RESEARCH ARTICLE

PHENOTYPIC CHARACTERIZATION OF GOAT ECOTYPES IN NORTHWESTERN TUNISIA

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ARTICLE DETAILS

Article History:

Received 28 July 2021

Accepted 29 August 2021

Available online 03 September 2021

ABSTRACT

The study aimed to identify and characterize the phenotype of goat genetic resources in NorthWestern Tunisia. Observation of physical attributes and morphology and morphometrical measurements were employed for data collection. Five hundred fifty adult heads including 211 adults, 191 females and 20 males from three governorates (Bizerte, Beja, and Jendouba) were studied. Twenty-six parameters were evaluated. The results showed that 67.3% of the females and 7.11% of the males had a straight profile and 61.68% of the females had curled horns. Besides, we found that 83.41% of animals do not have pendants, 82.94% have a goatee and 80.28% of them are horned. The average length of the head was 22.22 ± 2.29 cm. The length of the body was 62.13 ± 6.54 cm, the length of the pelvis was 16.55 ± 2.05 cm, and the length of the tail averaged 9.84 ± 2.91 cm. The width of the hips was 13.10 ± 1.75 cm, the width of the ischium was 10.16 ± 6.75 cm. While the width of the chest was 40.93 ± 4.65 cm. Besides, sex is a very highly significant factor of variation for the majority of studied traits. Finally, regarding the studied traits, Multiple Factorial Analysis (MFA) and Hierarchical Ascending Classification (CAH) identified five classes in the studied population.

KEYWORDS

Body measurements, goat population, genetic resources, phenotypic characterization

1. INTRODUCTION

Developing countries host a vast majority of animal genetic resources (more than 90%) which, unfortunately, are not improved to meet global food security needs (Abdel Aziz, 2010; Al-Atiyat, 2014; FAO, 1999). The FAO has estimated that 30% of livestock breeds were threatened with extinction and that six breeds are lost every month. In many countries, goats are raised for meat, milk, leather, fiber production, and cultural and religious purposes (Abdel Aziz, 2010; Al-Atiyat & Tabbaa, 2009; FAO, 2007). Their production levels, food preferences, and low investment costs make them a pliable species for use by farmers (Dubeuf *et al.*, 2004; Dubeuf & Boyazoglu, 2009). These animals tend to raise in low-input production systems that generally lack high levels of artificial selection, suggesting that their genetic composition may be less structured than other species (Kijas *et al.*, 2012). Different breeds of goats inhabit varied environments around the world (Molina-Flores *et al.*, 2020).

Africa has about 35% of the world's goat population, making it the most abundant animal species on the continent (FAO, 2014). Adapted to the local environment, goats represent a genetic resource for the producer. However, the need to increase the income and profitability of goat farms has led to the crossbreeding of these native breeds with imported exotic breeds or the direct replacement of native genotypes (Hassen & Tesfaye, 2014; Semakula *et al.*, 2010; Wollny, 2003). Nevertheless, in many African countries, indigenous breeds have not been characterized and it would be tragic to lose genetic control over these unique resources, which are the result of centuries of natural and human selection. Furthermore, more

than half of the goat breeds were found in developing countries (FAO, 2007). However, the conservation and sustainable use of these indigenous goat resources cannot begin until their genetic diversity was understood and quantified. Most indigenous goat breeds, although better adapted to local conditions, are not yet genetically classified and therefore cannot be exploited.

In Tunisia, research work on goats is limited compared to that carried out on other ruminant species. The work reported in the literature has focused on goat feeding, characterization of the main production systems (Ammar *et al.*, 2011; Ben Salem & Ben Hammouda, 1995), and phenotypic and genetic characterization in certain regions of the country (Gaddour *et al.*, 2007a; b). It should be noted that data on the phenotypic characteristics, production systems, and reproductive performance of the different indigenous goat populations remain scarce. Besides, despite the research carried out, much of the published work has been carried out under controlled conditions of the research stations and the results may not reflect the performance of goats in communal and traditional production systems in rural areas. The objective of this work is to carry out the phenotypic characterization of local goats in the northwestern region of Tunisia, which hosts a large part of the national livestock.

