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Morphological characterization of sheep in Djelfa province (Algeria)

Caracterización morfológica de ovejas en la provincia de Djelfa (Argelia)

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ABSTRACT

The morphological characterization of animal genetic resources is a fundamental approach to ensure food security in developing countries. The objective of this study was to morphologically characterize the sheep of the Djelfa province, a prominent region in sheep farming in Algeria. After evaluating 396 sheep, including 32 rams, and analyzing 34 parameters, including 19 quantitative ones, it was found that sheep in this region are characterized by their white color, with hind limbs spotted in fawn, pigmentation around the nostrils, and drooping ears not exceeding the labial commissures, as well as a fine, long tail extending beyond the hock. The ewes are characterized by a long and eumetric body shape, with a subconcave to straight profile along the dorsal line, and a semi-invading fleece with pigmentation around the udder. Rams, on the other hand, are horned, hypermetric in body shape, with a straight profile of the muzzle, and an invading fleece with pigmentation around the scrotum and prepuce. Analysis of quantitative data by PCA and Hierarchical Cluster Analysis (HCA) revealed the presence of a small-sized group in the Western regions of Djelfa and a large-sized group in the Eastern regions. This morphological diversity results from the complex interaction of biological, environmental, and economic factors.

Key words: Sheep; morphological trait; PCA analysis; Djelfa

RESUMEN

La caracterización morfológica de los recursos genéticos animales es un enfoque fundamental para garantizar la seguridad alimentaria en los países en desarrollo. El objetivo de este estudio fue caracterizar morfológicamente las ovejas de la provincia de Djelfa, una región destacada en la ganadería ovina en Argelia. Después de evaluar 396 ovejas, incluidos 32 carneros, y analizar 34 parámetros, incluidos 19 cuantitativos, Se encontró que las ovejas de esta región se caracterizan por su color blanco, con miembros posteriores manchados de color leonado, pigmentación alrededor de las fosas nasales y orejas caídas que no sobrepasan las comisuras labiales, así como una cola fina y larga que se extiende más allá del corvejón. Las ovejas se caracterizan por una forma corporal larga y eumétrica, con un perfil subcóncavo a recto a lo largo de la línea dorsal y un vellón semi-invasor con pigmentación alrededor de la ubre. Los carneros, por otro lado, tienen cuernos, forma corporal hipermétrica, con un perfil recto del hocico y un vellón invasor con pigmentación alrededor del escroto y el prepucio. El análisis de datos cuantitativos mediante PCA y análisis de conglomerados jerárquicos (HCA) reveló la presencia de un grupo de tamaño pequeño en las regiones occidentales de Djelfa y un grupo de tamaño grande en las regiones orientales. Esta diversidad morfológica es resultado de la compleja interacción de factores biológicos, ambientales y económicos.

Palabras clave: Oveja; caracteres morfológicos; Análisis PCA ; Djelfa

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INTRODUCTION

The diversity of livestock genetic resources is vital for food security, requiring prevention of genetic dilution to maintain adaptability to climate change and diseases. Characterization of genetic resources is essential for conservation and can be morphological, genetic, or historical [1]. Morphological characterization details external traits and performance within specific contexts, especially important in developing countries. Molecular genetic characterization evaluates genetic diversity through proteins and desoxyribonucleic acid (DNA), offering high precision but needing significant resources [2]. Historical characterization explores the origins and evolution of genetic resources to aid sustainable conservation strategies. Both morphological and genetic approaches are complementary [3].

In Algeria, sheep (*Ovis aries*) farming is predominant in the steppe region, representing about 80% of animal production with around 20 million sheep, contributing over 50% of national red meat output. Eight sheep breeds are adapted to local conditions, with the Ouled-Djellal breed being particularly favored for its productivity and adaptability, notably in the central and eastern steppes, especially in Djelfa province [4]. Djelfa Province is a key area for sheep farming and meat supply. This study aims to characterize sheep in Djelfa using both quantitative and qualitative morphological traits according to the Food and Agriculture Organization of the United Nations (FAO) guidelines and identify any morphological differences within the breed.

