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Phenotypic characterization of local goat population in western Algeria (Wilaya of Relizane) with morphometric measurements and milk analysis

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Abstract

A morphological characterization of the local goat population with physicochemical analysis of milk was performed in the wilaya of Relizane. This study was conducted on 50 goats (42 does and 8 bucks) in 6 districts of Relizane. The goat farming in Relizane is mixed with sheep farming but sheep are the main purpose of the breeding for pure economical purposes (wool and meat), goats are used mainly to guide the herd during the grazing, the goats do not receive an important livestock management, their reproduction is uncontrolled and the milk is only used for family consumption. Nine qualitative and twelve quantitative variables were used to study our samples. 68 % of our samples have horns with the curved horns as the most dominant shape, the pendant ears are found at 62%, concerning the beard 52% of does and 12% of bucks have beard, whereas only 8% of does and 2% of bucks have wattles. A negative correlation of $r = -0.69$ was found between ear length (LOr) and lactose level (LACT), a negative correlation of $r = -0.69$ was found between ear length (LOr) and protein level (PROT). Principal Component Analysis (PCA) revealed that Body length (LC), Height at withers (HG), Chest circumference (TP), Chest depth (PP), Horn length (LCo) and Ear length (LOr) characterizes better our goats. The hierarchical cluster analysis (HCA) by the PCA showed three distinct groups in our samples. The classification of our samples according to the ear length, from the results of the PCA, showed that ears length is a discriminative factor in our sampling. The descriptive analysis of the milk revealed that the milk is of good quality with a fat content of 47.82 g / kg, a protein content of 33.35 g / kg and lactose of 48.82 g / kg.
Keywords: Goats, Local population, Goat milk, Morphometric, Relizane.

Introduction

Goats are rustic animals that can easily adapt to harsh environments, they are excellent climbers adapted to rocky cliffs and trees, and they are even used to eliminate the harmful weeds, this is why goats are practically in every farm in Algeria.

Currently Algeria has more than five million goats (FAO, 2016), among those, four local breeds have been identified phenotypically and genetically: Arbia, Mekatia, Naine de Kabyle and M'zabite (Tefiel et al ., 2018). Some exotic breeds such as the Alpine and the Saanen have been imported in Algeria to enhance the performance of our local breeds. However uncontrolled cross-breeding is identified as the main obstacle in studying the diversity of the locale goat breeds (FAO, 1999), moreover Algeria has a large climate diversity, a flora diversity and a livestock management that varies from one state to

another, that is why it is necessary to study goats not only according to the breeds but also according to the region of the livestock farming.

The aim of this study is to elaborate a phenotypic characterization of the local goat population in the Wilaya of Relizane along with a physicochemical analysis of the goat's milk.

Material and methods

This study was conducted in the wilaya of Relizane, located in the Northwest of Algeria. Relizane is mainly a rural area (more than 76 % of the total surface). It contains also a large forestry space approximately 60 289 ha (Issac, 2018).

Fifty healthy goats have been sampled including 8 bucks and 42 does; they are over one year old. The 50 goats are divides into 6 districts (Figure 1).

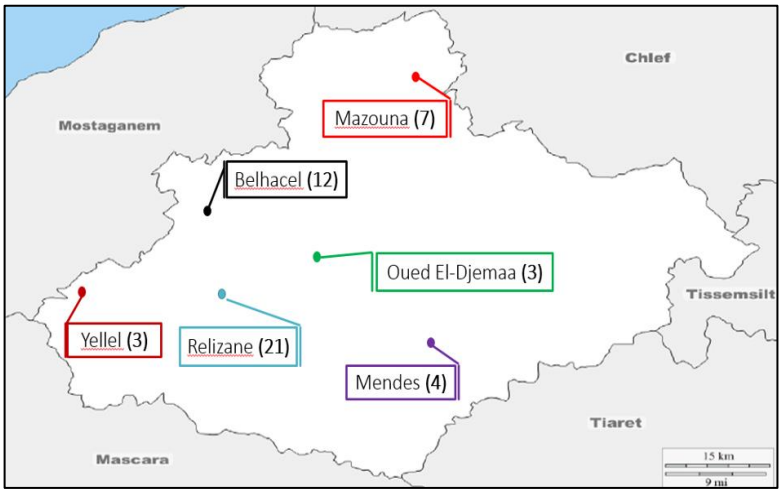

Figure 1. Map of Relizane showing the number of individuals sampled from each district.

