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# CHARACTERIZATION OF MORPHOLOGICAL TRAITS IN ALGERIAN INDIGENOUS GOATS BY MULTIVARIATE ANALYSIS

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**Abstract**
Goat farming is an important economical resource in rural and harsh areas worldwide. In Algeria, a population of more than 5 million of goats is present but until recent years, genetic characterization of different indigenous breeds was not performed. A description of morpho biometric traits has been performed to establish characteristics distinguishing 4 different goats breed: Naine de Kabylie, Arbia, Mekatia and M'zabite bred in 4 different environments in north-central Algeria. A total of 416 goats, aged up to twelve months old, belonging to the four indigenous breeds were used for the analysis. Multivariate analysis was performed considering the following 5 quantitative traits: height at wither (HW), thoracic circumference (TC), ears length (EL), horns length (HoL) and hair length (HaL). In addition, 7 qualitative traits were used: the coat colour (black and white, black, white, brown, brown and white), type of hair (three levels: short, mid-long and long), type of ears (three levels: drooping, pedunculated and dressed), type of chamfer (two levels: curved or straight), incidence of horns (Ho, presence/absence), incidence of beard (Br, presence/absence) and incidence of wattles (W, presence/absence). Least square means of the morphometric measurements traits for sex were generally significant ($p < 0.01$). Component analysis and common factor analysis were used to analyse interrelationships among variables. Phenotypic frequencies of the qualitative traits were calculated. To analyse the pattern of relationships among the qualitative variables a multiple correspondence analysis (MCA) was performed. The first component accounts for the 61% of the variance and is associated with measures of height (HW) and length (TC, EL, HoL). The second component is associated with HaL with a correlation of 97%. The considered breeds were not perfectly clustered as some qualitative traits were in common between breeds.
**Keywords**: Algerian goats, morphometric parameters, multivariate analysis, PCA, MCA.

## Introduction

A population of more than 5 million goats is present in Algeria (FAOSTAT, 2014) with the majority represented by indigenous breeds managed by traditional farmers (Kadi *et al.*, 2014). Indigenous goats are a valuable resource to be preserved due to their adaptation to harsh climatic conditions and resistance or tolerance to infectious diseases common in their habitatsDespite their multiple roles and economic importance, information collected by the Food and Agriculture Organization (FAO) of the United Nations indicated that the proportion of breeds of livestock classified as at risk of extinction in the world grew by 15 to 17 per cent between 2005 and 2014 (FAO, 2015) although the maintenance of animal indigenous breeds represent the most economical way to preserve the landscape and habitat diversity and to preserve cultural and sociological traditions (Ozimec, 2013).

Algeria, like other countries in Africa, is faced with a continuous erosion of animal genetic resources, mainly due to the replacement of livestock by more productive commercial breeds (Gaouar *et al.*, 2015) or by crossbreeding local breeds with exotic ones, to generate populations with the desired phenotypes. This hybridization process, however, has resulted in an increased reliance on a small number of breeds to meet the local's food requirements, which could lead to the disappearance of local breeds (Tolone *et al.*, 2012).

In Algeria, goat breeding represents an important resource in marginal area in which other economic activities are limited. In particular goats populations are located in diverse geographic areas with predominance of the "difficult" zones (mountain area, steppe and Sahara); their maximum milk production observed in M'zabite breed and estimated for 460 kg in 180 lactation days. In opposite, the minimum is about 80 kg in 120 lactation days for the Mekatia breed (Kerbaa, 1995). Milk production is mainly used for the consumption of the breeders and sometimes for cheese production. Little information is available on genetic and phenotypic characteristics of Algerian goats, which are essential for the development of appropriate breeding goals and programmes for each ecosystems. The knowledge of the extent of genetic variation within breed is essential for the development of appropriate breeding programmes in goat populations.

However, before that, a morphological characterization of the breeds and a study of the variation within and between breed are needed. The aim of this study was to study the morphometric characteristics of 4 Algerian goat breeds in order to facilitate their field identification and classification.

## Material and Methods

Recording of the different goat morpho biometric traits was carried out in 4 different locations: Mountainous regions with annual rainfall isohyet exceeds 600 mm, Northern Steppe regions with annual rainfall isohyet between 400 mm and 200 mm, Southern Steppe regions with annual rainfall isohyet between 200 mm and 100 mm and Saharan regions with annual rainfall isohyet less than 100 mm (**Figure 1**).

