Maure and Gobra zebus, the percentage of animals correctly classified was 95 and 94.12%, respectively (Table 6).

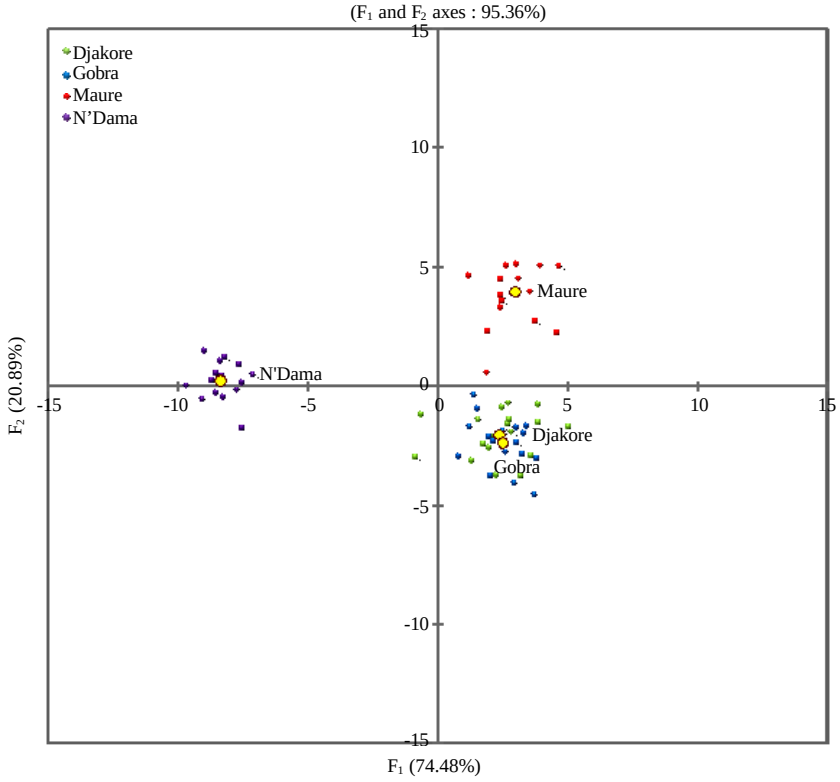

Fig. 2: Cows distribution of different cattle breeds in principal plan (F_1-F_2)

Table 5: Contributions of discriminant variables to F_1 and F_2 axes for the four local cattle breeds

Variables	MILK	HORN	HORNSH	DWSIZ	HUMPP	HUMPSZ	HUMPSH	EYELID	MUZZLE	BCOATA	BCOAT
F_1	0.343	0.323	0.084	0.375	0.959	0.519	0.894	0.431	0.360	0.037	0.091
F_2	0.151	-0.414	0.345	-0.148	-0.004	0.291	0.059	-0.015	-0.201	0.355	0.488

MILK = Average daily milk production; HORN = Horns Orientation; HORNSH = Horns Shape; DWSZ = Dewlap Size; HUMPP = Hump Position; HUMPSZ = Hump Size; HUMPSH = Hump Shape; EYELID = Eyelids color; MUZZLE = Muzzle color; BCOATA = Body Coat Appearance; BCOAT = Body Coat Color

Table 6: Percentage of cows correctly or incorrectly classified

Observed phenotypic types	Predicted genetic types (%) Djakore	Gobra	Maure	N'Dama	Number of cows
Djakore	100.00	0.00	0	0	20
Gobra	5.88	94.12	0	0	17
Maure	0.00	5.00	95	0	20
N'Dama	0.00	0.00	0	100	18

The percentage of well-classified cows reads on the first diagonal

Table 7: Contributions of variables to the factorial axes F_1, F_2 and F_3

Code/Active variables	F_1*	F_2*	F_3*
MILK/Milk production (L day^{-1})	0.08	0.03	0.05
LACT/Lactation length (days)	0.02	0.13	0.06
HORN/Horns orientation	0.04	0.12	0.21
HUMPSZ/Hump size	0.18	0.05	0.08
HUMPSH/Hump shape	0.18	0.05	0.03
MUZZLE/Muzzle color	0.07	0.05	0.03
BCOATA/Body coat appearance	0.03	0.19	0.03
BCOAT/Body coat color	0.13	0.23	0.18

* = %

Furthermore, 5.88% of Gobra cows were among the Djakore type. While 5% of Maure zebu cows were identified in the Gobra type.

