Genetics & Biodiversity Journal
Journal homepage: https://journals.univ tlemcen.dz/GABJ/index.php/GABJ
ISSN: 2588-185X

OPEN ACCESS

Original Research Paper

Phenotypic and molecular characterization of Tazegzawt and EL Ham sheep populations in Algeria

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Article history: Received: June 3, 2022 Revised: September 27, 2022 Accepted: December 1, 2022

Abstract

Several sheep breeds and populations are recognized in Algeria. They reveal high phenotypic and genotypic diversity underpinning specific features and adaptations levels. In spite of their distant geographic repartitions, some populations seem to be genetically close and share an ancestral origin. In this regard, the present study aims to compare, at the morphological and genetics levels, two Algerian sheep populations known by their small size: Tazegzawt and EL Ham bred in eastern and western of Algeria, respectively. A total of 74 sheep including 25 and 49 belonging to Tazegzawt and EL Ham populations, respectively, were analysed for twelve body measurements and eleven qualitative morphological traits. The comparison between the two populations (N=25 for Tazegzawt, N= 5 for El Ham) on at the molecular level was carried out using 15 microsatellites. The analyses showed that differences in body measurements between the studied populations were significant, and Tazegzawt was highest and longest and most body traits showed higher average values in this population. Besides, descriptive analysis of the qualitative characters in the two sheep populations also showed several differences. The molecular study revealed a high genetic diversity. The genetic distance between the two breeds is 0.479. The FST value obtained from all of them shows that 4.2% of the total genetic variation resulted from the differences between populations while 95.8% of the genetic variation is caused by the difference within individuals. Phylogenetic relationships among the individual and membership probabilities on microsatellite genotype data displayed a high genetic admixture between the two populations. Moreover, Discriminant analysis of principal components scatter plots showed that the two populations were superposed. This result could be explained by the same ancestral origin of Tazegzawt and El Ham; it also exhibits the effect of climate and the geographic location on the morphological characteristics of the animals. Generally speaking. The phenotypic characterization shows that these populations differ from each other but the molecular analysis shows the opposite. We therefore conclude that the two populations belong to the same breed and that the morphometric differences observed are due to the adaptation and the breeding system applied in the different regions.

Key words: Algeria; Characterization; Morphometric; Microsatellite; Sheep population; Tazegzawt and EL Ham.

الملخص
تتميز شعبة الأغنام في الجزائر بوجود العديد من السلالات التي تشيرإلى تنوع مظهري وجيني مرتفع غنيّ يؤدي إلى ميزات ومستويات عالية من التأقلم. على الرغم من إعادة تقسيمهم الجغرافي، يبدو أن بعض مجموعات الأغنام منغلقة وراثيًا وتشترك في أصل الأجداد. في هذا الصدد تهدف الدراسة الحالية إلى المقارن، على مستوى الوراثة المورفولوجية والجزيئية، بين مجموعتين من الأغنام الجزائرية المعروفة بفعاليتها الصغيرة: مجموعة تازغزاوت ومجموعة الحام، حيث تربى المجموعة الأولى في شرق الجزائر والثانية في المناطق الغربية. تم تحليل ما مجموعه 74 رأسًا من الأغنام موزعين كالآتي:25 فردا من مجموعة تازغزاوت 49 فردا من مجموعة الحام، عن طريق أخذ 14 قياسًا للجسم و11 صفة كليّة نوعيّة. أجريت المقارنة بين المجموعتين على المستوى الجزيئي باستخدام 15ميكرو ساتل جيني. أظهرت التحليلات أن الفروق في قياسات الجسم بين الفئات المدروسة لم تكن ذات دلالة، حيث كانت مجموعة تازغزاوت هي الأعلى والأطول وأظهرت معظم سمات الجسم قيمًا متوسطة أعلى في هذه الفئ ، إلى جانب ذلك ، أظهر التحليل الوصفي للصفات النوعية بين المجموعتين عدة اختلافات ، حيث كشفت الدراسة الجزيئية عن تنوع وراثي مرتفع . المسافة الجينية بين السلالتين.0.479 تظهر قيمة التي تم الحصول عليها من كلا المجوعتين أن 4.2% من التباين الجيني الكلي نتج عن الإختلافات بين المجموعتين فيما بينهما، بينما 95.8% من هذا الإختلاف ناتج عن الإختلاف داخل الأفراد.العلاقات الفيلوجينية بين الأفراد واحتمالات ظهورها على النمط الجيني بالميكرو ساتل أوضحت إختلاط جيني مرتفع بين المجموعتين، علاوة على ذلك، أظهر التحليل التبايني للمكونات الرئيسية مجموعات مبعثرة وومجموعتين متراكبتين .يمكن تفسير هذه النتيجة بالأشتراك بين مجموعتي تازغزاوت والحام، في نفس الأصل، كما أنها تُظهر تأثير المناخ والمنطقة الجغرافية على الخصائص المورفولوجية لأفراد المجموعتين بشكل عام. أظهرت هذه النتائج أن مجموعتي تازغزاوت والحام يجب اعتبارهما فئتين مختلفتين تماما ومُتباينتان فيما بينهما

الكلمات المفتاحية :الجزائر، التوصيف، قياس الحدة. ميكرو ساتل، عدد الأغنام؛ تزغزاوت والحام.

Introduction

In Algeria, sheep farming is one of the most traditional strategic activities; so, it plays an important role both in the national agricultural economy and for breeders. Thus, providing a considerable financial reserve. The national sheep herd numbered around 28 million heads in 2018 (MADRP, 2018) which ensures a red meat production of around 60% of the total national supply. Algerian sheep breeds exhibit a great phenotypic diversity and huge variation in population size. Based on animal numbers, the twelve different breeds of various origins can be separated in two categories, the first one including breeds with large number of animals as Ouled Djellal., Hamra, Ifilène and Sidaou and the second group consisting by local breeds with reduced number of animals as Rembi, D'man, Tâadmit, Berbère, Barbarine, Tazegzawt or EL Ham, Sardi (Srandi) and Darâa (Djaout *et al.*, 2017).

The Tazegzawt population is recognizable by its black spots with bluish reflections; this breed is located in the mountains of Kabylie (Tizi-Ouzou and Bejaia at altitudes of 1200m) where it has only a very low number (maximum 300 animals). This breed has been the subject of several research projects (Moula and El-Bouyahyaoui, 2015; Gaouar *et al.,* 2016; Ameur Ameur *et al.,* 2017; Djaout*et al,* 2017; Moula, 2018).

The EL Ham population is found mainly in the region of Mechria (Nâama) where the breeders give it the name EL Ham which also means blue in the local dialect. This breed has at least 400 animals with several breeders in this region. This breed is considered in danger of extinction in Algeria (Djaout*et al.*, 2017). Unfortunately, there is little research for this breed as it was only studied by Djaout and his collaborators in 2017.

The significant lack of information on these two populations as well as the visual morphological reconciliation between them pushed us to carry out this characterization work (morphological and molecular) in order to better characterise them and to find out if these two populations are varieties of the same breeds or they constitute different breeds.

Materials and Methods

Study zone

Our work was carried out at the level of two wilayas of western Algeria with different biotopes. the wilaya of Tlemcen (Maghnia, Ain Nahalla and El Aaricha) and the wilaya of Naama (Ain Ben khlil, Mechriya, ElByodh, Mekmen Ben Amar and El Kasdir) for the EL Ham population during the year 2019/2020 and from four wilayas of Eastern Algeria (Tizi-Ouzou, Bejaia, Biskra and Souk Ahras) for the Tazegzawt population during the year 2014/2015 (Figure 01).

Figure 01. Distribution of sampled flocks from two sheep populations

Animals

In this study, we had two sheep populations (Table 01). 25 adult sheep of the Tazegzawt population including (15 males and 10 females) from the population in two wilayas (Béjaia and Tizi-Ouzou) and 49 adult sheep of EL Ham population with (13 males and 36 females) in the wilayas of Tlemcen and Naama. were used for phenotypic study.

For molecular study. On 30 individuals were used (25 samples from Tazegzawt population and 05 EL Ham population).

Figure 02. Tazegzawt sheep population

Table 01. Summary of the distribution by sheep population and sex

Population	**Phenotypic study**				**Molecular study**
	Females	**Males**	**Total**	**% Males**	
Tazegzawt	10	15	25	60%	25
EL Ham	36	13	49	26%	5
Total	46	28	74	38%	30

Figure 03. EL Ham sheep population

The studied variables

The study was carried out on 12 and 11 quantitative and qualitative parameters, respectively. These measurements carried out for the phenotypic characterization of sheep require adult animals which have completed their growth. The body measurements studied were: Height at the withers (HW); scapulo-ischial length (SIL); heart girth(HG); chest depth (CD); shoulder width (SW); pelvis length (PL); Trochanter width (TW); Head length (hL); Head width (eW); Ear length (eL); Ear width (eW) and cannon Perimeter (CP) (Table 02).