Each visited farm has been subjected to a survey about the typology of farming with regard to goat's feeding, the management of goats and the conduct of reproduction.

Data collection

Twelve body measurements (Quantitative variables) and nine qualitative traits (Qualitative variables), recommended by FAO, (2013), were used to characterize each animal.

The body measurements are: Body length (LC), Height at withers (HG), Chest circumference (TP), Chest depth (PP), Shoulders spread (EE), Rump width (LaCr), Rump length (LCr), Head length (LT), Head width (LaT), Cannon circumference (TC), Horn length (LCo) and Ear length (LOr).

The qualitative traits chosen are: Age (dental estimation), Hair coat pattern (MR), Hair coat color (CR), Presence of horns (PC), Horn's shape (FC), Horn's orientation (OC), Ear's orientation (OR), Presence of beard (Bar) and Presence of wattles (Pmp).

Milk analysis

From our sampling, milk was collected from 20 goats in (Table 1) in 150mL sterilized pots, and analyzed in the dairy Sidi-Saada for it physicochemical parameters (Acidit (°D), Density, Fat (g/Kg), Proteins (g/Kg), Lactose (g/Kg), Freezing point (-°C) and pH).

Table 1. Distribution of milk samples in each district.

District	Number of goats
Relizane	08
Mazouna	05
Mendes	04
Belhacel	03

Statistical analysis

All statistical analysis was conducted by the software R (3.5.0) and the latter for analyzed the descriptive statistics, principal component analysis (PCA) with hierarchical cluster analysis (HCA) and correlations. About the descriptive statistics, the mean and standard deviation for the 12 body measurements and the milk parameters were calculated as well as the frequencies of the qualitative traits. The Principal Component Analysis (PCA) method allows us to describe proximities between individuals over which several quantitative characters have been measured. (Pierre *et al.,* 2011). In our study, the PCA was applied to the data collected from the 12 body measurements (Quantitative variables), a hierarchical cluster analysis was then established from the results of the PCA. The Pearson correlation coefficient was used to determine the correlation between the body measurements and the milk parameters.

Results and discussion

Typology of livestock farming

All the farms visited had a mixed animal husbandry between goats and sheep, with sheep as the main objective of breeding for pure economical purposes (wool and meat). Goats are kept in a small paddocks or pens (Figure 2). Goats are not used for commercial purposes instead they are sold in case of financial difficulties and stockbreeders do not consider them as an investment. Stockbreeders have specified that they use goats to lead the sheep herd in the grazing, according to them; goats walk longer distances than sheep in search for food.

Regarding goats feeding, different approaches are used by the breeders: In winter, in the rainy days and frosty moments, farmers feed goats exclusively at the paddocks, by distributing wheat bran and barley partially grind at the trough, no grazing is practiced during these days to avoid respiratory diseases, on warm days of the winter, stockbreeders feed goats at the trough in the morning and at the pasture during the afternoon; In autumn, spring and summer, goats are fed exclusively by grazing.

Stockbreeders have confirmed that the reproduction is uncontrolled, goats give birth to twins in most of the gestations, and goat's kids are always kept with their mothers. Goat's milk is reserved for the goat's kids and for family consumption.

Stockbreeders have stated that they characterize goats according to their length of ears, goats with short ears are said to be from the western regions of Algeria and goats with long ears are called GUEBALLA (meaning from the east).

Figure 2 . Goat pens. (*Original photo*)

Descriptive statistics

Table 2. Means and standard deviation of body measurements.