2. MATERIALS AND METHODS

2.1 Study area

This study was carried out in the North of Tunisia in the sub-humid

Quick Response Code

Access this article online

Website:
www.mahj.org.my

DOI:
10.26480/mahj.01.2021.33.39

bioclimatic area. The annual average temperature ranges from 5.5 to 42.3°C, while the annual rainfall ranges from 542 to 656 mm. The study covered six districts in three administrative zones namely Jendouba, Beja, and Bizerte as shown in figure 1. Pastoralism is common for all farmers.

Figure 1: Map of the Study Area

2.2 Data Collection and Measurement of Phenotypic Characters

The study was conducted from February to June 2019. The number of goats sampled for phenotypic characterization was 211 of which 191 were female and 20 were male. Based on the breed morphological characteristics descriptor list of FAO (2012) for morphological characterization of goats, both qualitative and quantitative data were collected [18]. For each animal, the external measurements (head length (LT), ear length (LO), neck length (LC), body length (LCrps), body length (LCrps), pelvic length (LB), hip-width (LH), pin width (LI)) are taken first, chest circumference (TP), chest depth (PP), Chest width (LP), Wither height (HG), Back height (HD), height at sacrum (HS), flank depth (PF), hair length (LPI), Front barrel circumference (TCA) and tail length (LQ)). Secondly, these measurements represent phenotypic visual appreciations (Head Colour (CT), Horn Presence (PC), Horn Shape (FC), Ear Shape (FO), Profile (P), Coat Colour (CR), Goatee (B), Pendeloques (PD) and Leg Colour (CP)). To avoid the genetic similarity of goats, 5 animals per household (based on the number of goats) were used for both qualitative and quantitative traits recording. Animals were randomly assigned according to delegation distribution and accessibility.

2.3 Statistical Analysis

All quantitative and coded qualitative data were entered into Microsoft Office Excel, 2016 for further analysis using Statistical Analysis System Version 9.4 (Statistical Analysis System, Release 9.4., 2012. SAS Institute Inc., Cary, NC, USA). Basic statistics (mean, standard deviation, frequency, and percentage) for body measurements such as qualitative and quantitative traits were carried out. A two-factor analysis of variance, using the GLM procedure (SAS version 9.4), was used to study the effects of area and sex of the animal as fixed factors. The model integrates the zone effect (Z), the sex effect (S), and the interaction (Z*S). The quantitative variables were expressed as the least square means ($\pm$ SD). The SNK test was used to compare zones and the T-test was used to compare between the two sexes at the 5% threshold.

The model equation is:

$$Y_{ijkl} = \mu + S_i + R_j + S^*R_{kj} + e_{ijkl}$$

With Y_{ijk} = the measured parameter, μ = the overall mean, S_i = fixed effect of gender ($i=1, 2$), R_j = fixed effect of the region ($j=1-6$), S^*R_{kj} = fixed effect of gender in each region ($k=1-11$), and e_{ijkl} = the random residual effect.

Principal Component Analysis (PCA) and Hierarchical Ascending Classification (HAC) were performed for the classification of populations with XISTAT software.

3. RESULTS

3.1 Quantitative Traits

The results for quantitative characteristics are presented in Table 1. The average length of the head was 22.22 ± 2.29 cm, that of the ears was 19.49 ± 4.04 cm and that of the neck was 23.84 ± 4.923 cm. Body and pelvis lengths averaged 62.13 ± 6.539 and 16.55 ± 2.052 cm, respectively. The average length of tail and hair was 19.84 ± 2.908 and 8.36 ± 3.456 cm respectively. We noted that the average width of the hips and pins was 13.10 ± 1.75 and

10.16 ± 6.75 cm, respectively. While the average width of the chest was 40.93 ± 4.65 cm. The means found for the circumference of the chest and the anterior barrel were 76.50 ± 7.316 and 9.59 ± 1.095 cm, respectively. The results of the height measurements showed that the average height at the withers was 70.08 ± 5.341 cm. This shows that the population studied was not dwarfed since the mean height at the withers exceeds 60 cm. Besides, we founded that the average heights at the back and sacrum were 71.15 ± 5.439 and 72.45 ± 5.704 cm, respectively. Finally, the average depth of the chest was 34.55 ± 3.197 cm and the average depth of the flank was 36.42 ± 3.32 cm (Table 1).