Table 02. Definition of the quantitative characters studied

Measurements	**Definition**
Scapular-ischial length (**SIL**). Body length	Distance between the point of the shoulder and the point of the ischium
Withers height (**WH**)	Distance between the ground and the highest point of the withers
Heart girth (**HG**)	Vertical distance between the point of the withers and the sternum
Chest depth (**CD**)	Measurement of the circumference of the chest taken behind the forelimbs and passers-by through the passage of the straps
Shoulder width (**SW**)	Distance between the two points of the shoulders
Trochanter width (**TW**)	Distance between the two trochanters (coxofemoral joint)
Pelvis length (**PL**)	Distance from tip of hip to tip of ischium or ileo-ischial distance
Head length (**hL**)	Distance between the top of the forehead and the mouth
Head width (**hW**)	Maximum distance between the two zygomatic bones
Ear length (**eL**)	Distance from the base to the tip of the right ear along the dorsal surface
Ear width (**eW**)	Distance between the two side edges of the right ear in the middle
Cannon perimeter (**CP**)	Perimeter of the lower limit of the upper 1/3 of the right anterior cannon bone

These measurements carried out for the phenotypic characterization are inspired by work on the sheep population across the world, in particular those of Harkat et al. (2015); Moula. (2015); El-Bouyahiaoui. (2015); Belharfi et al. (2017) and Djaout et al. (2017) and other animal species: goat (Rout*et al.*, 2000); equines (Kefena*et al.*, 2012), bovine (Yilmaz *et al.*, 2012); camelina (Adamou *et al.*, 2013; Bedhiaf-Romdhani*et al.*, 2014), porcine (FAO, 2013) and avian (Melesse and Negesse, 2011).

The qualitative parameters studied

The qualitative parameters considered in this study were: the colour of the head; the colour of the skin; colour of the hock; colour of the knee and the pastern. The type of fleece and the presence or absence of horns and wattles. Ear shape and the presence or absence of blue spots at the tongue and cephalic profile are also concerning by our study.

The molecular study

Blood samples were collected from the jugular veins of the animal material using vacutainer tube containing Tri-Potassium Ethylene Diamine Tetra Acetic Acid (K3EDTA), collected blood were stored at -20°C until analyses. Blood samples were taken from 25 unrelated animals of the Tazegzawt population and 5 individuals of the EL Ham population (Table 3), the genomic DNA was extracted according to salting out method procedures described by Miller et al. (1988). Afterward, quantification and qualification of DNA were controlled using NanoDrop 2000 (Thermo Scientific. Waltham. MA), PCR and fragment analysis were performed according to AmeurAmeur et al. 2018.

Table03. The sample distribution of the sheep populations studied according to the region.

Molecular study		
Population	**Wilaya**	**Effective**
Tazegzawt	Bejaïa	**24**
	Biskra	**01**
EL Ham	Naama	**04**
	Souk Ahras	**01**
Total		**30**

Genomic analysis was performed on 30 samples using 15 microsatellites, most of which belong to the list established by the FAO for the study of the genetic structure of sheep breeds at the time. The primers used are labelled with four different fluorophores: Dye 2 (emits in blue), Dye 3 (emits in green), Dye 4 (emits in black), the primers received are resuspended, using ultra-pure water, for a final concentration of 16.1 nmol/µl. Subsequently, the markers are grouped into multiplexes of three markers so that they can be distinguished by their fluorophore. Thus, 2 multiplexes were formed (M1 and M2). The information relating to these markers are given in Table 04.

Statistical analysis

The phenotypic descriptors were analysed by SPSS 19 software. The effect of age and sex on phenotypic parameters were compared using the one-way ANOVA test. A principal component analysis (PCA) was carried out in order to group together homogeneous individuals based on body measurements. Finally, to obtain the optimal number of groups an ascending hierarchical classification (CHA) was used. The Shannon and Weaver index was used to get an idea of the degree of selection of each trait at the level of each region. The Malanahobis distance was used to get an idea of the degree of similarity between the two breeds.

All molecular statistics were performed using GenAlEx 6.5 (New Brunswick. NJ) (Peakall and Smouse 2006; 2012). The analysed variables were: Mean number of Alleles (MNA); Number of allele (Na); Effective Alleles (Ne); Information Index (I); LComm Alleles (≤25%) and (≤50%); Observed Heterozygosity (Ho); Expected Heterozygosity (He); Unbiased expected Heterozygosity (uHe); Fixation Index (Fis) and number of loci not in the HWE ($p < 0.05$) (F) also known as the ranking of the overall diversity of all sheep populations. Finally, we performed the pairwise population matrix through Nei genetic distance, Fst value and Molecular Variance (AMOVA) with Shannon information (sH) to know the classification of the global diversity of all the sheep populations.

We considered other four sheep breeds: Ouled Djellal, Rembi, Hamra, Sidaou data of (Ameur et al.,2018) to construct individual unrooted tree, Discriminant Analysis of Principal Components (DAPC) scatterplots and membership probabilities barplot using the packages adegenet (Jombart, 2008)., ade4 (Drayet al., 2007), ape (Paradis et al., 2004) and RColourBrewer (Neuwirth & Neuwirth,2014) of R program 4.1.2.

Table 04. Characteristics of the panel of 15 microsatellite markers used in this study

Multiplex	Microsatellites	Location Chromo-somal	Primer Sequences	Size of Alleles (bp)		Marking
				ISAG	*FAO*	
	OarFCB 193	11	FTTCATCTCAGACTGGGATTCAGAAAGGC R GCTTGGAAATAACCCTCCTGCATCCC		96-136	Dye 3
	OarFCB 304	19	FCCCTAGGAGCTTTCAATAAAGAATCGG R CGCTGCTGTCAACTGGGTCAGGG	148-190	150-188	Dye 3
	INRA0023		F GAGTAGAGCTACAAGATAAACTTC R TAACTACAGGGTGTTAGATGAACTC	201 -219	195-225	Dye 3
M1	OarCP34	3	F GCTGAACAATGTGATATGTTCAGG R GGGACAATACTGTCTTAGATGCTGC		112-130	Dye 2
	INRA0132	20	F AACATTTCAGCTGATGGTGGC R TTCTGTTTTGAGTGGTAAGCTG	152–172		Dye 2
	D5S2	17	F TACTCGTAGGGCAGGCTGCCTG R GAGACCTCAGGGTTGGTGATCAG	190 -210		Dye 2
	BM1818	20	F AGCTGGGAATATAACCAAAGG R AGTGCTTTCAAGGTCCATGC	258 -270	248-278	Dye 2
	BM8125	17	F CTCTATCTGTGGAAAAGGTGGG R GGGGGTTAGACTTCAACATACG		110-130	Dye 3
	McM0527	5	F GTCCATTGCCTCAAATCAATTC R AAACCACTTGACTACTCCCCAA	165 -179	165-187	Dye 3
	CSRD0247	14	F GGACTTGCCAGAACTCTGCAAT R CACTGTGGTTTGTATTAGTCAGG	209-261	220-247	Dye 3
M2	OarFCB 128	2	F ATTAAAGCATCTTCTCTTTATTTCCTCGC R CAGCTGAGCAACTAAGACATACATGCG		96-130	Dye 4
	BM1329	6	F TTGTTTAGGCAAGTCCAAAGTC R AACACCGCAGCTTCATCC	145-161	160-182	Dye 4
	HSC	20	F CTGCCAATGCAGAGACACAAGA R GTCTGTCTCCTGTCTTGTCATC	267-301		Dye 4
	OarJMP29	24	F GTATACACGTGGACACCGCTTTGTAC R GAAGTGGCAAGATTCAGAGGGGAAG		96-150	Dye 2
	MAF214	16	F GGGTGATCTTAGGGAGGTTTTGGAGG R AATGCAGGAGATCTGAGGCAGGGACG	181-265	174-282	Dye 2

Results

1. Quantitative characters

Variation in body measurements by population

The results according to the measurements by population (Tazegzawt and EL Ham) were presented in table 05.

In general, the differences of morphology between the two breeds were very highly significant ($P < 0.001$) for the characters: SIL; PL; hL; hW; eL; eW; HG, highly significant ($P < 0.01$) for HG and SW, and significant ($P < 0.05$) for the two traits WH and CP. It seems that the two breeds are heterogenous.