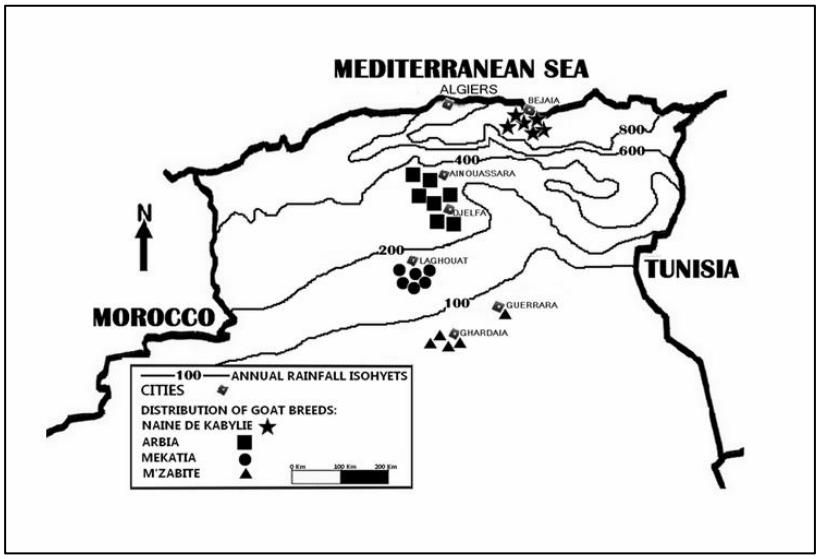


**Figure 1**. Sites of Algerian goat breed samples according to annual rainfall areas.

A total of 416 goats, aged up to twelve months old, belonging to the 4 indigenous breeds (99 Naine de Kabylie, 125 Arbia, 105 Mekatia and 87 M'Zabite) were used for the analysis. Data were collected selecting from 5 to 10 adults individuals from 49 farms located in these regions. In this study **5** quantitative traits were considered: height at wither (HW), measured vertically in a flat platform from the surface of the platform to the wither using a measuring stick; thoracic circumference (TC) taken just behind the forelimbs; ears length (EL), horns length (HoL), hair length (HaL), for these four last measurements a tape-rule are used (**Figure 2**).

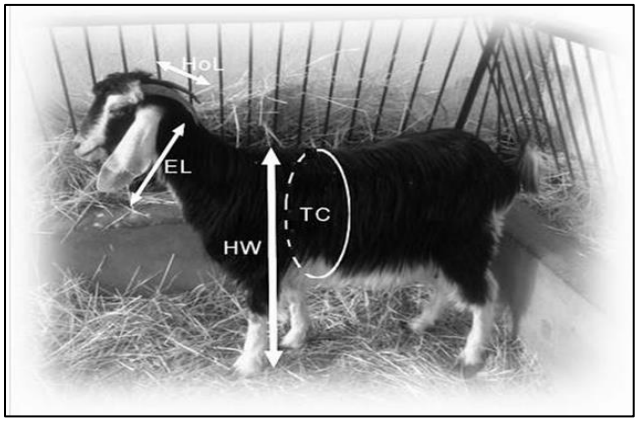


**Figure 2.** Morphometric measurements recorded in this study.

Records were also taken for 7 qualitative traits: the coat colour (5 levels: black and white, black, white, brown, brown and white), type of hair (3 levels: short, mid-long and long), type of ears (3 levels: drooping, pedunculated and dressed), type of chamfer (2 levels: curved or straight), incidence of horns (Ho, presence/absence), incidence of beard (Br, presence/absence) and incidence of wattles (W, presence/absence). Quantitative traits were analysed with the General Linear Models procedure of the SAS v.9.2 software using LSMEANS option for mean comparison between breed and sex. In order to evaluate the interdependence of continuous body measurements, a factor analysis was carried out for each breed.

Data were processed using the PROC FACTOR of the SAS v.9.2 software. A varimax rotation was applied in order to obtain the factor pattern coefficient (Morrison, 1990). The objective is to find a way of condensing the information contained in a number of original variables into a smaller set of variables with a minimal loss of information (Hair *et al*., 2010). Phenotypic frequencies of the qualitative traits were calculated. Moreover to analyse the pattern of relationships among the qualitative variables a multiple correspondence analysis (MCA) was performed using FactoMineR (Husson et al., 2012) and factoextra (Kassambara and Mundt 2017) packages of R environment.