Table 1: Descriptive statistics of quantitative traits					
Measured Parameter	N	Mean	Min	Max	SD
Length measures					
Head Length	211	22.22	16	29	2.298
Ears Length	211	19.49	12	38	4.040
Neck Length	211	23.84	17	35	4.923
Body Length	211	62.13	42	87	6.539
Pool Length	211	16.55	12	25	2.052
Hair Length	210	8.36	2	21	3.456
Tail Length	210	19.84	14	29	2.908
Width measures					
Hips Width	211	13.10	9	23	1.754
Ischiums Width	211	10.1611	7	15	6.754
Chest Width	211	40.9289	31	54	4.653
Peripheral measures					
Chest Circumference	211	76.50	56	100	7.316
Turn of the front barrel	211	9.59	7	14	1.095
Height measurements					
Height at withers	211	70.08	52	90	5.341
Height at the back	211	71.15	50	88	5.439
Height to sacrum	211	72.45	55	97	5.704
Depth measurements					
Depth of the chest	211	34.55	26	46	3.197
Depth of the flank	210	36.42	28	47	3.317

N= number of observations; Mean= average; min= minimum; Max= maximum; SD= Standard deviation

3.2 Variation in quantitative traits by sex

The different measures found for both genders were shown in Table 2. The average length of the head was the same for males and females ranging from 22.04 to 22.95 cm. Similarly, neck length averaged 23.94 and 25.70 cm for females and males, respectively. Nevertheless, the length of ears, body, pelvis, hair, and tail was significantly associated with sex ($P < 0.001$). Indeed, the length of ears in males (22.65 cm) was higher than that of females (19.16 cm). The same trend was found for body length (67.70 and 61.56 cm in males and females, respectively). The average pelvic length in males (17.50 cm) was always higher than in females (16.46 cm). The hair length of females is 8.03 ± 3.35 cm. It was less than that of males that have an average of 11.50 ± 2.89 cm. The same is true for tail length (19.59 ± 2.68 and 22.25 ± 3.85 cm in females and males, respectively). For width measurement, the average hip-width measured was 13.06 and 13.50 cm for females and males, respectively. We note that it was identical in both sexes. However, the pin width and chest width vary significantly ($P < 0.001$) with sex. Indeed, the width of the pins in females (10.06 cm) was less than in males (11.1 cm). Similarly, for chest width (40.75 and 40.55 cm in females and males, respectively) (Table 2). Chest circumference and anterior cannon circumference were strongly affected by sex ($P < 0.001$). Our results showed that males always have higher chest

circumference and anterior barrel circumference than females (81.05>76.02; 11.60>9.38 cm). All height measurements, i.e. height at the withers, back, and sacrum were significantly affected by sex ($P<0.001$). Indeed, the average value of the height at the withers was of the order of 69.55 cm in females and 75.10 cm in males. Likewise, for the height at the

back and height at the sacrum, males have higher averages than females (75.95 cm > 70.65 cm; 77.15 cm > 71.15 cm). The average chest depth was 34.23 cm in females and 37.60 cm in males. Besides, the depth of the flank has an average value of 36.17 cm in females and 37.60 cm in males.

Table 2: Variation in Quantitative traits by Gender

Measured parameters	Sexe	N	Mean	Min	Max	SD
Lengths measurements						
Head Length	F	191	22.04	16	29	2.23
	M	20	22.95	17	28	2.76
Ears Length	F	191	19.16 ^a	12	33	3.49
	M	20	22.65 ^b	14	38	6.85
Neck Length	F	191	23.94	17	35	5.03
	M	20	25.70	20	33	3.79
Body Length	F	191	61.56 ^b	42	78	5.55
	M	20	67.70 ^a	53	87	11.39
Pool Length	F	191	16.46 ^b	12	25	1.87
	M	20	17.50 ^a	13	25	3.24
Hair Length	F	190	8.03 ^b	2	21	3.35
	M	20	11.50 ^a	8	19	2.89
Tail Length	F	190	19.59 ^b	14	28	2.68
	M	20	22.25 ^a	16	29	3.85
Width measurements						
Hips Width	F	191	13.06	9	23	1.61
	M	20	13.50	9	19	2.84
Ischium Width	F	191	10.06 ^b	7	13	5.60
	M	20	11.1 ^a	8	13	13.32
Chest Width	F	191	40.75 ^b	31	50	4.39
	M	20	44.50 ^a	34	54	5.76
Peripheral measurements						
Chest Circumference	F	191	76.02 ^b	56	90	6.29
	M	20	81.05 ^a	61	100	13.12
Turn of the front barrel	F	190	9.38 ^b	7	12	0.82
	M	20	11.60 ^a	10	14	1.31
Height measurements						
Height at withers	F	191	69.55 ^b	52	89	4.32
	M	20	75.10 ^a	57	90	9.96
Height at the back	F	191	70.65 ^b	50	85	4.67
	M	20	75.95 ^a	58	88	9.06
Height to sacrum	F	191	71.96 ^b	55	97	5.01
	M	20	77.15 ^a	59	91	9.14
Depth measurements						
Depth of the chest	F	191	34.23 ^b	26	43	2.74
	M	20	37.60 ^a	30	46	5.21
Depth of the flank	F	190	36.17 ^b	28	46	2.97
	M	20	38.75 ^a	29	47	5.21