The Tazegzawt population is as higher (WH: 85.12 ± 4.75 cm; HP: 38.76 ± 3.33 cm) and longer (SIL: 87.00 ± 9.28cm); it has a wider pelvis. (PL: 32.04 ± 2.68 cm); wider in front (SW: 24.72 ± 3.31 cm); a longer head and ears (hL: 31.42 ± 3.09 cm; eL: 21.88 ± 1.64 cm); wider (hW: 18.82 ± 4.03cm; eW:

10.00 ± 0.54 cm) and more developed barrel perimeter (CP: 9.44 ± 0.75 cm) compared to the EL Ham population. However, the EL Ham population has a developed chest (CD: 110.71 ± 10.64 cm).

Table 05. Body measurements variation by breed

Characters/N	Tazegzawt 25	EL Ham 49	P value
WH(cm)	85.12±4.75	81.69±6.79	*
HG (cm)	109.04±7.67	110.71±10.64	**
SIL (cm)	87.00±9.28	71.33±8.51	***
PL (cm)	32.04±2.68	22.17±3.41	***
TW (cm)	27.48±2.10	27.05±3.5	ns
SW (cm)	24.72±3.31	21.47±4.55	**
hL (cm)	31.42±3.09	25.52±2.98	***
hW (cm)	18.82±4.03	13.96±2.33	***
eL (cm)	21.88±1.64	15.42±1.70	***
eW (cm)	10.00±0.54	8.20±0.89	***
CD (cm)	38.76±3.33	32.86±3.30	***
CP (cm)	9.44±0.75	8.96±0.89	*

*Pvalue: * Significant at 0.05; ** Significant at 0.01; *** Significant at 0.001; Ns: Not significant. Quantitative characters: Withers height (WH); Heart girth (HG); Chest depth (CD); Scapular-ischial length (SIL) or Body length. Pelvis length (PL); Trochanter width (TW); Shoulder width (SW); Head length (hL); Head width (hW); Ear length (eL); Ear width (eW); Chest depth or Chest height (CD); Cannon perimeter (CP).*

Variation in body measurements by sex

The body measurements studied in both sexes (males and females) of two sheep populations were in table 06.

Table 06. Variation of individuals by sex

Characters	Males		P	Females		P
	Tazegzawt	EL Ham		Tazegzawt	EL Ham	
	15	13		10	36	
WH(cm)	87.73±3.47	82.92±6.62	*	81.20± 3.61	81.25± 3.86	ns
HG (cm)	111.87±7.78	103.08±6.03	**	104.80 ±5.43	101.22±11.56	ns
SIL (cm)	90.40± 10.62	73.15±12.81	**	81.90±10	70.67± 6.44	***
PL (cm)	32.87±2.72	22.50± 3.21	***	30.80± 2.37	22.06± 1.61	***
TW (cm)	27.93± 2.25	27.77±3.51	ns	26.80± 1.75	26.79±3.78	ns
SW (cm)	25.60± 3.81	22.31±4.31	*	23.40± 1.84	21.17± 4.66	ns
hL (cm)	31.97± 3.80	25.31± 2.95	***	30.60± 1.35	25.60±3.03	***
hW (cm)	20.57± 2.69	13.31± 4.78	***	16.20± 1.75	14.19± 2.18	*
eL (cm)	21.47± 1.77	14.85±2.27	***	22.50± 1.27	15.63± 1.43	***
eW (cm)	10.07±0.53	7.96±0.97	***	9.90±0.57	8.28± 0.85	***
CD (cm)	40.40±2.87	34.31± 2.56	***	36.30± 3.48	32.33± 2.06	**
CP (cm)	9.80±0.70	9.42±1.04	ns	8.90±2.36	8.79±3.41	ns

P : Significant at 0.05; ** Significant at 0.01; *** Significant at 0.001. ns: Not significant. characters: Withers height (WH); Heart girth (HG); Chest depth (CD); Scapular-ischial length (SIL) or Body length. Pelvis length (PL); Trochanter width (TW); Shoulder width (SW); Head length (hL); Head width (hW); Ear length (eL); Ear width (eW); Chest depth or Chest height (CD); Cannon perimeter (CP).*

The morphometric measurements of the two sheep populations Tazegzawt and EL Ham varied according to sex. We observed in one hand significant differences between the males of the two sheep populations at 0.05 for the characters: WH and SW and highly significant differences at 0.01 for the characters: HG and SIL and very highly significant differences at 0.001 for the characters: PL; hL; hW; eL; eW; CD. On the other hand,The sex of the animals did not have a significant effect (P> 0.05) on the two morphometric measurements: TW and CP in males of the two sheep populations.

It has been noticed that the males of the Tazegzawt population are higher (WH: 87.73 ± 3.47 cm) and longer (SIL: 90.40 ± 10.62 cm). They have a more developed chest (CD: 111.87 ± 7.78cm; HG: 40.40 ± 2.87 cm). They have longer and wider head and ears (hL: 31.97 ± 3.80 cm; hW : 20.57 ± 2.69 cm). (eL: 21.47 ± 1.77 cm; eW: 10.07 ± 0.53cm), they are wider in front (SW: 25.60 ± 3.81 cm) and they have a wider pelvis (PL: 32.87 ± 2.72cm) compared to males of the EL Ham population.

Significant differences were observed between females of the two sheep breeds at 0.05 for the traits: hW ($P <0.05$) and highly significant differences at 0.01 for the trait: HG ($P <0.01$) and very highly significant differences at 0.001 for the characters: SIL; PL; hL; eL and eW ($P <0.001$).

Finally, the sex of the animals did not have a discriminating effect ($P> 0.05$) for morphometric measurements: WH; SIL; TW; SW and CP in females of the two sheep populations.

Females of the Tazegzawt breed are longer (LSI: 81.90 ± 10 cm), they have a longer and wider head (hL: 30.60 ± 1.35cm; hW: 16.20 ± 1.75 cm); longer and wider ears (eL: 22.50 ± 1.27cm; eW: 9.90 ± 0.57cm); a more developed breast (CD: 36.30 ± 3.48cm) and a wider pelvis (PL: 30.80 ± 2.37cm) compared to females of the EL Ham population.

Variation in body measurements by age

The body measurements studied according to the age for two sheep populations are shown in table 07.

While there was not a significant difference ($P> 0.05$) for the majority of the morphological characteristics of the Tazegzawt and the EL Ham populations with respect to age. A significant difference was observed at 0.05 for the height at the withers (WH) character ($p <0.05$). The 3-year-old animals were taller and 1-year-old antennas 5 were smaller.

Variation of individuals according to body measurements

Analysis of variables

A principal component analysis (PCA) is performed with the variables SIL, WH, HG, CD, SW,TW and CP. The explained variance was 66.42% of which 48.47% and 17.95% explained by the first and second PCA component, respectively (Figure 04).

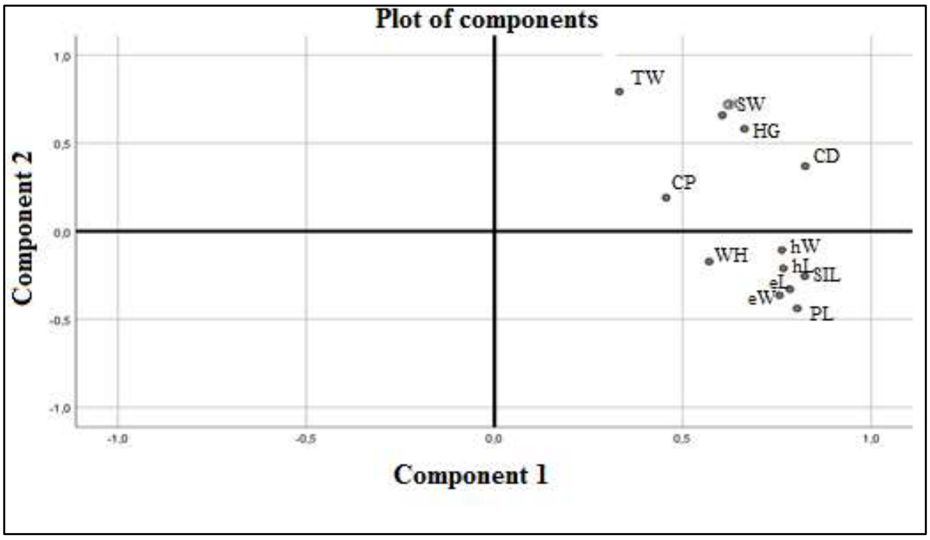

Figure 04. Plot of first and second PAC components representing the morphometric traits from Tazegzawt and the EL Ham populations. PCA1: (48.47%): is represented by the following variables: WH; HG; CD; SIL; PL; hL; hW; eL; eW and CP. PCA2:(17.95%): is represented by the following variables: SW; TW.