## Results and Discussion

**Table 1**. Descriptive statistics of morphometric measures of Algerian goats breed

| | N | Min (cm) | Max (cm) | Mean (cm) | Std. Dev. (cm) | CV (%) |
|---|---|---|---|---|---|---|
| HW | 416 | 57.50 | 74.00 | 66.76 | 3.53 | 5.29 |
| TC | 416 | 66.50 | 83.50 | 74.09 | 4.22 | 5.70 |
| EL | 416 | 9.00 | 23.00 | 14.95 | 3.23 | 21.58 |
| HoL | 402 | 12.00 | 26.50 | 18.46 | 3.11 | 16.85 |
| HaL | 416 | 3.00 | 11.00 | 6.50 | 2.66 | 40.98 |

*Means within a column with different superscript differ (P < 0.01); HW, height at withers; TC, thoracic circumference; EL, ears length; HoL, horns length; HaL, hair length.*

Among the body morpho biometric measurements, HaL showed the highest variability followed by EL and HoL while HW and TC had relatively low coefficients of variation (**Table 1**).

**Table 2.** Least squares means (±SE) of morphometric measures for sex of Algerian goats breed.

| Sex | Breeds | HW (cm) | TC (cm) | EL (cm) | HoL (cm) | HaL (cm) |
|---|---|---|---|---|---|---|
| Female | Naine de kabylie | $59.6^{a}$±0.2 | $69.2^{a}$±0.2 | $11.2^{a}$±0.2 | $14.2^{a}$±0.2 | $7.7^{a}$±0.1 |
| | Arbia | $67.8^{a}$±0.1 | $76.0^{a}$±0.2 | $19.1^{a}$±0.1 | $19.4^{a}$±0.2 | $9.0^{a}$±0.1 |
| | Mekatia | $64.3^{a}$±0.2 | $73.3^{a}$±0.2 | $13.7^{a}$±0.2 | $18.7^{a}$±0.2 | $3.1^{a}$±0.1 |
| | M'zabite | $64.2^{a}$±0.2 | $68.8^{a}$±0.2 | $13.1^{a}$±02 | $17.0^{a}$±0.2 | $4.0^{a}$±0.1 |
| Male | Naine de kabylie | $67.2^{b}$±0.2 | $72.2^{b}$±0.2 | $12.3^{b}$±0.2 | $15.3^{b}$±0.2 | $8.5^{b}$±0.1 |
| | Arbia | $70.7^{b}$±0.2 | $79.3^{b}$±0.2 | $19.5^{a}$±0.2 | $24.1^{b}$±0.2 | $9.6^{b}$±0.1 |
| | Mekatia | $71.0^{b}$±0.2 | $80.1^{b}$±0.2 | $14.5^{b}$±0.2 | $20.1^{b}$±0.2 | $4.0^{b}$±0.1 |
| | M'zabite | $67.1^{b}$±0.2 | $70.8^{b}$±0.2 | $13.4^{a}$±0.2 | $18.0^{b}$±0.2 | $4.4^{b}$±0.1 |

*Means within a column with different superscript differ (P < 0.01); HW, height at withers; TC, thoracic circumference; EL, ears length; HoL, horns length; HaL, hair length.*

The coefficients of variation for HW, EL and HoL were lower than those reported by Dossa et al. (2007) and Pires et al. (2012). Least square means of the morphometric measurements traits considered in this study were generally higher for bucks than for does (**Table 2**), similar to the Beni Arrous goats in Morocco (Hilal, 2013).

The measure of association between the quantitative traits and sex was very strong as confirmed by Parés-Casanova (2015). Among the breeds, in decreasing order, HW was higher in Arbia (69.2±0.1) than in Mekatia (67.6±0.1), M'zabite (65.7±0.1) and Naine de Kabylie (63.4±0.1). Overall body measurements for the Arbia breed were higher compared to Mekatia, M'zabite and Naine de Kabylie. Moula *et al.* (2013), described the Naine de Kabylie breed as small (male: 68.23 cm vs female: 65.41 cm), in contrast Sahraoui and Madani (2014) report that Arbia breed is bigger (male: 74.23 cm vs female 72.57 cm).

The values reported by these authors were higher than our measurements. The highest body measures of Arbia goats imply that they are good walkers with long hair to resist the cold in the steppe agro

systems. The Naine de Kabylie is short in size and adapts better to the steep places of the mountains of ''Kabylie''. The Mekatia and M'zabite breeds have an intermixed height, they have short hairs and adapt better to the high temperatures of the Sahara.