N= number of observations; Mean= average; Min= minimum; Max= maximum; SD= Standard deviation. abc The means of the variables followed by different letters on the same line are significantly different ($P < 0.05$)

Table 3: Variation of quantitative parameters among regions

Traits	Region	Ain Drahem	Beja	GharDimaou	Nefza	Sajnene	Tabarka
Length measurements							
Head Length	Mean	22.36 ^a	22.5 ^a	21.65 ^b	22.38 ^a	22.46 ^a	21.086 ^b
	SD	0.456	0.926	0.55	0.34	0.25	0.37
Ears Length	Mean	20.04 ^b	26.83 ^a	18.47 ^c	19.64 ^b	19.59 ^b	17.97 ^c
	SD	0.77	1.56	0.93	0.57	0.	0.63
Neck Length	Mean	22.16 ^b	23.50 ^b	25.76 ^a	25.3333 ^a	24.68 ^{ab}	22.03 ^b
	SD	0.9569	1.9532	1.1604	0.71	0.53	0.7866
Body Length	Mean	62.52 ^b	68.33 ^a	58.23 ^b	62.77 ^b	63.2840 ^b	59.3514 ^c
	SD	1.251	2.56	1.52	0.93	0.69	1.03
Pool Length	Mean	16.48 ^{ab}	16.83 ^{ab}	15.29 ^b	16.93 ^{ab}	17.25 ^a	15.16 ^b
	SD	0.3799	0.7754	0.4606	0.2831	0.2110	0.3122
Length of hair	Mean	8.1250 ^b	12.6666 ^a	8.5294 ^b	9.01 ^b	7.27 ^b	9.32 ^{ab}
	SD	0.6755	1.3511	0.8027	0.4933	0.3677	0.5441
Tail length	Mean	20.95 ^a	20.83 ^a	19.41 ^b	19.08 ^b	19.18 ^b	20.13 ^a
	SD	0.59	1.18	0.70	0.43	0.32	0.47
Width measurements							
Hip width	Mean	13.48 ^a	14.16 ^a	11.94 ^b	13.53 ^a	13.56 ^a	11.67 ^b
	SD	0.32	0.64	0.38	0.24	0.17	0.26
Ischium Width	Mean	10.6 ^b	11.5 ^b	13.94 ^a	10.24 ^b	10.48 ^b	10.76 ^b
	SD	1.3533	2.7624	1.6411	1.0087	0.7518	1.1124
Chest Width	Mean	41.88 ^{ab}	44.83 ^a	40.76 ^{ab}	41.95 ^{ab}	40.92 ^{ab}	39.51 ^b
	SD	0.918	1.87	1.11	0.68	0.51	0.75
Peripheral measurements							
Chest circumference	Mean	77.92 ^a	81.01 ^a	71.58 ^b	78.35 ^a	77.68 ^a	72.22 ^b
	SD	1.37	2.81	1.67	1.03	0.76	1.13
Front barrel turn	Mean	9.83 ^a	10.66 ^a	9.61 ^a	9.55 ^a	9.43 ^a	9.62 ^a
	SD	0.22	0.44	0.26	0.16	0.12	0.17
Height measurements							
Height to the withers	Mean	71.32 ^a	71.166 ^a	68.17 ^b	70.93 ^a	71.07 ^a	66.70 ^b
	SD	1.02	2.08	1.24	0.76	0.56	0.83
Back height	Mean	72.28 ^a	72.83 ^a	68.76 ^b	71.01 ^a	72.48 ^a	68.45 ^b
	SD	1.05	2.14	1.27	0.78	0.58	0.86
Height to the sacrum	Mean	73.68 ^a	74.01 ^a	69.47 ^b	72.33 ^a	73.92 ^a	69.67 ^b
	SD	1.09	2.24	1.33	0.82	0.61	0.91
Depth measurements							
Chest depth	Mean	35.04 ^a	33.83 ^b	34.23 ^{ab}	36.04 ^a	34.22 ^{ab}	33.35 ^b
	SD	0.62	1.26	0.75	0.46	0.35	0.51
Depth of flank	Mean	37.08 ^{ab}	38.67 ^a	35.83 ^b	37.01 ^{ab}	36.36 ^b	35.32 ^b
	SD	0.67	1.34	0.79	0.48	0.36	0.549