Table 07. Variation of variables according to age

	1 year	2 years	3 years	4 years	≥ 5 years	P
Characters/N	**16**	**10**	**6**	**7**	**10**	
WH(cm)	78.25^{c}± 5.20	84.60^{ab}±7.43	88.17^{a}±7.00	81.86^{abc}±7.43	80.30^{bc}±4.60	*
HG (cm)	96.38±10.07	103.30±7.96	105.83±7.78	104.71±7.34	104.10±14.97	ns
SIL (cm)	31.75±3.96	34.50±2.59	33.17±3.49	32.57±2.51	33.00±2.98	ns
PL (cm)	69.19±7.25	73.40±12.97	74.67±9.87	70.57±3.78	71.20±6.80	ns
TW (cm)	22.09±3.06	22.20±4.23	23.67±3.61	22.00±2.52	21.50±3.87	ns
SW (cm)	20.63±4.47	22.00±4.47	21.58±6.71	22.36±4.01	21.60±4.38	ns
hL (cm)	26.16±4.09	27.75±1.84	26.75±4.26	28.14±1.95	27.20±3.50	ns
hW (cm)	24.53±2.28	24.60±3.13	26.33±2.34	27.00±3.32	26.50±3.57	ns
eL (cm)	13.63±3.14	13.70±2.31	14.83±1.17	14.57±1.99	13.80±1.62	ns
eW (cm)	14.69±1.74	16.05±1.77	16.17±1.47	15.86±1.77	15.20±1.40	ns
CD (cm)	7.91±0.84	8.40±0.70	8.83±0.75	8.36±0.94	7.94±7.01	ns
CP (cm)	8.84±0.77	9.55±0.90	8.92±0.80	8.50±1.19	8.90±0.74	ns

*P * Significant at 0.05; ** Significant at 0.01; *** Significant at 0.001. ns: Not significant.; Withers height (WH); Heart girth (HG); Chest depth (CD); Scapular-ischial length (SIL) or Body length. Pelvis length (PL); Trochanter width (TW); Shoulder width (SW); Head length (hL); Head width (hW); Ear length (eL); Ear width (eW);; Cannon perimeter (CP).*

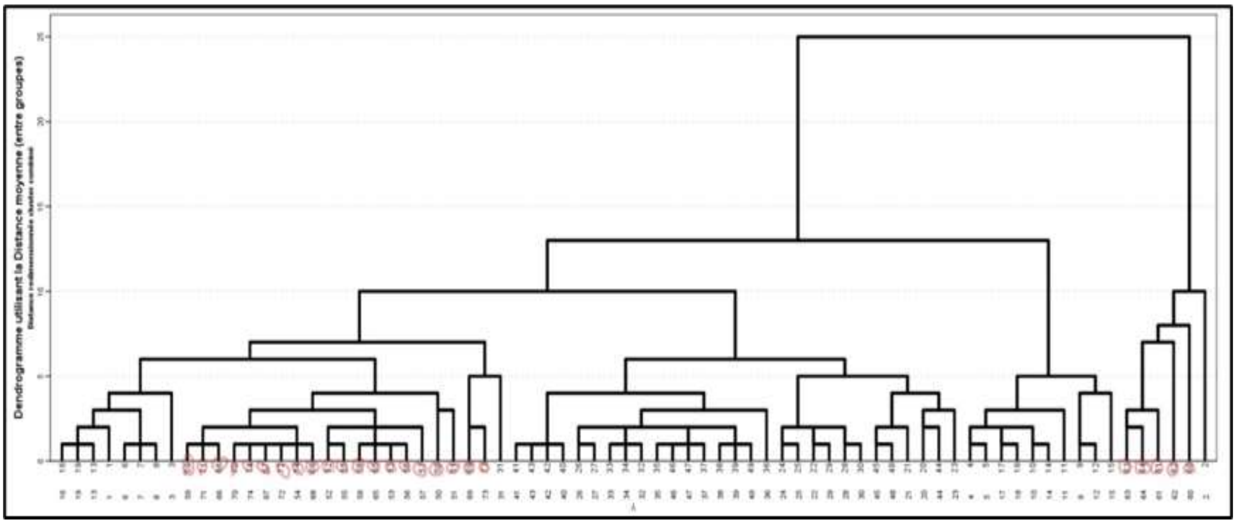

Figure 05. Hierarchical tree using the mean distance of sheep morphological traits.

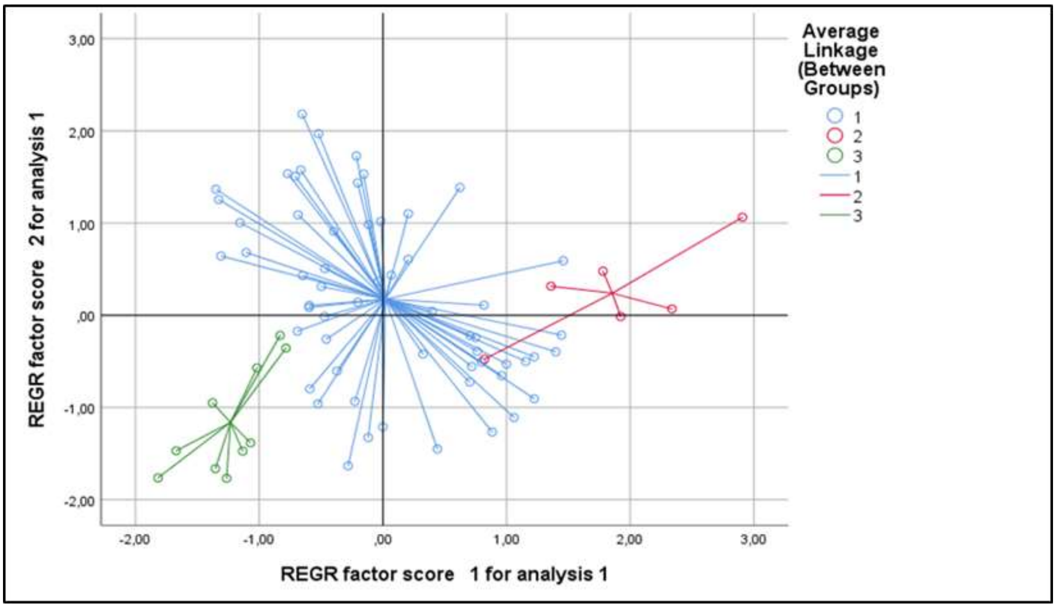

Figure 06. Presentation of individuals by PCA in the sheep populations studied

The morphological characteristics for each class are shown at table 08.

Table 08. Classification of animals from two sheep populations studied by PCA

	Class 1	Class 2	Class 3
N	58	06	10
WH (cm)	82.60±6.21	90.33±6.31	79.80±3.61
HG (cm)	105.84±6.09	119.33±5.85	85.50±6.87
CD (cm)	35.21±3.12	41.33±4.72	28.90±3.12
SIL (cm)	75.45±9.04	101.67±5.68	68.40±5.52
SW (cm)	23.11±3.45	28.17±4.62	16.05±1.38
TW (cm)	27.69±2.50	29.00±2.00	23.25±3.82
CP (cm)	9.07±0.83	10.33±0.41	8.70±0.71

Characters: Withers height (WH); Heart girth (HG); Chest depth (CD); Scapular-ischial length (SIL) or Body length. Pelvis length (PL); Trochanter width (TW); Shoulder width (SW); Cannon perimeter (CP).

Analysis of individuals

Combining PCA and hierarchical ascendant classification, we were able to highlight three distinguished groups of animals (Figure 05 and 06).

Class 01: 58 individuals from Tazegzawt and EL Ham sheep populations are represented in this group. The animals of this class constituted the majority of the studied populations. They are slender (SIL = 75.45 ± 9.04cm); higher on the legs (WH = 82.60 ± 6.21cm); wide in front (SW = 23.11 ± 3.45 cm). wide behind (TW = 27.69 ± 2.50 cm) with a chest (HG = 105.84 ± 6.09cm) and a well-developed cannon perimeter (CP = 9.07 ± 0.83cm).

Class 02: represented by six individuals: five Tazegzawt individuals and one single individual from the EL Ham population. The animals in this class are totally different from other classes. They are the most developed compared to other animals, they are the longest (SIL = 101.67 ± 5.68 cm) with a more developed right chest circumference (HG = 119.33 ± 5.85 cm), they are taller on the legs with a height at the withers (90.33 ± 6.31cm).