The eigenvalue-one criterion, also known as the Kaiser-Guttman criterion (Kaiser 1960), was used in order to determine the number of meaningful components to retain. With this method, all components with eigenvalues greater than 1 are retained. This criterion, as suggested by Stevens (2002), should be used when the study involve fewer than 30 variables and communalities are greater than 0.70 or when the analysis is performed on more than 250 observations and the mean communality is greater than 0.59. According to this criterion two principal components were retained and were representative of the total information with 81.70% of the cumulative eigenvalues (**Table 3**).

**Table 3.** Principal components after Varimax rotation for morphometric measures of Algerian goats breed

| **Morphometric measures** | **Component 1** | **Component 2** | **Communality** |
|---|---|---|---|
| HW | 0.87489 | 0.06592 | 0.76978625 |
| TC | 0.89227 | 0.12485 | 0.81174276 |
| EL | 0.69383 | 0.54016 | 0.77316874 |
| HoL | 0.88099 | 0.08923 | 0.78410822 |
| HaL | 0.05138 | 0.97144 | 0.94632982 |
| Variance explained | 3.071 | 1.01 | |
| % of Total variance | 61.44 | 20.27 | |

*HW, height at withers; TC, thoracic circumference; EL, ears length; HoL, horns length; HaL, hair length.*

The first component accounts for the 61% of the variance and is associated with measures of height (HW) and length (TC, EL, HoL). The second component is associated with HaL with a correlation of 97%. Since components are by definition uncorrelated, results suggest that morphometric measures of HW, TC, EL and HoL are not related to the hair length then improvement of these traits implies a little variation in hair length in the four breeds.

The principal components observed in the present study could be used alongside other economic parameters in evaluating animals for management purpose. Similar results of the PC have been reported (Herrera *et al.*, 1996; Yakubu *et al.*, 2010; Yakubu *et al.*, 2011; Yakubu and Mohammed, 2012) and it has been employed in determining carcass traits of goats (Bonvillani *et al.*, 2010). The phenotypic frequencies of the qualitative characteristics of the Algerian goat breeds are presented in **Table 4** by sex. The type of short hair, which is an ordinal qualitative characteristic estimated *in visu*, was very common for the Mekatia and M'zabite breeds (95.24% and 80.46%).

Indeed, the name of the Mekatia breed has its origin in the qualifier attributed to the smooth stone (Mekat) used as paving stone (Khemici *et al.*, 1995). Arbia, on the other hand, was long (28.8%) and mid-long (71.2%) haired while the Naine de Kabylie has medium hairs (91.92%). Hair length protects these last two breed from the cold of steppic and mountainous regions, respectively. Regarding coat colour Arbia has black or black-white phenotype (95.2%) with white colour found in the legs and the lower flank of the animal (**Figure 3**).

**Table 4:** Proportions of qualitative traits of Algerian goats according to breeds and sex.

| Traits | Breeds / Class level | *Naine de Kabylie* | | *Arbia* | | *Mekatia* | | *M'zabite* | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** | **Females** | **Males** |
| Type | Short | **-** | **-** | **-** | **-** | **53** | **47** | **38** | **32** |
| Hair | Mid-Long | **41** | **50** | **65** | **24** | **-** | **5** | **4** | **13** |
| | Long | **-** | **8** | **11** | **25** | **-** | **-** | **-** | **-** |
| Type | drooping | **30** | **46** | **73** | **47** | **28** | **14** | **3** | **12** |
| Ears | pedunculate | **4** | **8** | **3** | **2** | **24** | **35** | **36** | **32** |
| | Dressed | **7** | **4** | **-** | **-** | **1** | **3** | **3** | **1** |
| Horns | Horned | **39** | **56** | **74** | **47** | **51** | **50** | **41** | **44** |
| | not horned | **2** | **2** | **2** | **2** | **2** | **2** | **1** | **1** |
| Bread | Not Breaded | **40** | **50** | **-** | **-** | **-** | **-** | **10** | **9** |
| | Breaded | **1** | **8** | **76** | **49** | **53** | **52** | **32** | **36** |
| Wattles | Not Wattled | **38** | **53** | **11** | **5** | **-** | **-** | **-** | **-** |
| | Wattled | **3** | **5** | **65** | **44** | **53** | **52** | **42** | **45** |
| Chamfer | curved | **2** | **2** | **4** | **3** | **53** | **52** | **37** | **35** |
| | straight | **39** | **56** | **72** | **46** | **-** | **-** | **5** | **10** |
| Coat | Black+White | **-** | **-** | **59** | **36** | **-** | **-** | **-** | **-** |
| colour | Black | **3** | **3** | **12** | **12** | **-** | **2** | **-** | **-** |
| | White | **2** | **3** | **1** | **-** | **-** | **-** | **-** | **-** |
| | Brown | **1** | **13** | **3** | **1** | **48** | **38** | **36** | **37** |
| | Brown+White | **35** | **39** | **1** | **-** | **5** | **12** | **6** | **8** |
| **TOTAL / breeds / sex** | | **41** | **58** | **76** | **49** | **53** | **52** | **42** | **45** |