^{abc} Means of variables followed by different letters on the same line are significantly different ($P < 0.05$)

3.3 Variation in Quantitative Traits among districts

The results of the variation of quantitative traits by region are presented in Table 4. The highest values of head length and ear length were found in the region Beja (22.5 ± 0.92 and 26.83 ± 1.55 cm, respectively) while the lowest values were recorded in the Tabarka and were 21.08 ± 0.37 and 17.97 ± 0.63 cm, respectively. Animals reared in the district of Ghar Dimaou have the longest necks (25.77 ± 1.1604 cm) while those reared in Tabarka had the shortest necks (22.03 ± 0.78 cm). Body length was greater in the Beja ecotype (68.33 ± 2.56 cm). However, the lowest values were observed in the GharDimaou district (58.24 ± 15.55 cm). The highest pool length (17.25 ± 0.21 cm) was recorded in Sajnene ecotype, while the lowest was reported in the Tabarka ecotype (15.16 ± 0.31 cm). Moreover, hair length was strongly related to the region ($p < 0.001$) with the highest value recorded in Beja (12.67 ± 1.35 cm) and the lowest in Sajnene (7.27 ± 0.37 cm). For width parameters, only the widths of the hips, pins, and chest differed significantly between study districts ($P < 0.001$). The highest value for hip-width was reported in The Beja ecotype (14.16 ± 0.64 cm) while the lowest value was noted in Tabarka (11.67 ± 0.25 cm). For pin width, the lowest value was found in Nefza (10.24 ± 1.01 cm). However,

the highest value was about 13.94 ± 1.64 cm and was recorded in GharDimaou. As for the width of the chest, the lowest value was marked in Tabarka with an average of 39.51 ± 0.75 cm, while the highest average was 44.83 ± 1.87 cm. In addition, peripheral measurements differed between regions ($P < 0.001$). Indeed, the highest value of chest circumference appeared in Beja (81 ± 2.81 cm). In contrast, the lowest value was recorded in the GharDimaou ecotype (71.59 ± 1.67 cm). The lowest anterior barrel circumference was recorded in the Sajnene population (9.43 ± 0.12 cm). On the other hand, the highest value was reported in Beja (10.67 ± 0.44 cm). The highest wither height was recorded in Ain Drahem (71.32 ± 1.02 cm) while the lowest was in Tabarka (66.70 ± 0.83 cm). The highest back height was remarked in the Beja ecotype (72.83 ± 2.14 cm) while the lowest value was reported in Tabarka (68.49 ± 0.86 cm). The highest value for height at the sacrum was recorded in Beja (74 ± 2.234 cm) and the lowest in Ghar Dimaou (69.47 ± 1.33 cm). Chest and flank depths varied significantly among districts ($P < 0.001$). Indeed, the highest value of chest depth (36.04 ± 0.4625 cm) was recorded in Nefza and the lowest (33.35 ± 0.51 cm) in Tabarka. Similarly, for flank depth, the highest value (38.67 ± 1.34 cm) was recorded in Beja, and the lowest value in Tabarka (35.32 ± 0.54 cm).