Typology of cows

Contribution of different variables to the discriminating axes: The multiple correspondence factor analysis showed that the first three axes explained 64.17% of the total variation. Four descriptors including the hump size (18%), the hump shape (18%), the body coat colour (13%), and the average milk production (8%) permit to construct the F_1 axe (Table 7). This axe can be assimilated as axe of animal format, colour and milk production. For the F_2 axe, 4 variables like as the body coat colour, the body coat appearance, the lactation period length and the horns orientation with contributions of 23, 19, 13 and 12%, respectively have allowed to production of this axe (Table 7). So the F_2 axe can be considered as axe of colour, appearance and lactation. Whereas, the F_3 axe that described 8.01% of the variability of cows was best represented by the variables like as horns orientation and body coat colour (Table 7). This axe can be considered as the axe of animal format and colour.

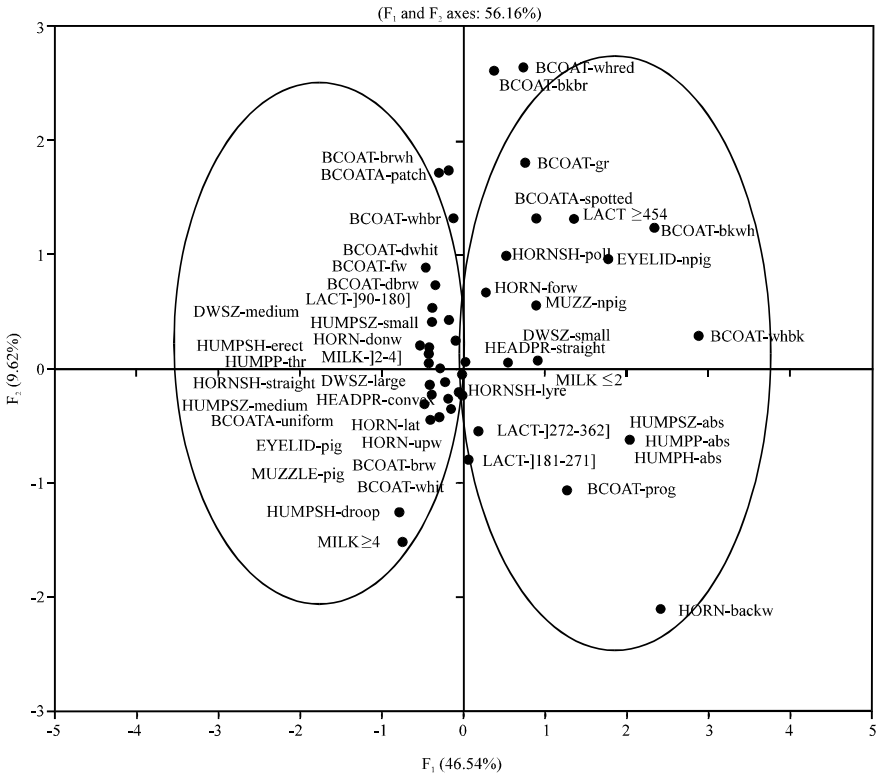

Fig. 3: Cows typology according to different variables in factorial plan (F_1-F_2)

Regarding the contributions of the first 3 axes, the animal format, the colour and the average milk production were the most preponderant variables in distinction of cows.

Identification of lactating cows' groups: The principal plan (F_1-F_2) of modalities reported the different possible correlations within variables (Fig. 3).