Class 03: This class is made up of 10 individuals from only the EL Ham population. They are less developed with a less developed right chest circumference (HG = 85.50 ± 6.87cm). They are less elongated (SIL = 68.40 ± 5.52cm) and narrower (SW = 16.05 ± 1.38 cm) with a fairly fine cannon perimeter (CP = 8.70 ± 0.71 cm) compared to individuals from the other classes.

Variations of individuals according to qualitative characteristics
Descriptive statistic:

The results of the descriptive analysis of the qualitative characteristics in the two sheep populations (Tazegzawt and EL Ham) are shown in table 09.

The total sheep populations has a head colour (50.0% pigmented and 25.7% white), the skin colour (78.4% white and 21.6% pigmented), the colour of the pastern (55.4% white and 23.0% black), the colour of the knee (56.8% white and 39.2% black), the horns (25.7% presence and 74.3% absence), wattles (36.5% presence and 63.5% absence), blue spots on the tongue (70.3% presence and 29.7% absence), the fleece (36.5% invade and 55.4% semi-invasive and 8.1% non-invasive), the cephalic profile (73% Hooked. 27% Slightly hooked).

The results of descriptive analysis of the qualitative characters in the two sheep populations are in table 10.

Table 09: Descriptive analysis of the qualitative characteristics of the two sheep populations.

Qualitative characters	**Head colour**	
	Number	Percentage
pigmented	37	50
White	19	25.7
Tricolor	15	20.3
redhead and black	3	4.1
Skin colour		
White	58	78.4
pigmented	16	21.6
Total	74	100
White	45	60.8
Black	29	39.2
Pastern colour		
White	41	55.4
Black	17	23.0
black magpie	16	21.6
Total	74	100
White	42	56.8
Black	29	39.2
black magpie	3	4.1
knee colour		
White	42	56.8
Black	29	39.2
black magpie	3	4.1
Horns		
Present	19	25.7
absent	55	74.3
Wattles		
Present	27	36.5
absent	47	63.5
Blue spots in the tongue		
Present	52	70.3
absent	22	29.7
Fleece cover		
Invasive	27	36.5
semi-invasive	41	55.4
non-invasive	6	8.1
Cephalic profile		
Hooked	54	73
Slightly hooked	20	27

It emerges from Table 10 that the Tazegzawt sheep population studied presents a black magpie head in 60% of individuals and tricolor in 40%; the skin colour is white (68%) in the majority of individuals and 32% pigmented; the hock colour is white (76%) or black (24%); the colour of the pastern is white in 52% of individuals and 48% black; the horns are presented in 40%; the pendants and blue spots on the tongue are presented in 76%; the fleece is invasive in 48% of individuals and this population has an arched cephalic profile (100%) and the ears are hanging in 92% of individuals.

The EL Ham sheep population studied has a black (44.90%), white (38.78%), tricolour (10.20%), bicolour (6.12%) head, the skin colour is white (83.7%) in the majority of individuals, the colour of the hock is white (53.1%) or black (46.9%), the colour of the pastern is white in 57.1% of individuals, the colour of the knee is white (42.9%); black (51%) or black magpie in 6.1% of animals; horns are absent in 85.7% of the population, pendants are absent in the majority of individuals (83.7%), blue spots on the tongue are present in 67.3% of individuals, the fleece is 69.4% semi-invasive, the cephalic profile is 59.2% hooked and 40.8% slightly hooked and the ears are 100% hanging.

Table 10. Descriptive analysis of the qualitative characteristics in the two sheep populations Tazegzawt and EL Ham

Qualitative characters	Tazegzawt	EL Ham
Ears	Hanging (92%) Long and Hanging (8%)	Hanging (100%)
Head colour	Black magpie (60%); Tricolour (40%)	Black magpie (44.90%); White (38.78%); Tricolour (10.20%); Bicolour (6.12%)
Skin colour	White (68%); Pigmented (32%)	White (83.7%); Pigmented (16.3%)
Hock colour	White (76%); Black (24%)	White (53.1%); Black (46.9%)
Pastern colour	White (52%); Black (48%)	White (57.1%); Black (10.2%); Black magpie 32.7%
Knee colour	White (84%); Black (16%)	White (42.9%); Black (51%); Black Pie (6.1%)
Horns	Presents (40%); Absents (52%); Blanks (8%)	Presents (14.3%); Absents (85.7%)
Wattles	Presents (76%); Absents (24%)	Presents (16.3%); Absents (83.7%)
Blue spots on the tongue	Presents (76%); Absents (24%)	Presents (67.3%); Absents (32.7%)
Fleece	Invasive (%48%); Semi-invasive (28%); No-invasive (24%).	Invasive (30.6%); Semi-invasive (69.4%)
Cephalic profile	Hooked (100%)	Hooked (59.2%); Slightly hooked (40.8%)

Variation of individuals according to qualitative characteristics

Analysis of variables

The analysis of the studied variables on a graphical representation showed that the two axes present respectively 27.52% and 25.84% of the total inertia (Figure 07).

Axis 1 (27.52%): is represented by the following variables: colour of the pastern; head colour; knee colour; blue spots on the tongue; cephalic profile.

Axis 2 (25.84%): is represented by the following variables: skin colour; fleece; hock colour; horn and watteles.

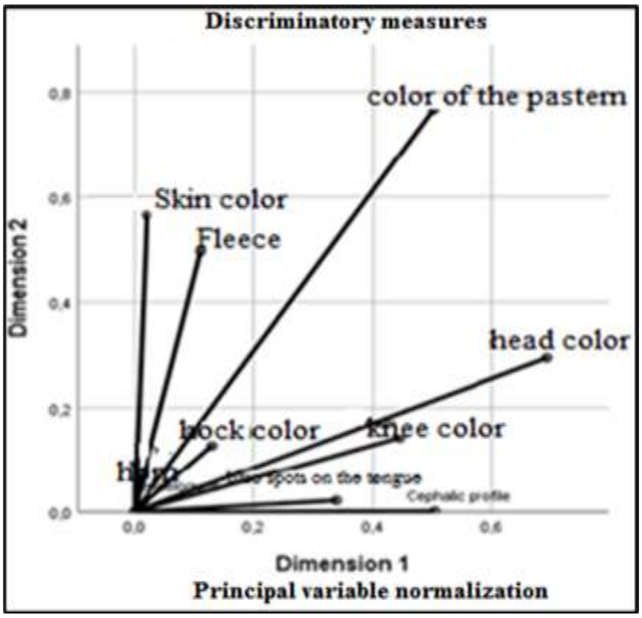

Figure 07: Graphical representation of variables by Multiple Correspondence Analysis (MCA)

Analysis of individuals

The hierarchical tree and the MCA analysis were established between classes in all the individuals of the two sheep populations (Figures 8 and 9).

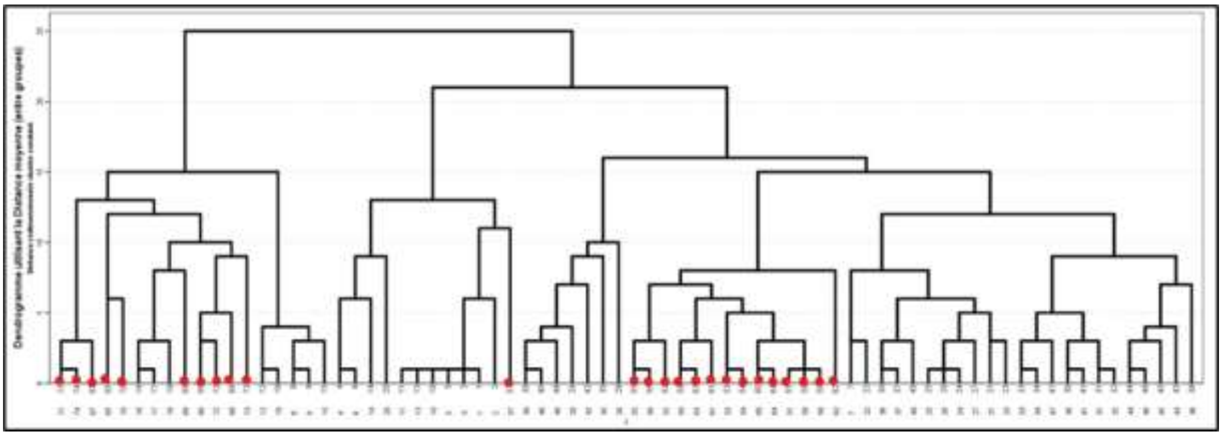

Figure 8. Hierarchical tree using the mean distance (between classes) in the animals studied