Table 4: Qualitative traits

Trait	Variable	Male (%)	Female (%)	P
Head Color	Black	2.37	15.64	0.001
	White	0.95	7.11	0.001
	Mixed	6.16	67.77	0.001
Color of the dress	Black	3.32	20.85	0.001
	White	0.47	5.21	0.001
	Mixed	5.69	64.45	0.001
Color of the legs	Black	2.84	20.85	0.001
	White	0.95	4.27	0.001
	Mixed	5.69	65.4	0.001
Horns	Present	5.29	75	0.001
	Absent	3.85	15.87	0.001
Horns Shape	Rolled	1.2	61.68	0.001
	spirals	5.39	31.74	0.001
Ear shape	Drop-down	6.64	36.49	0.001
	Semi-horizontal	2.84	53.08	0.001
	Drawn up	0	0.95	0.001
Profile	straight	7.11	67.3	0.001
	busk	3.09	22.5	0.001
Barrows	Present	8.53	74.41	0.001
	Absent	0.95	16.11	0.001
Pendleton	Present	3.32	13.27	0.001
	Absent	6.16	77.25	0.001

3.4 Qualitative traits

The qualitative traits are presented in Table 5. The most common head color was the mixed color with 73.93% for both sexes (67.77 and 6.16%). However, white color was very rare (7.11%) for females and (1%) for males. The black color was present in 18.01% of animals between the two sexes. Regarding coat color, the percentage of mixed color exceeded 70%. This means that the white and black colors were very rare in our local population. As for the shape of the ears, the erect form existed in only 1% of the animals. On the other hand, 55.92% of the animals had a half-horizontal shape and 43.16% had drooping ears. According to the results of our study, we noted the importance of the straight profile in 67.3% of females and 7.11% of males (74.41%). Contrarily to the bushy profile which presents only 25.59% of the population (Figure 2), our study showed that the majority of the local population studied (83.41%) did not own a goat of which 77.25 and 6.16%, respectively for females and males.

Figure 2: Body measurements by PCA in the goat population

3.5 Descriptive Data Analysis

3.5.1 Cluster Analysis

Principal component analysis (PCA) was applied to the entire sample (211 heads). All individuals are adult females. The results showed that these variables accounted for 81.78% of the total inertia on the first two axes, which constitutes a weighting scheme in the discrimination of the variables (Table 5). Analysis of the parameters studied showed that the two axes presented 61.27 and 20.51% of the total inertia respectively (Figure 2). Axis 1 (61.27%) was represented by length and height measurements; head length ($r=0.89$), ear length ($r=0.83$), body length ($r=0.96$), pelvis length ($r=0.84$), hip-length ($r=0.97$), height at the withers ($r=0.89$), and back and height at the sacrum ($r=0.92$). Axis 1 was represented by goats characterized by a well-developed body length, as well as hip-width and chest circumference. However, Axis 2 (20.51%) was represented by hair length ($r=0.57$) and anterior barrel circumference (TCA; $r=0.73$). It represented animals with highly developed chest depth, hair length, and anterior barrel circumference. These goats had reduced chest circumference and body length.

Table 5: Eigenvalue

Component	Initial Eigenvalue		
	Eigenvalue	CV	% cumulative
F1	10.41	61.27	61.27
F2	3.48	20.51	81.78

3.6 Ascending Hierarchical Classification (AHC)

Based on the various measurements made during the measurements carried out, the hierarchical ascending classification (C.A.H.) of our sample allowed us to distinguish five classes (Figure 3) whose numbers are 62. 81. 45. 17 and 6.

Figure 1: Hierarchical ascending classification

- Classes 1 and 4 were represented by small animals. They have the lowest averages for body length (60.94 and 58.24 respectively). Similarly, for the height at the withers, back, and sacrum, class 1 animals had averages of 69.01. 70.38. and 71.68 cm. respectively. Class 4 animals have averages of 68.18. 68.77. and 69.47 cm. These were generally small goats.

- Classes 2 and 3 were composed of animals with a medium body build) but with a slight difference.

- Class 5 consisted of highly developed, heavy-bodied individuals with the highest body length (68.33 cm), height at withers (71.17 cm), height at back (72.83 cm), and height at sacrum (74 cm).

4. DISCUSSION

4.1 Descriptive Analyses of Quantitative traits

According to Denis (2000), the hair was not an interesting criterion for establishing a group classification, for this reason, Sanson suggested Sanson's classification (Sanson, 1910), which took into account the characteristics of the ears and attributed to each breed a particular fossil ancestor. However, Peters and Horst (1981) considered body length as an