Thereby, the F_1 axe divided lactating cows into two groups with 46.54% of the total phenotypic variation. The cows that formed the group I (left group to F_1 axe) were characterized by the following modalities: HUMPSZ-medium, -small, -erect, -droop, BCOAT-whit, -brw, -dbrw, -fw, -dwhit, -whbr, -brwh, MILK-[2-4] and >4 (Fig. 3). Lactating cows of this group are identified by their different size and shape of hump, a unique color of body coat and a highly milk production. To this group opposes group II (the right group to F_1 axe) which has characters such as HUMSZ-abs, -abs, BCOAT-porg, -gr, -whbk, -bkwh, -bkbr, -whred and MILK<2 (Fig. 3).

Therefore, the cows of group II are distinguished by their absence of hump their compound colour of body coat and their low milk production.

DISCUSSION

Phenotypic description of cattle breeds by discriminating characters: The results showed that the four genetic types could be identified with the following phenotypic descriptors.

N'Dama breed: The N'Dama bovine is a trypanotolerant long horns taurine cattle essentially reared in tsetse-infested areas like the regions of Casamance and Eastern Senegal. The N'Dama cattle is small sized animal with a straight head profile and pigmented or not muzzle. The variation of muzzle colour has been previously observed in N'Dama cattles originated from Lower, Middle and Upper Casamance. Its eyelids are habitually pigmented or black coloured. Its horns are in lyre-shape usually and directed on forwards, often some individuals are encountered with horns directed on upwards. Sokouri had described this shape and horns' orientation at Baoule and N'Dama cattle of Cote d'Ivoire. The N'Dama breed presents a small dewlap size and rarely subjects with a developed dewlap can be met through herds. The N'Dama is a rustic animal without hump. The body coat appearance of the N'Dama cattle is uniform in general and often spotted. Therefore, the body coat

colour presents a variety of colour that can be varied between the pale orange, fawn or reddish brown, white-black and white. However, the pale orange color is the most frequent and is an element that characterized this breed. This variability of body coat color has been same noted at N'Dama and Baoule of Cote d'Ivoire. Concerning the milk production of N'Dama cows, it is on average 1 L day^{-1}. Comparatively, the Senegalese N'Dama cows have been characterized previously by a very weak daily milk production varying from 2-3 L (FAO, 2012); nevertheless, their production remains higher than those of currently N'Dama lactating cows.

Djakore breed: The Djakore population is to become a fixed phenotypic type in the region of "Bassin Arachidier". It constitutes a homogenous population recognized by the local breeders. The Djakore cattle is crossbreed of Gobra zebu originated from the northern and the N'Dama taurine from the southern. The Djakore is medium sized cattle and characterized by a straight head profile with pigmented muzzle and eyelids. These same characters are described in Mere cattle (a crossbreed between Peul zebu and Baoule taurine). The horns are in lyre-shape often turned upwards in the majority of cases but in some subjects, the horns are often directed forwards. This type of orientation of horns is also frequent in Mere cattle. Its dewlap size is enough developed. The Djakore thoracic hump is erect and less developed than Gobra's hump. The hump can even be occasionally absent. These same characteristics of hump have been found in Mere breed in Cote d'Ivoire. The body coat appearance of Djakore cattle is uniform and often spotted. While, the body coat color is generally white colored and rarely brown colored. The white color of body coat is frequent in this breed. The milk production of Djakore is 1.7 L day^{-1}.

Gobra breed: The Gobra zebu is located in the Northern of Senegal and in the region of "Bassin Arachidier" area. The Gobra cattle have a straight and long head with pigmented muzzle and eyelids. Its dewlap is enough developed and even large in some subjects. Its horns are directed in high lyre-shape and turned on upwards in general but in some subjects, the horns are often directed on forwards. The Gobra zebu is characterized by the presence of a thoracic hump with a very variable size. This hump in erect shape or rarely drooping on backwards is medium sized in general. And sometimes, it can be very developed. These characteristics of Gobra zebu have been well described previously. The body coat color of Gobra zebu is uniformly white. In accordance with Missohou, this color of body coat is characteristic at Gobra breed.