**Figure 3.** The four Algerian studied breeds: *Naine de Kabylie* (1), *Arbia* (2), *Mekatia* (3) and *M'zabite* (4).

Brown and white coat colour was observed in Naine de Kabyle breed (74%) while Mekatia and M'zabite had brown coat colour (82% and 84% respectively). Hair length and coat colour are crucial factors determining the ability of a breed to tolerate the daytime heat load. The number of dimension to retain for data interpretation has been determined using a **scree plot** (**Figure 4**).

According to the graph, only dimension 1 and 2 should be used in the solution as above the average eigenvalue of 16.7% highlighted by the red line. Dimension 1 and 2 explains 30.5% and 17.8% that corresponds to a cumulative total of 48.3% of total variance retained by the two dimensions.

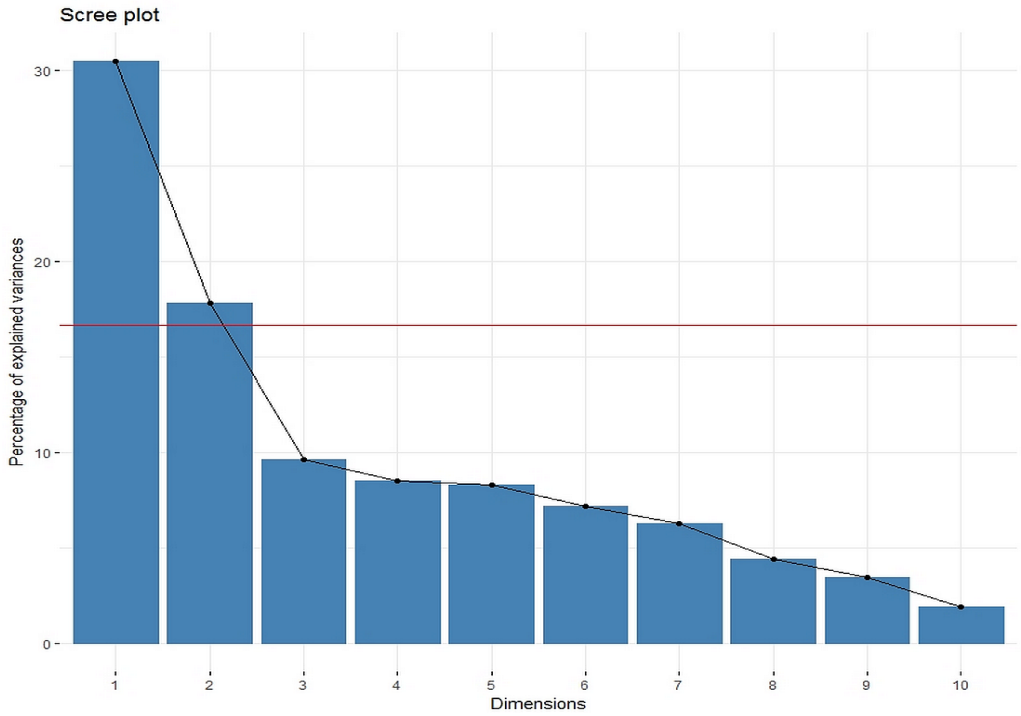


**Figure 4.** Histogram of eigenvalues (scree plot) of the main Algerian goat studied breeds

In **Figure 5** a **biplot** of the individuals and variable categories is showed by breeds of membership. The category of the variables that contributed most to the dimension 1 were in decreasing order TypeHairs_1, i.e. the short hair followed by the absence of wattles (Wattles_0), curved type (Head_0) of chamfer, brown coat colour (Color_4), straight type of chamfer (Head_1), absence of beard (Beard_0), mid-long hairs (TypeHairs_2), straight type of chamfer (TypeEars_2) and finally brown-white coat colour (Color_5).