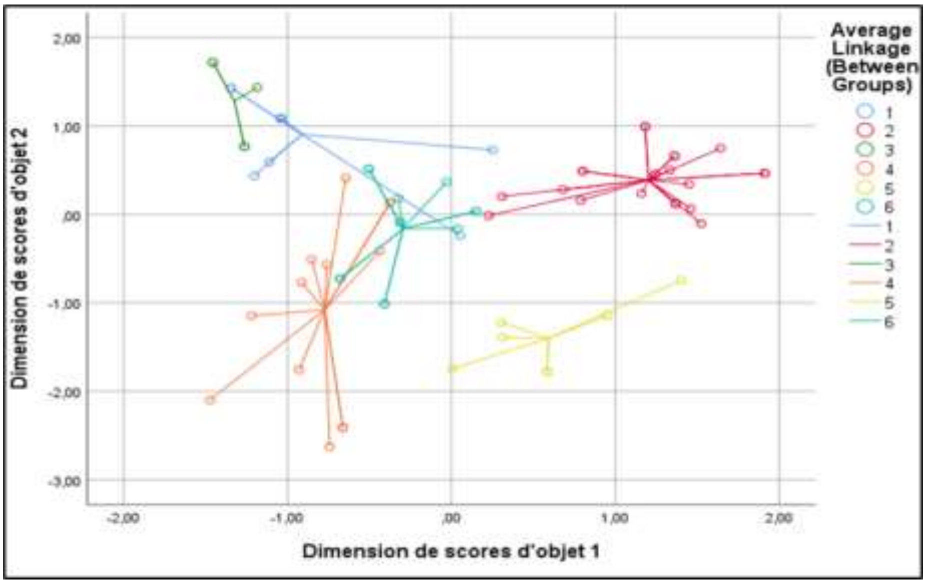

Figure 9. Presentation of individuals by MCA

The hierarchical tree and the MCA analysis showed six classes of all individuals which explains the presence of phenotypic heterogeneity between the individuals in the two sheep populations studied. Those results are shown in Table 11.

From this table there were:

Class 01: The animals of this class (12 individuals) presented a black head for 29.7% of the total population, their skin (19.0%) is white, their hock and their knees are white and the pastern is black pie. The animals of this class do not have horns and wattles; they show spots blue on the tongue with a semi-invasive fleece and a hooked cephalic profile.

Class 02: The animals of this class (23 individuals) have a white head and skin with white pasterns and black hocks and knees. The horns are absent in the majority of this class with absence of wattles and blue spots on the tongue which is the dominant character of the total population (68.2%) with a slightly hooked cephalic (70.0%). the fleece in these animals is either invasive (33.3%) or semi-invasive (34.1%).

Class 03: The animals of this class (05 individuals) have a red and black head (100% of the population) or a tricolour (13.3%) with white skin. white knees and shanks and black magpie pastern. These animals are hornless and without wattles but they have blue spots on the tongue. The fleece is semi-invasive and they have hooked cephalic profiles .

Table 11. Characteristics of the classes determined by the MCA analysis.

Class		**1**	**2**	**3**	**4**	**5**	**6**
N		**12**	**23**	**05**	**13**	**07**	14
Head colour	Black	11 (29.7%)	5 (13.5%)	0 (0%)	0 (0%)	7 (18.9%)	14 (37.8%)
	White	1 (5.3%)	18 (94.7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	Tricolour	0 (0%)	0 (0%)	2 (13.3%)	13 (86.7%)	0 0%)	0 (0%)
	Red and black	0 (0%)	0 (0%)	3 (100%)	0 (0%)	0 (0%)	0 (0%)
Skin colour	White	11 (19%)	23 (39.7%)	5 (8.6%)	5 (8.6%)	0 (0%)	14 (24.1%)
	pigmented	1 (6.3%)	0 (0%)	0 (0%)	8 (50%)	7 (43.8%)	0 (0%)
Hock colour	White	10 (22.2%)	11 (24.4%)	4 (8.9%)	8 (17.8%)	1 (2.2%)	11 (24.4%)
	Black	2 (6.9%)	12 (41.4)	1 (3.4%)	5 (17.2%)	6 (20.7%)	3 (10.3%)
Pastern colour	White	0 (0%)	23 (56.1%)	0 (0%)	6 (14.6%)	2 (4.9%)	10 (24.4%)
	Black	1 (5.9%)	0 (0%)	0 (0%)	7 (41.2%)	5 (29.4%)	4 (23.5%)
	Black magpie	11 (68.8%)	0 (0%)	5 (31.3%)	0 (0%)	0 (0%)	0 (0%)
Knee colour	White	7 (16.7%)	6 (14.3%)	5 (11.9%)	10 (23.8%)	0 (0%)	14 (33.3%)
	Black	2 (6.9%)	17 (58.6%)	0 (0%)	3 (10.3%)	7 (24.1%)	0 (0%)
	Black magpie	3 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Horns	Presence	1 (5.3%)	2 (10.5%)	0 (0%)	1 (5.3%)	4 (21.1%)	11 (57.9%)
	absence	11 (20.0%)	21 (38.2%)	5 (9.1%)	12 (21.8%)	3 (5.5%)	3 (5.5%)
Wattles	Presence	2 (7.4%)	6 (22.2%)	0 (0%)	5 (18.5%)	1 (3.7%)	13 (48.1%)
	absence	10 (21.3%)	17 (36.2%)	5 (10.6%)	8 (17%)	6 (12.8%)	1 (2.1%)
Blue spots on the tongue	Presence	11 (21.2%)	8 (15. 4%)	5 (9.6%)	11 (21.2%)	6 (11.5%)	11 (21.2%)
	absence	1 (4.5%)	15 (68.2%)	0 (0%)	2 (9.1%)	1 (4.5%)	3 (13.6%)
Fleece	Invasive	0 (0%)	9 (33.3%)	0 (0%)	1 (3.7%)	6 (22.2%)	11 (40.7%)
	Semi-invasive	12 (29.3%)	14 (34.1%)	5 (12.2%)	6 (14.6%)	1 (2.4%)	3 (7.3%)
	No invasive	0 (0%)	0 (0%)	0 (0%)	6 (100%)	0 (0%)	0 (0%)
Cephalic profile	Hooked	12 (22.2%)	9 (16.7%)	5 (9.3 %)	13 (24.1%)	1 (1.9%)	14 (25.9%)
	Slightly hooked	0 (0%)	14 (70%)	0 (0%)	0 (0%)	6 (30%)	0 (0%)

Class 04: The animals in this class (13 individuals) have a tricolour head (86.7% of individuals); pigmented skin (50.0%); knee, pastern and hock that are white or black with an absence of horns. Wattles are present (21.1%) or absent but the blue spots on the tongue are present. The cephalic profile is hooked and the fleece is semi-invasive.

Class 05: The animals of this class (07 individuals) have a black head (18.9%), pigmented skin (43.8%); black hock (20.7%), black pastern (29.4%) and black knee (24.1%). The horns are either present or absent, the blue spots on the tongue are present (11.5%) but the wattles are absent (12.8%). These animals have a slightly hooked cephalic profile (30%) and an invasive fleece (22.2%).

Class 06: Animals of this class (14 individuals, all of them are a part of the Tazegzawt population) have a black head (37.8% of individuals), white skin, a white shank, pastern and knee, a hooked cephalic profile and an invasive fleece, blue tongue spots and wattles are present. 57.9 % of animals of this class have horns.

Molecular study

The genetic diversity parameters were calculated for each sheep population (Table 12) using 15 microsatellites loci.

Table 12: Genetic diversity measures for Tazegzawt and El Ham sheep populations.

Population	Tazegzawt		EL Ham	
	Mean	SE	Mean	SE
Mean number of Alleles	13.667	0.779	5.867	0.236
Na Freq. ≥ 5%	6.467	0.446	5.867	0.236
Effective Alleles	7.650	0.775	4.758	0.273
Information Index	2.236	0.081	1.642	0.047
No. Private Alleles	8.933	0.740	1.133	0.236
No. Lcomm Alleles (≤25%)	0.000	0.000	0.000	0.000
No. Lcomm Alleles (≤50%)	0.000	0.000	0.000	0.000
Observed Heterozygosity (Ho)	0.832	0.028	0.847	0.040
Expected Heterozygosity (H_e)	0.848	0.016	0.780	0.013
Uhe	0.866	0.016	0.870	0.014
F_{IS}	0.037		0.019	
Fixation Index	0.018	0.032	-0.091	0.056
number of loci not in the HWE ($p < 0.05$)	1		ns	

The highest and lowest allele number values, effective allele, information index and number of private alleles were seen in Tazegzawt and EL Ham sheep populations respectively. Tazegzawt sheep population showed the highest values in terms of mean expected heterozygosity. It has been determined that not all of the studied loci in EL Ham sheep population are in the HW equilibrium. But it is not the case about the microsatellite loci in Tazegzawt sheep population. All F_{is} values are positive, which are an important parameter in defining the population structure and indicating the loss of heterozygosity, and they are 0.037 and 0.019 for Tazegzawt and EL Ham population respectively. While, the Nei genetic distance was calculated by pairwise population matrix and F_{st} values (Table 13). The assignment Outcome was also done to 'self' or 'other' population (Table 14).