The Gobra zebu is characterized by an average milk production of 2.7 L day^{-1}. According to Cisse, the cow Gobra was characterized by a low milk production in traditional herds which varied between 1.5-2 L day^{-1}.

Maure breed: The Maure zebus are sahelian cattle with short horns encountered in West African countries. In Senegal, its populations are located primarily in the long Mauritania frontier, more precisely, the Senegal River Valley. The Maure zebu presents a long and fine head with straight profile. Its eyelids and muzzle are pigmented or not. The dewlap is fairly developed. Its short horns are straight or in lyre-shape and are directed on forwards; sometimes they turn on laterally or on upwards. According to Kane, these traits are characteristic of Maure cattle. The thoracic hump of Maure zebu is in erect shape and more or less developed. This hump shape has been described Maure zebu by Meyer. The body coat appearance is uniform in general and often patchy or spotted. The body coat color is very variable; it can be unique color such as dark brown, brown, pale orange or compound color like as white-brown and brown-white. This variability of body coat color is a discriminant descriptor of this breed. The cow Maure zebu produces on average 2.6 L of milk per day. As to current lactating cows, the previously cows were considered as good milk producers with a production of 4-5 L day^{-1} in rainy season and in extensive breeding.

Phenotypic structure of Senegalese local cattle breeds

Discriminating characters and classification of phenotypic types: The discriminant analysis factor has permitted to conclude that the hump position and the body coat color were the characters that enabled to best discriminate the different cattle breeds in the 3-agroecological zones of Senegal. The hump position with a contribution of 0.959 has allowed distinguishing cows of N'Dama to those of Gobra, Maure and Djakore. This confirms effectively that the N'Dama cows are part of the taurine type without hump. Furthermore, the coat color with a contribution of 0.488 has enabled to identify the Maure zebu amongst Gobra and Djakore cattle. This is explained by the fact that the coat color is in general light in the Gobra and Djakore cattle whereas it is dark in Maure zebu. Thus, the coat color is a fundamental character because it allowed considering the Gobra and Djakore breeds as a same population. According to N'Goran *et al.* (2008) the animal conformation and the body coat colour are key characters of distinction of cows in dairy breeding. Based on the variability given by F_1 and F_2 axes, diversity encountered among breeds is therefore a variability in populations rather than individual variability.

As regards to classification of cows, the N'Dama with 100% of cows correctly classified is part of the most homogenous breeds. Thought, it seems that it is less affected by uncontrolled crossings. This could explain the stability of this breed. Moreover, this breed is widely isolated to the other breeds in terms of geographic distribution. Comparatively, the N'Dama bovine of Cote d'Ivoire has been considered as a homogenous population because less affected by anarchic crossings. Moreover, the survey that has been conducted on breed production environment has revealed that 56% of N'Dama breed did not make transhumance. The transhumant N'Dama cattle did not go beyond 30 km of Kolda department which is area of dispersal of N'Dama breed or Djakore breed. In view of that the N'Dama breed in Middle and High Casamance could be supposed as a purebred because of the homogeneity of characters shared by its individuals and the isolation of its populations.

With 100% of cows well classified, the Djakore bovine appears as a breed enough homogenous. This could be explained by the fact that this breed is less affected by anarchic crossings or submitted to more or less controlled crossings. However, any cow of Djakore has not been found in Gobra or N'Dama breeds, even though it is a natural cross product of Gobra-N'Dama. In addition, despite the pressure of crossbreeding which is exerted on Djakore in the south of the region of "Bassin Arachidier" it has become a steady and fixed breed through the years. This proves that the characters which the Djakore cattle have inherited of both parents have evolved for becoming constant and allowing therefore, the maintaining of this breed in his own production environment. As comparing to the Mere in the Northern region of Cote d'Ivoire (Korhogo) according to Sokouri, it is also a fixed breed. Furthermore, the stockbreeders in this area favored well this breed because his format is well suited for draught power and effectively in this study 22% of Djakore cattle are used in draught power.