Body measurement	Mean (cm)	Standard deviation
Body length (LC)	65.00	7.42
Height at withers (HG)	69.74	4.58
Chest circumference (TP)	74.01	6.59
Chest depth (PP)	31.88	3.51
Shoulders spread (EE)	8	1.4
Rumps length (LCr)	19.98	1.72
Rumps width (LaCr)	11.72	1.53
Head length (LT)	21.24	1.94
Head width (LaT)	10.28	1.82
Cannon circumference (TC)	8.24	0.82
Horn length (LCo)	21.09	6.8
Ear length (LOr)	18.8	2.73

Body length

In our study the general average of body length is 65cm with an average of 74 cm for bucks and 63.29cm for does, our results (Table 2) are inferior by 23.5% (17.5cm) for bucks and 49% (31cm) for does in comparison with the work of Manallah (2012) who found an average of 91.49cm and 94.48cm respectively for bucks and does in the population of Setif.

Height at withers

Our results showed an average of 69.74cm for the height at withers (table 2), with 73.75 cm and 68.98cm respectively for bucks and the does. In the population of Setif studied by Manallah, (2012) the average of height at withers was 68.06cm for bucks and 66.89cm for does. Our results are superior by 8% (7.7cm) and 3% (2.1cm) to Manallah's results, respectively for the bucks and the does (Table 3).

Chest circumference and depth

For the chest circumference, the bucks in our study had an average of 76.69 cm and the does 73.50 cm with a chest depth of 34.88 cm and 31.31 cm respectively for bucks and does, comparing these results with the population of Setif studied by Manallah (2012) we note that the average chest circumference for the does is 74.94 cm and 71.98 cm for the bucks, we also note that the average chest depth in the population of Setif is 25.39 cm and 24.19 cm respectively for bucks and does, our results are higher by 6% (4.7cm) for the chest circumference of the bucks and higher by 25% (8cm) for the chest depth of the bucks than those of Manallah (2012). The results of the does in our study are inferior to the does of Tlemcen studied by Benyoub *et al.*, (2018), the mean of chest circumference and chest depth in the population of Tlemcen are respectively 80.83 cm and 33.09 cm.

Length and width of the head

Our results marked for the bucks an average of 21.38cm and 11.25cm respectively for the length and the width of the head, and for the does 21.21cm and 10.10cm respectively for the length and width of the head. In the population of Setif studied by Manallah (2012) an average head length of 18.77 cm and 18.86 cm respectively for bucks and does was found. Our results are approximately 10% (3cm) higher than the population of Setif (Table 3).

Table 4, present the comparison of body measurements between our sample and the four Algerian indigenous breeds (Arbia, Mekatia, Naine de Kabyle and M'zabite) studied by Ouchene *et al.*, (2015)

Table 3. Comparison of this study's results with the results according to the four Algerian breeds.

	Mean ± Standard deviation				
Measurement	**Relizane**	**Mekatia**	**Arbia**	**Naine de Kabylie**	**M'zabite**
LC	65.00 ± 7.42	69.90 ± 9.37	71.54 ± 5.52	67.58 ± 2.70	71.81 ± 4.60
HG	69.74 ± 4.58	65.11 ± 6.49	71.07 ± 4.34	64.95 ± 4.06	66.76 ± 3.84
TP	74.01 ± 6.59	-	-	-	-
PP	31.88 ± 3.51	31.54 ± 3.38	31.13 ± 2.34	29.25 ± 5.02	29.60 ± 3.03
EE	8 ± 1.4	-	-	-	-
LCr	19.98 ± 1.72	23.13 ± 4.43	21.80 ± 2.66	19.54 ± 1.92	21.22 ± 1.88
LaCr	11.72 ± 1.53	-	-	-	-
LT	21.24 ± 1.94	16.82 ± 2.86	17.72 ± 2.30	13.52 ± 1.10	15.45 ± 1.56
LaT	10.28 ± 1.82	-	-	-	-
TC	8.24 ± 0.82	7.37 ± 1.08	8.11 ± 0.82	7.48 ± 0.42	7.33 ± 0.81
LCo	21.0 ± 6.8	-	-	-	-
LOr	18.8 ± 2.73	17.23 ± 2.56	20.02 ± 2.82	14.30 ± 2.15	17.01 ± 2.49

Age

The animals in our sample have an age ranging from 1 year to 11 years, with the most dominant year-classes being 1 year, 2 years and 6 years respectively 30%, 20% and 28% of our population.