The category of the variables that contributed most to the dimension 2 in decreasing order were the black and white coat colour (Color_1), long hairs (TypeHairs_3), absence of beard (Beard_0), brown and white coat colour (Color_5) and the absence of wattles (Wattles_0).

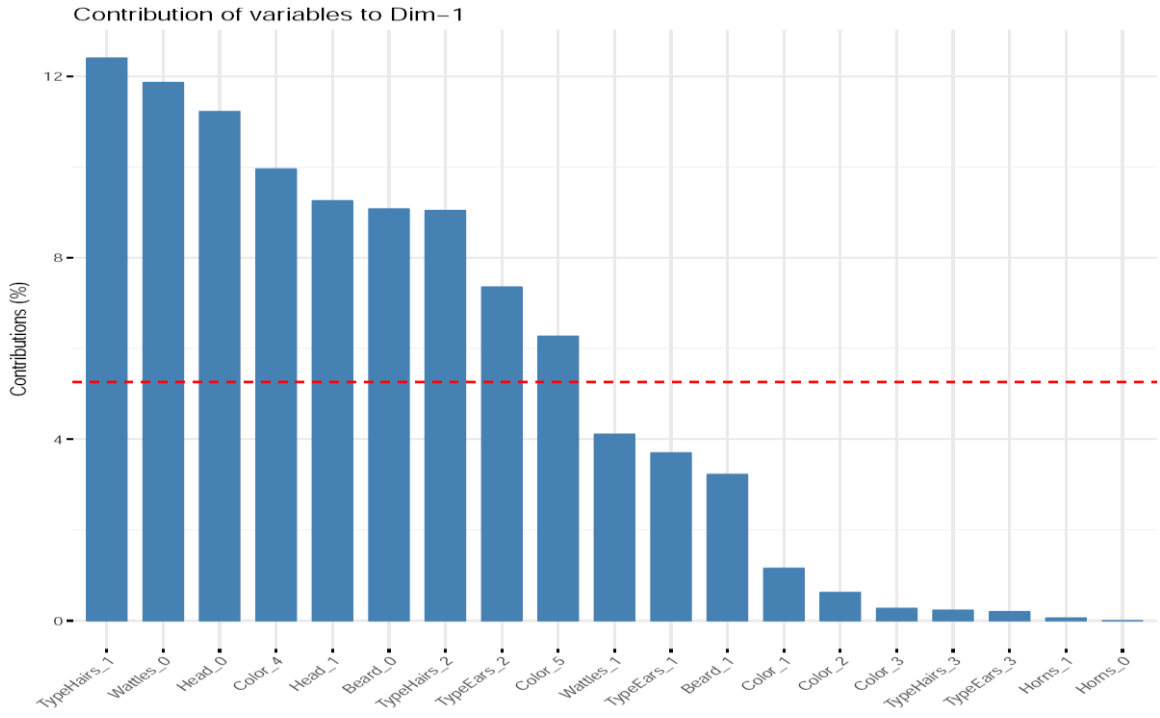


**Figure 5.** Histogram of contributions of variables for dimension 1 of the main Algerian goat studied breeds

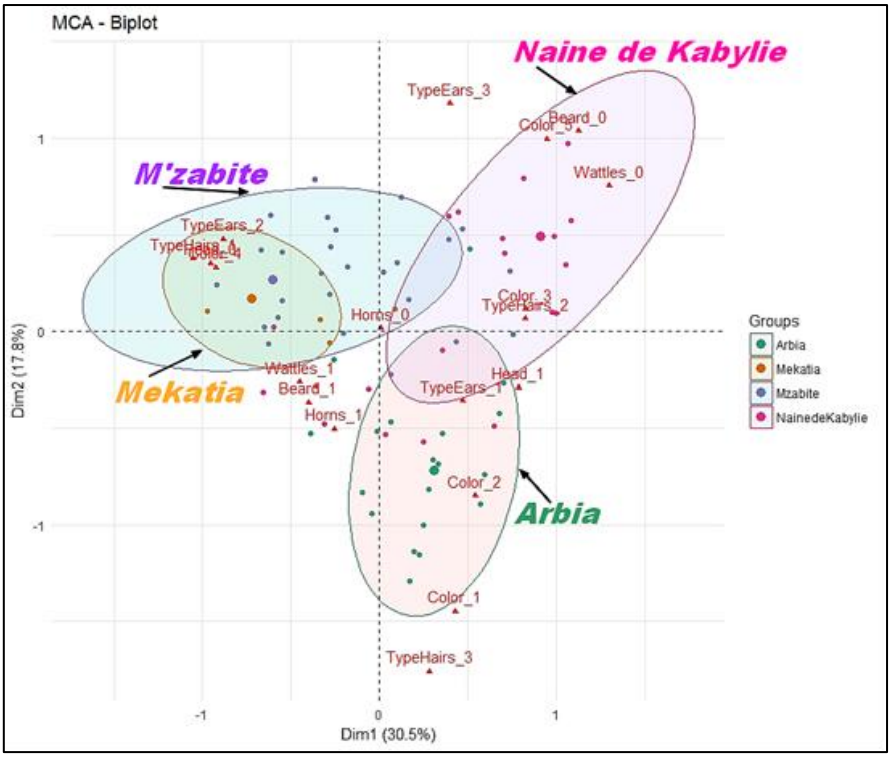


**Figure 6.** MCA biplot of categorial variables and breeds

The considered breeds were not perfectly clustered as some qualitative traits were in common between breeds. M'Zabite and Mekatia goat breed were overlapped and were clustered together; in fact, these breeds were characterized by similarity for some qualitative traits as short hair type and curved type of chamfer but also for ear type. Arbia breed was characterized by long hair type (TypeHairs_3) and black and white coat colour (Color_1) while Naine de Kabylie breed was clustered mainly for the absence of beard (Beard_0) and brown-white coat colour (Color_5) (**figure 6**) .

The breeders use the length of the hairs as the unique criterion of distinction. However, Denis (1988) showed that the hair does not constitute a discriminating criterion for establishing a ranking between the different breeds. He proposed the classification of Sanson (1910) which takes into account the characteristics of the ears and which affects each breed a particular fossil ancestor. Compared to the goat's literature, we observed a very great diversity in certain visible characters. Espérandieu and Chaker (1994) reported that in North Africa 5 types of goats could be recognized: the first, *Capra hircus*, which has been very old introduced (the Kabyle goat ancestor of the actual Naine de Kabylie); *Hircus manbrinus*, *Hircus thebaïcus*, *Hircus reversus*, which have occupied vast Areas in eastern Africa, the Sahara and the Sahel, and finally the more recent introduction of the Arabian goat ancestor of the Arabia.