Table13. Pairwise Population Matrix of Nei Genetic Distance above and Fst Values below diagonal

Tazegzawt	EL Ham	
0.042	0.000	**EL Ham**
0.000	0.479	**Tazegzawt**

Table14: Summary of Population Assignment Outcomes to 'Self' or 'Other' Population (With Leave One Out Option)

Population	Self-Pop	Other Pop
Tazegzawt	25	
EL Ham	3	2
Total	28	2
Percent	**93%**	**7%**

The ranking of the overall diversity of all sheep populations in the present study was carried out by AMOVA and Shannon Information (sH) (Figure 10 A and B). The result showed that the percentage of variation between the populations obtained is 7% and between the individuals within these groups. It is 2% on the other hand. The great variation is recorded within the individuals, it is 91%. This result means that overall diversity is mainly due to the diversity between individuals rather within populations. The Shannon Information (sH) whose variation is within and not between populations also shows this. Table15 shows that there is an average genetic distance between the two breeds studied, as well as a slight differentiation shown by the Fst value around 4.2%.

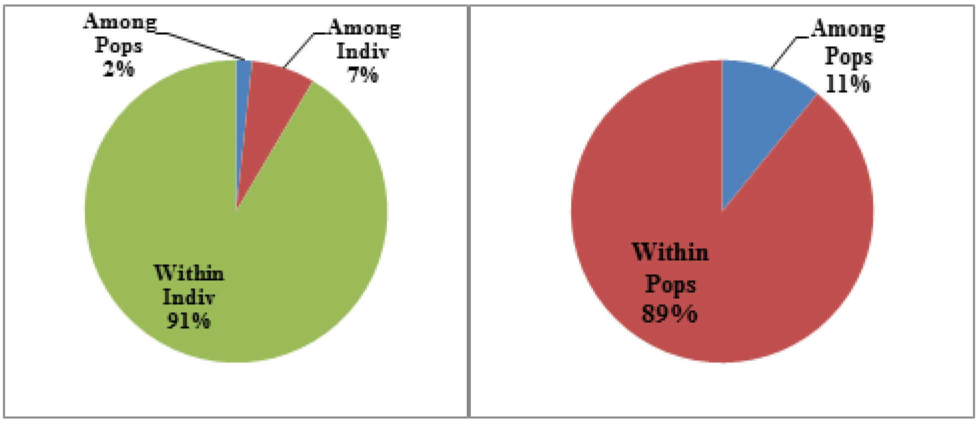

Figure 10. A. B. Shanon diversity informations (sH) using 15 microsatellites in the studied sheep populations.

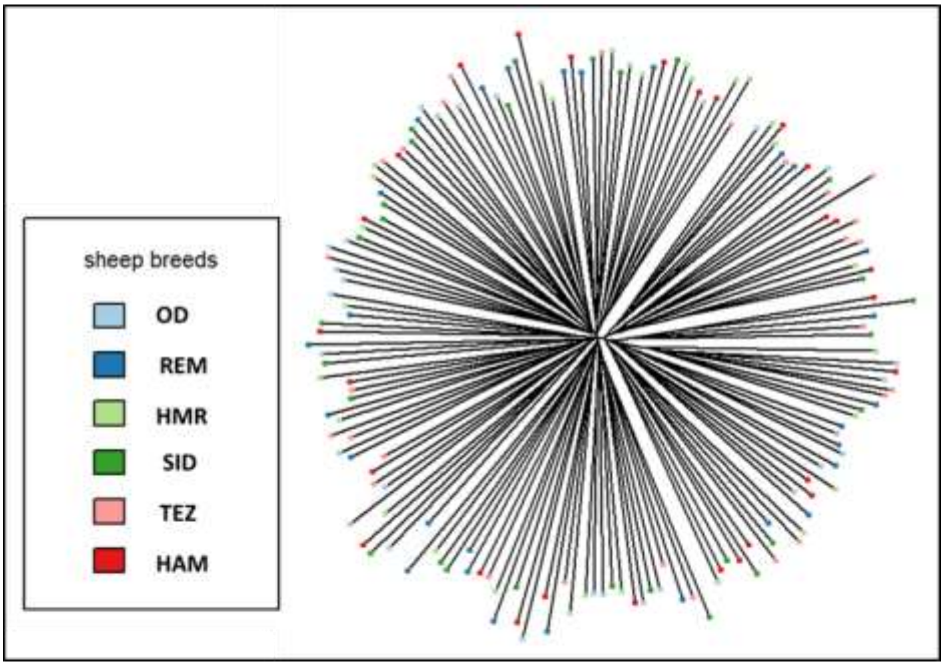

Figure11. Phylogenetic relationships among the individual sheep according to microsatellite genotypes. Plots represent individuals. OD : Ouled Djellal, REM : Rembi, HMR : Hamra, SID : Sidaou, HAM : Ham, TEZ : Tezagzewt.

DAPC scatter plots (Figure 12B) and barplot membership (Figure 12A) showed evidence of genetic admixture between EL Ham and Tazegzawt populations.

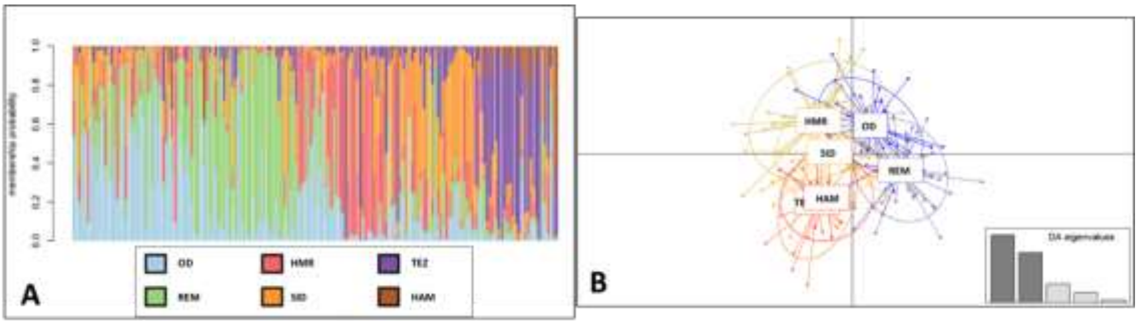

Figure 11. Discriminant analysis of principal components (DAPC) scatterplots (A) and membership probabilities (B) on microsatellite genotype data. Breeds are represented by different colours, and dots represent different individuals. OD: Ouled Djellal, REM: Rembi, HMR :Hamra, SID : Sidaou, HAM : Ham, TEZ : Tezagzewt

Discussion

Quantitative characters

According to El Bouyahiaoui (2017), the body conformation of the Tazegzawt population indicates good meat ability. The Tazegzawt population is tall and elongated, it has a wider pelvis and wider in front, a long and broad head and ears, perimeter of the barrel developed compared to the EL Ham population except that the latter has a chest more developed therefore it is more developed than that of other populations: Rembi, Srandi, Darâa, Barbarine, Hamra, Berbère and Ouled Djellal(Djaout *et al.,* 2015; Harkat *et al.,* 2015; Laoun *et al.,* 2015; Belharfi *et al.,* 2017; Afri-Bouzebda *et al.,*2018). The Ouled Djellal breed studied by Belharfi et al. (2017) presented a thoracic perimeter close to the Tazegzawt population herein and that studied by El Bouyahyaoui et al. (2021).

The measurements of two populations Tazegzawt and "El Ham are higher than the breeds Hamra, Berbère, Barbarine (Belharfi *et al.,* 2017; Afri-Bouzebda *et al.,* 2018) and Rembi studied by Djaout et al. (2015) and lower than these breeds.

The size of two populations studied "El Ham" and "Tazegzawt" are higher than the breeds: Hamra, Berbère, Barbarine(Belharfi *et al.,* 2017; Afri-Bouzebda *et al.,* 2018) and Rembi studied by Djaout *et al.* (2015) and lower than the Ouled Djellal breed (Belharfi *et al.,* 2017; Afri-Bouzebda *et al.,* 2018) but they are quite similar in height to those of Hamra, Srandi and EL Ham of Nâama (Belharfi *et al.,* 2017) and the Rembi breed reported by Laoun et al. (2015).