Color and pattern of the coat

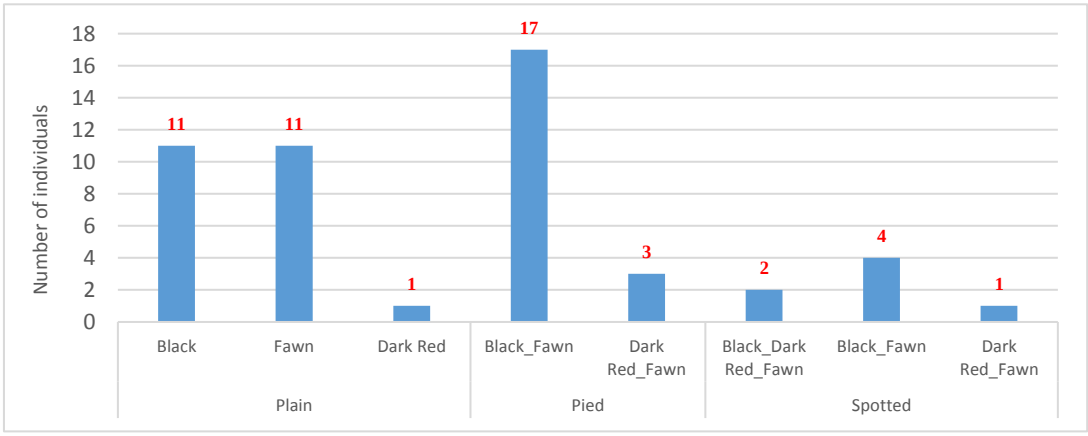

Figure 3. Frequency of the coat color according to the coat pattern.

From figure 3, we notice that the plain pattern is the most dominant in our sampling (46%) with 3 colors: fawn, black and dark red. The pied pattern represent 40% with two color combinations: black with fawn and dark red with fawn.

Shape and orientation of the horns

The percentage of animals with horns is 68% with curved and spiral horns as the most dominant shapes, representing respectively 47% and 38% of the horned animals (Figure 4). Manallah (2012) stated in her work on the Setif population that 45.38% of the samples have horns and the curved shape is the most dominant (75.05%), whereas the spiral shape represents only 24.95%.

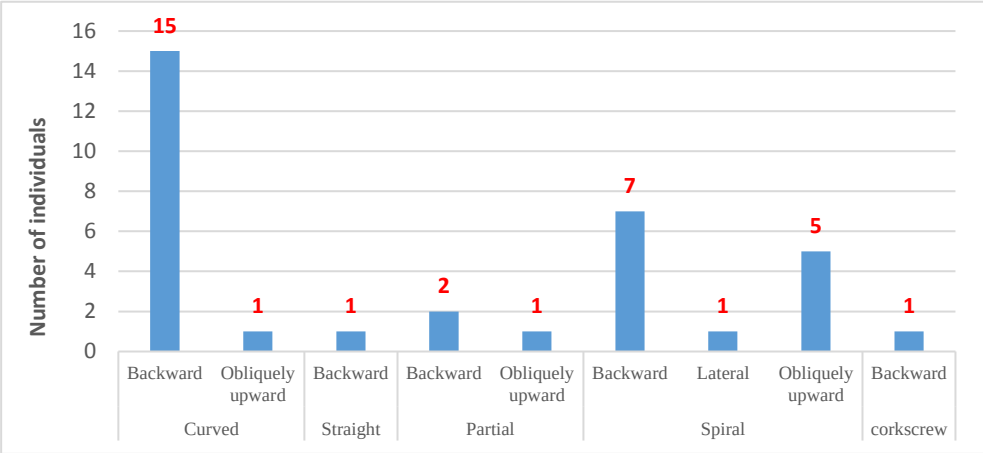

Figure 4. The orientation of the horns according to their shape.

Ears orientation

In our sampling the pendant ears are found at 62% while the semi-pendant orientation represent only 38%. Manallah (2012) found results close to our work, she states that the pendant ears are found at 67.35%.