appropriate criterion for classification. Devendra and Burns (1983) classified tropical goats according to their size, i.e. large (> 65 cm at the withers), small (51 to 65 cm), and dwarf (<50 cm). Our study showed that different width measurements of the goat population were very close to those of Arandas *et al.* (2017). For the chest and the anterior barrel, our results were in agreement with those of Arandas *et al.* (2017), who reported values of 80.38 ± 5.06 and 8.98 ± 0.89 cm for the chest and gasket circumferences, respectively. Nevertheless, they were higher than those found in Morocco by El Moutchou *et al.* (2017) (68.4 ± 6.1 and 8.2 ± 0.8 cm, respectively). Referring to the studies of Weldeyesu and Rohatash (2017), the Tunisian population showed a slight superiority for height measurements in males with average values of 61.65 cm and 63.55 cm for back height and sacrum height, respectively, and females with average values of 57.45 and 59.35 cm. Our results were similar to those of Marichatou *et al.* (2012), who found values of 71, 69.96, and 70.38 cm, respectively, for the height at the withers, back, and sacrum in the Bega-Medir breed. However, they were superior to the results of Weldeyesu and Rohatash (2017) who reported height measurements of 59.55 ± 3.89 ; 60.32 ± 3.75 , and 61.45 ± 4.46 cm for withers, back, and sacrum height, respectively. Our results showed that the average value of depth of the chest was similar to those of Benyoub (2016) who found an average value of 33.09 ± 2.64 cm in an Algerian population and were higher than those of Manallah (2012) with an average value of 24.79 ± 5.6 cm. Moreover, Gaddour *et al.* (2007a; 2007b) reported the average value depth of the flank, a value close to 37.5 ± 6.13 cm.

4.2 Variation in Quantitative Traits by Sexes

Our study revealed that the average value length of the head was the same for males and females. These values were relatively lower than values reported by Habbi (2014) who found the long head of 24.4 and 25.1 cm, respectively for females and males in the Ghardaïa region of Algeria. For neck length, our results were in agreement with Weldeyesu and Rohatash (2017) who found a similar neck length in males and females ($P > 0.05$). They recorded values of 25.52 and 26.43 cm, respectively. However, the length of ears, body, pelvis, hair, and tail was significantly different between males and females. Correspondingly, Weldeyesu and Rohatash (2017) reported that females had a lower ear length than males in the Maefur breed in northern Ethiopia. Regarding body length, our results were in agreement with that of Jeda and Asefa (2016) who showed that males always had higher body length than females in the southeastern Ethiopia ecotype ($61.73 \pm 0.4 > 58.1 \pm 0.7$ cm). Moreover, a significant between the sexes occurred on width parameters. This was in agreement with the results of Belkhadem *et al.* (2019) who found that all width parameters were significantly affected by sex ($P < 0.001$). Our results were less than the finding of Manallah (2012) who found that the width of the hips and pin widths were 15.69 and 15.47 and 13.46 and 13.31 cm (for females and males), respectively. While the width of the chest was higher than the results reported in that of the Algerian population and were equal to 24.19 and 25.39 cm for females and males, respectively (Manallah, 2012). Results showed that chest circumference and anterior cannon circumference were significantly different between sexes ($P < 0.001$). This was confirmed by Belkhadem *et al.* (2019). On the other hand, Manallah (2012) reported that females were superior to males for chest circumference in the local population of Setif in Algeria. All height measurements, i.e. height at the withers, back, and sacrum were significantly affected by sex ($P < 0.001$). Our results were consistent with the conclusions reported by Belkhadem *et al.* (2019). The same was true for the Malagasy breeds reported by Razainandraina [34] that had a height at withers of 68.7 and 59.5 cm for males and females, respectively.

4.3 Variation in Quantitative Traits by Region

Our results were similar to those of Belkhadem *et al.* (2019) who indicated that all length measurements vary significantly by region except for the tail and pelvic length. Correspondingly, Arandas *et al.* (2017) reported that a significant difference for most length measurements except for body length ($p < 0.05$). Regarding width parameters, our results corroborated those of Belkhadem *et al.* (2019) who reported variability of width measurements between the study areas. Besides, our results were in agreement with those of Belkhadem *et al.* (2019) in western Algeria and Arandas *et al.* (2017) in northeastern Brazil who showed a significant difference ($P < 0.001$) in peripheral parameters between regions. Moreover, all height measurements (height at withers, back, and sacrum) were significantly influenced by the region ($P < 0.001$). This was consistent with Hilal's study [35] at Beni Arouss in Morocco. Similarly, Arandas *et al.* (2017) confirmed this significant variation in their results for local populations in Morocco and Brazil. Chest and flank depths varied significantly by region. This was in agreement with Belkhadem *et al.* (2019) and Arandas *et al.* (2017) who found that the variation of these two parameters was highly regionally significant in the northeast Brazil populations.