According to Djaout et al. (2017) in the Tlemcen region, breeders believe that the EL Ham breed is a variety of the Sardi or Srandi breed. The EL Ham and Tazegzawt populations studied perform better than the Sardi breed studied by Belharfi et al. (2017) except that the Sardi breed is longer (LSI: 81.33 ± 5.33 cm) than EL Ham.

The animals (Tazegzawt and EL Ham) perform better than other breeds such as Rembi, Darâa, Srandi, Hamra, Berbère and Barbarine (Djaout*et al.,* 2015; Laoun*et al.,* 2015; Belharfi *et al.,* 2017; Afri-Bouzebda *et al.,* 2018).

Males of the Tazegzawt population are tall and slender and they have a more developed chest, they have a longer and wider head and ears. They are wide in front, a wide pelvis compared to the males of the EL Ham population.

The females of the Tazegzawt population are slender, they have a longer and wider head and ears. They have a higher chest and a wider pelvis compared to the females of the EL Ham population.

This superiority of males to females has been observed in the Sardi breed (Chikhi and Boujenane, 2003); Ouled Djellal, Hamra, Barbarine and Rembi(Djaout *et al.,* 2015; Belharfi*et al.,* 2017; Djaout*et al.,* 2018a; AfriBouzebda *et al.,* 2018).

Qualitative characters

The Tazegzawt breed is called the blue in Kabyle and called EL Ham in the region of Mechria (Nâama). It presents bluish-black pigmentations in the eyes, with a white and semi-invasive fleece (Djaout *et al.* .2017). But our study shows that The Tazegzawt population presents a head of either black or tricolour magpie colour and white or black pastern and knee colour, The fleece is invasive and presence of horns and wattles in most animals with a hooked cephalic profile.

The results of the Tazegzawt population are comparable to those reported by (Hambli and Tazarat, 2003; El Bouyahiaoui *et al.,* 2015; Djaout*et al.,* 2017; Moula, 2018 ; El Bouyahyaoui *et al*,.2021); the males of this studied population have horns, while half of the males are clods as reported by El Bouyahiaoui *et al*. (2015).

The EL Ham population presents a head coloured in black or white (black or white). Tricolour or bicolour, pastern and knee colour are white, black or black magpie, the horns and the watteles are absent, with a semi-invasive fleece and an arched and slightly hooked cephalic profile in most of the animals studied.

Considering the lack of data on the phenotypic characterization of the EL Ham population. It should be noted that our results could not be discussed.

Molecular study

The parameters of genetic diversity such as the average number of alleles and the effective number of alleles in the Algerian Tazegzawt sheep population d compared to the data reported by AmeurAmeur et al. (2018) was considerably higher than the values of the Algerian sheep breeds Dâraa, Ifilène and Srandi and lower than the other breeds Ouled Djellal, Hamra, D'man, Sidaou, Rembi and Barbarine. On the other hand, the number of effective alleles of the sheep population studied EL Ham compared to the same data showed a low average number of alleles and effective number of alleles, which can be explained by the low number of this breed represented. in this study (Andru, 2012).

Private alleles are a source of genetic diversity (Petit et al., 1998); The number of private alleles of the Algerian Tazegzawt sheep population studied (8.933±0.740) is higher than that of the Algerian sheep breeds: (Hamra, D'man, Darâa, Tâadmit, Sidaou, Barbarine, Berbère, Sardi, Ifilène and Rembi) reported by AmeurAmeur et al. (2018). The Algerian sheep population EL Ham expressed a low frequency of private alleles (1.133±0.236). The low allelic frequencies indicate a low contribution of these alleles to the genetic variation. Moreover, the existence of numerous private alleles in a population demonstrates its originality (Fotsa, 2008).

The observed heterozygosity (0.832±0.028 and 0.847±0.040 for Tazegzawt and EL Ham respectively) and the expected heterozygosity (0.848±0.016 and 0.780±0.013 for Tazegzawt and EL Ham respectively) show that in the together the breeds studied show significant genetic diversity for the 15 microsatellites studied.

The average heterozygosity of these two local Algerian sheep populations (Ho: 0.832±0.028 and 0.847±0.040; He: 0.848±0.016 and 0.780±0.013; Uhe: 0.866±0.016 and 0.870±0.014 for Tazegzawt and EL Ham respectively) are close to the values of the heterozygosity rates of Algerian sheep breeds (Ouled Djellal, Hamra, Tazegzawt, D'man, Darâa, Tâadmit, Si-daou, Barbarine, Berbère, Sardi, Ifilène, Rembi) reported by AmeurAmeur et al. (2018) with 15 microsatellites; higher than those reported in Turkish breeds (Yilmaz et al., 2014); Tunisian breeds (Ben Sassi-Zaidy et al., 2014) with 17 microsatellites and Kdidi et al. (2015) ; Moroccan breeds (Gaouar et al., 2016a); Algerian breeds (Gaouar et al., 2015 b; Gaouar et al., 2016 b); Greek breeds (Loukovitis et al., 2016) with 11 markers and Egyptian breeds (Othman et al., 2016) with 22 microsatellites. A high level of heterozygosity observed may be explained by the high homogenization and uncontrolled crossings observed in herds in Algeria (Gaouar, 2002; Gaouar, 2009).

The two populations (Tazegzawt and EL Ham) present a positive fixation index (FIS) (greater than 0). The F_{IS} value of two studied sheep populations (0.037 and 0.019 for Tazegzawt and EL Ham respectively) is lower than that of the Tazegzawt breed (0.07) studied by EL Bouyahiaoui, (2017) by SNP markers and lower than reported values by Gaouar et al (2015a) in the Hamra, Tâadmit (0.05) and D'man (0.06) breeds, by Ciani et al. (2013) in the Italian Leccese breed (0.05), by Hoda et al. (2009) in

Albanian sheep breeds (0.061). The FIS value of the Tazegzawt population in our study is comparable to those obtained in the Greek sheep breeds Boutsiko and Thessaly (0.031; 0.034 respectively) reported by Loukovitis et al. (2016) and the value of F_{IS} in the Icelandic sheep breed KRK PRAMENKA (0.034) by Salamon et al. (2012). The F_{IS} value of the EL Ham population studied is comparable to the F_{IS} value reported by Ocampo et al. (2016) in the Colombian Corriedale breed (0.01). The value of the F_{IS} estimate in the two sheep populations studied is lower than that of the Spanish Lojeña breed (0.104) reported by Pablo et al. (2013); the Romanian Tsigai sheep population (0.0981) by Zahan et al. (2011), fine-tailed and fat-tailed Tunisian breeds (0.112) by Ben Sassi-Zaidy et al. (2014) ; of the Brazilian breed Morada Nova (0.166) by Ferreira et al. (2014) and that of Moroccan breeds Boudjaâd, D'man and Beni Guil (0.165; 0.163 and 0.132; respectively) by Gaouar et al. (2016a) using 22 microsatellite markers.

Figure 10 and Figure 11 revealed the high genetic admixture between the studied breeds but this admixture is very interesting between EL Ham and Tezagzewt. These two breeds seem to be superposed in the Figure 11 B suggesting that these populations were the result of recent mating between individuals belonging to the same Breed. The results can be explained also by retention of shared ancestral polymorphisms.

Conclusion

According to our morphometric study, the Tazegzawt population studied has a bigger format than EL Ham population, which is less tall and less slender compared to the first,and these two populations have a better meat conformation. The phenotypic characterization shows that these populations differ from each other mainly for the presence of wattles (dominant character in the Tazegzawt breed) which are absent in most EL Ham animals. However, both populations have blue spots on the tongue

Molecular characterization using a 15 set of microsatellite markers showed that there is an average genetic distance between the two breeds, as well as a slight differentiation shown by the Fst value around 4.2%. As the phenotypic characteristics and on the individual level we note that the two populations have a very high heterogeneity. However, the two sheep breeds are slightly different from each other.

This morphometric difference between these lesser-known sheep requires extensive phenotypic, genotypic and zootechnical characterization in greater numbers to establish a breed standard.

We therefore conclude that the two populations belong to the same breed and that the morphometric differences observed are due to the adaptation and the breeding system applied in the different regions.

Acknowledgment

The authors thanks ovine breeders for providing samples.

Author's Contributions

F.Z. Belharfi: morphometric sampling and Drafting the article
N. Tabet-Aoul : translation of the article
R. El-Bouyahyaoui, H. Ainseba, D. Hadjmohammed: morphometric sampling
A. Djaout S. Kdidi : Statistics
A. Ameur Ameur : Molecular part
S.B.S. Gaouar : Corrections

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