Beard and wattles

In our sample 12% of the bucks and 52% of the does have beard, our results are close to those of Benyoub *et al.*, (2018) who worked on does only in the wilaya of Tlemcen, Benyoub et al., (2018) stated that 63% have beard. The presence of wattles in our study is 10%, Manallah (2012) stated in her study in the wilaya of Setif that the presence of wattles is limited to 12.80% for the bucks and 7.13% for the does.

Milk analysis

Table 4. Description of physicochemical analysis of the milk.

Parameters	Mean	Standard deviation
Acidity (°D)	15.03	2.10
Density	1029.96	3.38
Fat (g/Kg)	47.82	20.99
Proteins (g/Kg)	33.35	2.90
Lactose (g/Kg)	48.82	3.76
Freezing point (°C)	-0.53	0.07
pH	6.77	0.10

The milk analyzed present a good quality with a fat content of 4.7%, a protein content of 3.3% and a lactose level of 4.8%. We compared our results with the results found by Benyoub *et al.*, (2018) in the population of Chouli (Tlemcen) and with the results of the Alpine and Saanen breed. The results are presented in Table 4 and 5.

Table 5. Comparison of the milk analysis results with the results from the population of Tlemcen and with the Alpine and Saanen breeds.

	Mean ± Standard deviation			
Milk parameters	**Relizane** (Our study)	**Chouli (Tlemcen)** Benyoub *et al.,* (2018)	**Alpine** Da Costa *et al.,* 2014	**Saanen**
Fat (g/Kg)	47.82 ± 20.99	42.±13.0	34.5 ± 0.7	35.5 ± 2.1
Protein (g/Kg)	33.35 ± 2.90	43.9± 4.6	36.0 ± 0.7	31.5 ± 0.1
Lactose (g/Kg)	48.82 ± 3.76	-	50.2 ± 0.1	48.5 ± 0.1

According to table 6, the fat content in both Relizane's and Tlemcen's local goat breeds is higher than the Alpine and Saanen breeds. This difference may be due to two new mutations in the *DGAT1* gene that produce a significant decrease of the fat content in Alpine's and Saanen's milk. (Martin *et al.,* 2017).

Principal component analysis (PCA)

a. Number of axes to retain

Principal component analysis (PCA) is used to analyze and visualize a dataset containing individuals described by several quantitative variables. The PCA synthesizes this information into only a few new variables called principal components. These new variables correspond to a linear combination of the original variables. The objective of the PCA is to identify the principal components along which the data variation is maximum. (Kassambara, 2017). The PCA in our study is performed on the 50 goats sampled, using the 12 body measurements as quantitative variables.

Table 6. Eigenvalues of the principal components

Component (Axis)	**Eigenvalue**	**Percentage of variance**	**Cumulative percentage of variance**
Component 1	5.26	58.43	58.43
Component 2	1.24	13.73	72.16

From Table 6 we notice that the two first components explain the maximum of variance (72.16%).

b. Correlation circle

According to Kassambara, (2017) in the circle of correlation:

- Positively correlated variables are grouped together.
- Negatively correlated variables are positioned on opposite sides from the center of the circle (opposite quadrants).
- The distance between the variables and the center of the circle measures the quality of representation of variables. Variables that are far from the center are well represented by the PCA.

From figure 5 we notice that ear length (LOr), chest circumference (TP) and chest depth (PP) have a high quality of representation and contribute the most to the axes. We also note that body length (LC),

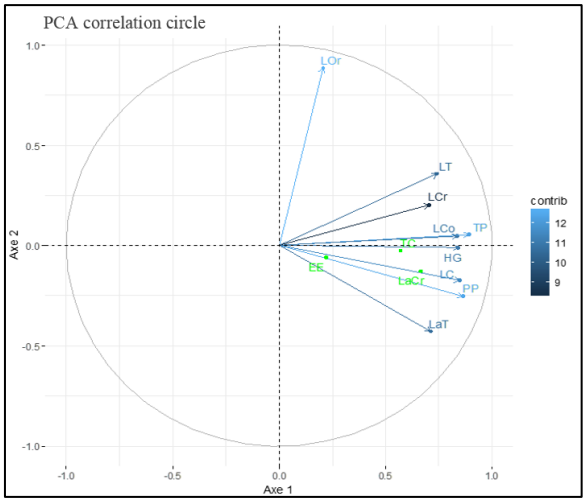

Figure 5. Correlation circle of the variables according to their contribution to the two axes.
Note: The points in green are the supplementary quantitative variables.