Trouette in Espérandieu and Chaker (1994) described Berber as the "Kabyle goat". He describes it as follows: "a small goat with long hair, drooping ears, a convex profile with a slight nasal break. Its robe goes from dark brown to black; its skeleton has preserved the main characters of the fossil goats of the Neolithic. It has preserved itself in the initial state in all the mountainous massifs of the littoral, from the Kabylie to the Moroccan Rif. However, the introduction of Arab goats from the early middle Ages has significantly altered the caprine herd of the Maghreb and northern Sahara. The large and hornless Arabian goat, its composite dress has semi-long hairs. The profile is convex with marked fracture, with a strong beard and half-drooping ears. In the *Mzab* and in the *Oued Rhir* regions (Southern Oasis) a type is created in which these characters predominate, it is known under the name of "Red goat of the Mzab". In the end, all the old descriptions of the races studied compared to this study reveal a great change that is due to the random crossings between the races. Some fixed characters should be a reference to preserve and select our breeds.

## Conclusion

The Algerian goat populations are probably very polymorphic for a wide range of characteristics (e.g. size, length of hair and ears, and colour). Goat breeding in different regions is generally associated with mixed farming of other livestock species simultaneously (sheep, chickens and rabbits for example). Compared to the literature, we observed a great diversity in certain visible characters such as colour and hair type. This is due to uncontrolled mixing between local breeds in addition to imported breeds (Maltese, Saanen, Alpine). The Naine de Kabylie breed is the oldest that has undergone major changes before the introduction of the Arbia breed, which remains more stable. In our study, we showed the changes and a big polymorphism of our goat populations. The notion of breed tends to disappear, which forces us to double the effort to characterize and identify this heritage and use the biotechnology and/or genomics to facilitate this task and confirm the affiliation to these studied breeds.

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