4.4 Qualitative traits

Our results were in agreement with those of Manallah (2012) who noted the dominance of the mixed color with more than 70% and more than 47% respectively for females and males of the local goat population in the region of Setif in Algeria. This was the case in the results of Weldeyesu and Rohatash (2017), who found a majority for spotted coat types (32.3%) in the indigenous goat population of Ethiopia. However, Lanari *et al.* (2003) found a majority of animals with a white coat (84.9%) in the local population of Criollo goats in Argentina. Castanheira *et al.* (2010) reported that coat color was useful to protect deep tissue from excessive exposure to short-wave solar radiation in tropical areas of central Brazil.

In our study, the most frequent color of the legs was the mixed color with more than 60% in females and 5% in males. However, for the color of the legs, Manallah (2012) showed that white was the most dominant color (more than 50%). We noted that 80.28% of the population of northwestern Tunisia is horny. Several authors have also reported that the majority of animals are horny (Castanheira *et al.* (2010) but the results of our study contradict other previous studies (Weldeyesu & Rohatash, 2017; Manallah, 2012) in different regions of Algeria. Among the 80.28% of horned individuals in our study population, 62.87% had horns with curved shapes. Hassen *et al.* (2014) noted the majority presence of the curled form in 80% of goats in Ethiopia. Similarly, Weldeyesu and Rohatash (2017) noted that the spiral form only presents 18%. The presence of horns in animals' was considered an advantage for blood drainage through the cavernous sinus as a control mechanism for thermal homeostasis (Robertshaw, (2006), as well as for improved reproductive performance (Hassen *et al.*, 2012).

Our results were similar to those of Weldeyesu and Rohatash (2017) who found that 92% of the indigenous population of Ethiopia was characterized by a thin, and laterally oriented ear. In contrast to Manallah (2012), who mentioned that the drooping shape of the ears was very remarkable with 60.30% in females and 74.40% in males. We noted the importance of the straight profile. In this regard, Manallah (2012) observed that more than 90% of the population had a straight profile, in Algeria. Similarly, El Moutchou *et al.* (2017) confirmed that in both sexes and all regions of Morocco, the majority of goats have the right profile (>94%). In the local goat population of northwestern Tunisia, more than 80% of the population had a goatee. These observations were similar to those of Traoré *et al.* (2008) who detected a high prevalence of bearded animals in local goats in Burkina Faso. Our findings were consistent with those of Hassen *et al.* (2014) who showed that more than 50% of Gumuz and Agew goats in the Chifra region of Ethiopia had beards in contrast to Benyoub (2016) who found that, only 37% had a goatee in Algeria.

Our study showed that 83.41% of the studied ecotypes did not own a goatee. Our results were similar to those of Benyoub (2016) who indicated that more than 80% of goats are free of pendants in northwest Algeria. The same was true for the work of Lanari *et al.* (2003) who showed that more than 94% of the goat population present in Argentina was free of pendants.

5. CONCLUSION

The field survey revealed that the majority of the animals observed were horned with curled horns, drooping and semi-erect ears, with a dominant straight profile, and have a mixed coloration for the whole body (coat, head, and legs). The goat was marked by several individuals, unlike the goatees that were almost absent or non-existent. The sex factor was highly significant for all parameters and showed that males were generally more developed than females especially concerning length and height parameters. Regarding the variations related to the region. We found that the most developed, or heaviest-bodied individuals are located in the Beja and Ain Drahem regions. The hierarchical ascending classification (CAH) defined five classes in the local goat population of the Northwest. Also, a great heterogeneity between the measured parameters was observed probably reflecting the heterogeneity of this population that confirmed that our local goat population in the Northwestern region of Tunisia is not homogeneous. This can also be explained by the uncontrolled crossbreeding practiced by breeders. This study on the phenotypic characterization of goats can be used as a prerequisite for other genetic characterization studies of the local populations studied.

CONFLICT OF INTEREST

There is no conflict of interest.

ETHICAL CONSIDERATION

All procedures related to animal care, handling, and sampling were conducted under the approval of the Official Animal Care and Use

Committee of the Higher School of Agriculture of Mateur (protocol no. 05/15) before the initiation of research and followed the Tunisian guidelines.

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