height at withers (HG) and horn length (LCo) have a good quality of representation and a good contribution to the axes. These variables measure mainly the size, the ears and the horns of the goats. In the hierarchical cluster analysis by the PCA we will focus more on these measurements.

- Individuals' plot

In figure 6, we note that there is a dispersal of individuals in the plane and thus it is difficult to delimit groups of individuals well defined, the only method to define groups out of our result is the hierarchical cluster analysis.

Before proceeding with the hierarchical cluster analysis, it was found in the field survey that farmers make the difference between goats according to their ear length, we also note that in the PCA ear length (LOr) had shown a strong contribution and a high quality of representation.

For the reasons mentioned above, we created a new variable of ear length with two classes, class A: short ear and class B: long ears.

- Variable name: LORC1
- Class A : ear length $\leq$ 19cm
- Class B: ear length > 19cm

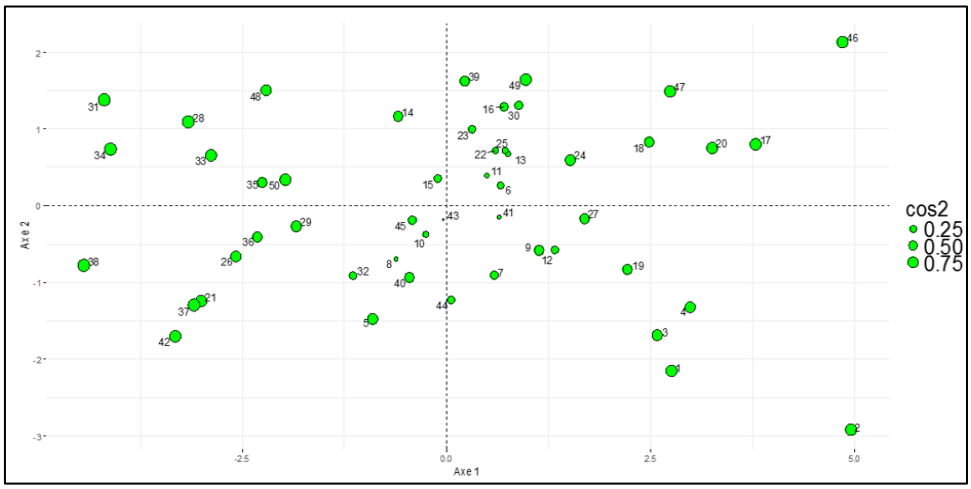

Figure 6. PCA individuals' plot according to their quality of representation (cos2).

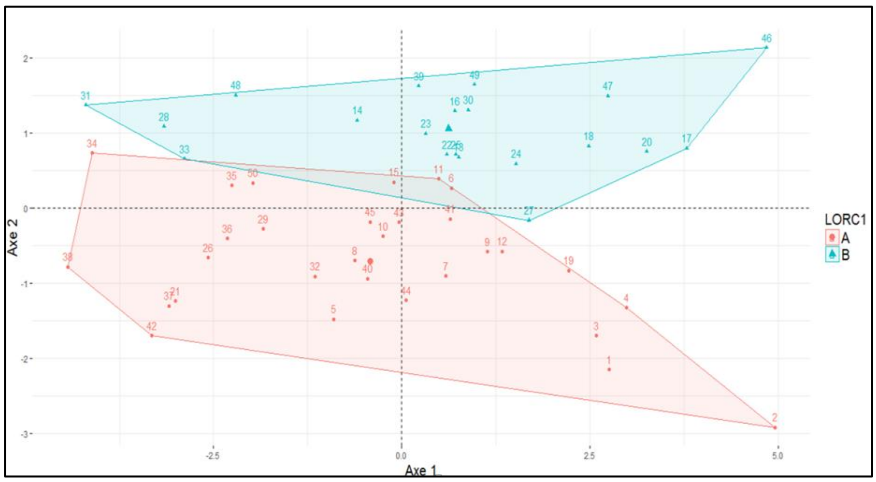

Figure 7. Individuals' plot according to the ear length classes.