The Gobra cattle belonging to the South of the region of "Bassin Arachidier" and the Senegal River Valley are correctly classified in 94.12% of cases. However, 5.88% of its subjects which reclassified in Djakore breed, showed that this breed is undergone to uncontrolled crossings. Furthermore, some breeders of the agroecological area of the South of Region of "Bassin Arachidier" mistook Gobra breed for Djakore one in general because the resemblance of the two phenotype. Accordingly, a continuous and no controlled crossbreeding will endanger the Gobra breed in aid of Djakore cattle.

In the Maure cattle 95% of them were well classified, however 5% were found into the Gobra breed. As compared to Gobra, this breed is affected too by no controlled crossings in the South of Bassin Arachidier and the Senegal River Valley. The investigation showed that 67% of Maure herds did not make transhumance; thought 75% of Gobra-Maure herds went to transhumance in Debi (near Djoudj Park, Department of Saint-Louis) and crossed during other herds of the same breeds. This proves that the Gobra and Maure cattle mate often between them without any control. These non-oriented crossings may favor introgression which could constitute a threat for the conservation of Maure zebu breed.

Typology of cows: Correlation between qualitative variables by multiple correspondence factor analysis has let to identify two phenotypic groups of cows which are distinguished mainly by their format, coat color and milk production. The group I which its subjects are characterized by the presence of hump with various size and shape, a unique colour of body coat and a highly milk production, is formed by Gobra, Maure and Djakore breeds. However, the subjects of group II are identified by their absence of hump, compound colour of coat and low milk production. Taking into account the results of discriminating characters, classification and typology of cows, three genotypes that keep up a correspondence to phenotypes of zebu and taurine can be distinguished. The zebu phenotype gathers two genotypes whose are the Djakore breed and the Gobra-Maure zebus. Therefore, the taurine phenotype groups the N'Dama genotype. In accordance to ours results, we can emit the hypothesis that: the current bovine breeds in Senegal would constitute in phenotypic level three genotypes which are the Djakore, the N'Dama and the Gobra-Maure zebus. Further, studies in the same background could verify if the current phenotypic grouping has a genetic base.

CONCLUSION

The survey of breeding herds in the agroecological areas of South of "Bassin Arachidier", Senegal River Valley and Middle and Upper Casamance has permitted to characterize four phenotypic types which are the Gobra zebu, Maure zebu, Djakore and N'Dama. The discriminating factor analysis has revealed that the descriptors that allowed discriminating at best the different bovine types were the hump position and the coat colour.

The breeders appeared well to recognize the N'Dama and Djakore breeds throughout breeding herds because all subjects of these breeds sampled to their observed phenotype have been reclassified in the same predicted genetic type. However, the Gobra and Maure breeds

appear to be more or less heterogeneous because certain subjects have been respectively classified into Djakore and Gobra. Whereas, the breeders often mistake Djakore and Gobra breeds on one hand and Gobra and Maure in the other hand because they share the same production environment that lead to uncontrolled mating. The N'Dama cattle can be easily distinguished from the humped cattle but it is to make distinction between Djakore, Gobra and Maure cattle. The Djakore presents a homogenous population and through the years, it has become a newly fixed breed. There is an emergence of Djakore phenotype in the Senegalese livestock whose certain characteristics are not know by the breeders of the South of the Region of "Bassin Arachidier". Therefore, the N'Dama cattle would be further a "supposed purebred". Two phenotypes corresponding to 3 genotypes have been discriminated amongst cows: the N'Dama genotype, Djakore genotype and Gobra-Maure zebus' genotype. The first constitutes its own phenotype and the latter two form their own phenotype too. However is there a need to worry about consequences of the uncontrolled crossbreeding which the Gobra and Maure cattle are exposed? Or quite there must be involved to animal genetic resources conservation in order to monitoring them. Afterwards, the molecular characterization of these cattle will be indicating with accuracy the status of local Senegalese bovine breeds.

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