Figure 7 shows the plot of individuals' according to the variable (LCOR1), from the figure we notice that there are two groups of individuals with a slight overlap. We can conclude that the ear length in our sampling is a discriminative factor.

Hierarchical cluster analysis (HCA)

Figure 8 shows the dendrogram of the hierarchical cluster analysis by the PCA. Table 7 present the description of each group by the body measurements.

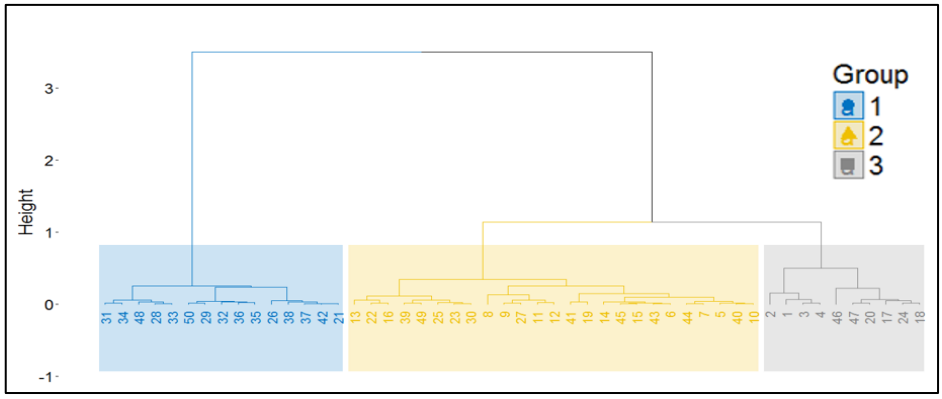

Figure 8. Dendrogram of hierarchical cluster analysis.

From Figure 8 and Table 7, and based on the variables that had a strong contribution and representational quality in the PCA (LOr, TP, PP, HG, LC and LCo), we find that:

Group 1: All the means in this group are lower than the overall mean so it can be concluded that in this group the goats have a small size with short horns and short ears. This group represents 30% of our sample.

Group 2: All the body measurements have a non-significant p-value except for the ear length (LOr) and thus the goats in this group have a heterogeneity in all body measurements but they are characterized by a length of ears of about 20 cm. This group represents 50% of our sample.

Group 3: we note firstly that the ear length presented a non-significant P-Value so this group is not characterized by the length of the ears. The goats in this group are characterized by a large size and long horns. It represent 20% of our sample.

Table 7. Description of the hierarchical cluster analysis groups by the body measurements.

Variables	Mean in the group	Overall mean	p-Value
Group 1			
Ear length (LOr)	17,60	18,80	0,042
Rump length (LCr)	18,87	19,98	0,002
Body length (LC)	58,13	65,00	1,82 e-05
Horn length (LCo)	15,33	21,30	5,14 e-06
Head length (LT)	19,27	21,24	2,61 e-06
Head width (LaT)	8,40	10,28	1,71 e-06
Height at withers (HG)	64,93	69,74	1,15 e-06
Chest circumference (TP)	66,93	74,01	6,67 e-07
Chest depth (PP)	28,00	31,88	3,22 e-07
Group 2			
Ear length (LOr)	19,6	18,8	0,03846
Group 3			
Body length (LC)	75,40	65,00	7,16 e-07
Chest circumference (TP)	82,35	74,01	7,67 e-06
Chest depth (PP)	36,10	31,88	2,19 e-05
Rump length (LCr)	22,00	19,98	3,30 e-05
Horn length (LCo)	28,40	21,30	3,42 e-05
Height at withers (HG)	74,50	69,74	0,0002
Head length (LT)	23,10	21,24	0,0007
Head width (LaT)	12,00	10,28	0,0008

Correlation

In the correlations, the relationship between milk parameters and body measurements was studied. We used the results of the body measurements of the 20 goats that were used for milk analysis and we studied their body measurement's correlations with the milk's physicochemical results obtained from these 20 goats.

Figure 9 shows the matrix of Pearson's coefficient correlations obtained after the elimination of correlations that had a p-Value greater than 0.05.

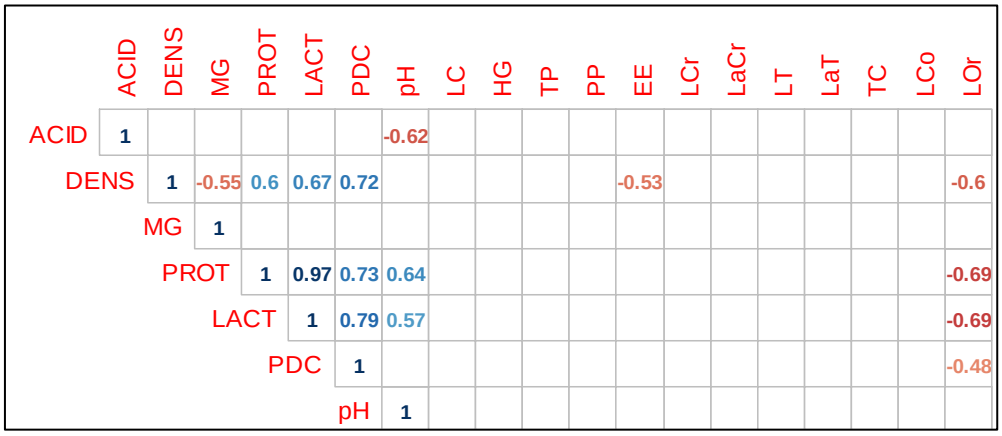

Figure 9 . Pearson's coefficient correlation matrix between milk analyzes and body measurements.
Note: ACID (Acidity), DENS (Density), MG (Fat), PROT (Protein), LACT (Lactose), PDC (Point of freezing), LC (Body length), HG (Height at withers), TP (Chest circumference), PP (Chest depth), EE (Shoulders spread), LaCr (Rump width), LCr (Rump length), LT (Head length), LaT (Head width), TC (Cannon circumference), LCo (Horn length), LOr (Ear length).

From figure 9, we notice a negative correlation of $r = -0.69$ between the ear length and the lactose level, there is also a negative correlation of $r = -0.69$ between the ear length and the protein level.

Conclusion

In the present work we studied the morphology of local goat breeds in the wilaya of Relizane, 50 goats (42 does and 8 bucks) were sampled, they were characterized based on 09 qualitative variables and 12 quantitative variables. Goats in this study are raised along with sheep, and sheep are the principal goal of farming. Goats are used only to guide the sheep in the grazing, their reproduction is uncontrolled and the goat's milk is used mainly for family consumption. Descriptive analysis showed that the goats in our population have an average size, with a body length of 65 cm, height at withers of 69.74 cm and an ear length of 18.8 cm. Sixty eight percent of our sample have horns, sixty four percent have beard and only ten percent have wattles. The descriptive analysis of the milk revealed that our milk is of good quality with a fat content of 47.82 g / kg, a protein content of 33.35 g / kg and lactose of 48.82 g / kg.
Among the correlations studied, the following correlations are the most distinctive: *i:*The ear length (LOr) with the lactose content (LACT) $r = -0.69$ and *ii:* The ear length (LOr) with the protein content (PROT) $r = -0.69$
Principal Component Analysis (PCA) showed that the body length (LC), height at withers (HG), chest circumference (TP), chest depth (PP), horn length (LCo) and ear length (LOr) characterizes the most our sample. Hierarchical cluster analysis (HCA) by principal component analysis showed that our population is divided into three distinct groups, a group of goats that have a small size with short horns and ears, a group of goats that have a large size with long horns and long ears, and a third group comprising 50% of the samples and which exhibits heterogeneity towards all the body measurements except for the ear length. A classification according to the length of the ears based on PCA results showed two distinct groups in our population, a group with long ears and a group with short ears.

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