MATERIALS AND METHODS

Study area

This study was conducted in four municipalities in Djelfa Province: Aïn Oussera (AO), Birine (BR), Hassi Bahbah (HB), and Sidi Ladjel (SL). These areas are located between 650 m and 850 m above sea level, are central to the Algerian steppe and play a crucial role in sheep and merchandise transit. Livestock farming is the main income source, with 85% of the area being steppe-grazing lands. Djelfa, along with the studied municipalities, is renowned for sheep farming and hosts the largest livestock markets [5]. The region's climate is semi-arid with cool winters. The hottest month is July with an average maximum temperature of 36.9°C, while January is the coldest with an average minimum of 1.3°C. The rainy season lasts from September to May, and the dry season from June to August. Frost occurs between November and March, peaking in January. Hot summer winds, "Sirocco," prevail, averaging 3.4 $m \cdot s^{-1}$ [6].

The soil is mainly limestone with good soil found in depressions. Vegetation includes Aleppo pines, grasses like Alfa and sparte, *Chamaephytes* on slopes, and saline soil plants such as *Atriplex halimus* and *Salsola vermiculata* [6]. Livestock management of sheep in Algeria is typically classified into two categories based on mobility: sedentary or semi-sedentary systems, which utilize pastures within 50 km, and transhumant systems, characterized by movements of over 50 km that vary depending on the season. Djelfa breeders generally prefer provinces in central and eastern Algeria, such as Médéa, Bouira, Bordj Bou Arreridj, and Sétif [4, 5].

Animal sampling

The study was conducted on a total of 396 Ouled Djellal breed sheep, including 32 rams, spread across 10 farms ranging in size from 72 to 612 heads and covering five municipalities in different areas: Aïn Oussera, Birine, Hassi Bahbah, and Sidi Laadjel; the sample size ranged from 32 to 55 heads per farm. The phenotyping to individuals was restricted at least 24 months old and non-pregnant ewes; 24 months marks the point at which sheep cease to grow [7]. Age determination was conducted through dental examination using the method outlined by Wilson and Durkin [8].

Morphological Characterization

Morphological characterization involves the assessment of 34 parameters, including 19 quantitative and 15 qualitative ones (TABLE I, TABLE II), following FAO recommendations [1].

For the assessment of quantitative parameters, the following metric tools were used in addition to a 150 kg First Kamer electronic scale from France: a 150 mm Tiah digital caliper and a 150 cm tape measure from China. In addition, a wooden measuring stick and a palette composed of colored and coded leaves grouped in an improvised fan from Algeria were used.

Statistical analyses

Data obtained was submitted to separate descriptive statistical analyses for both sexes. For quantitative data, means, standard deviations (SD), minimums (Min), maximums (Max), and standard

TABLE I
Quantitative parameters for morphological characterization of Algerian sheep in Djelfa province

Parameter	Symbol	Definition
Body Weight[1]	BdW	Live weight
Head Length[2]	HdL	Distance between the upper limit of the forehead to the tip of the nose
Head Width[4]	HdW	Maximum distance between zygomatic arches
Ear Length[2]	ErL	Distance from the base to the tip of the right ear, along the dorsal surface
Ear Width[2]	ErW	Taken at the middle of the ear, on the outer side.
Neck Length[2]	NkL	Distance from the throat to the tip of the shoulder in the medium
Trunk length[3]	TrL	Measured from the tip of the shoulder to the tip of the hip.
Body Length[2]	BdL	Taken from the base of the head to the base of the tail.
Chest Width[3]	ChW	Maximum intercostal diameter at the level of the 6th rib, just behind the elbows
Rump Length[3]	RpL	Distance from hip to pin
Rump Width[3]	RpW	Maximum distance between left and right hurls
Ischium Width[3]	IsW	Distance between Ischia
Chest Girth[2]	ChG	Perimeter of the chest at the level of the 6th rib
Chest Depth[3]	ChD	Vertical distance from the top of the withers to the xyfoid process of the sternum
Wither Height[3]	WtH	Height from the top of the withers to the ground
Back height[3]	BkH	Back height taken at the middle of the back to the ground
Sacrum height[3]	ScH	Measured from the highest point of the sacrum down to the bottom of the hoof
Cannon Perimeter[2]	CnP	Perimeter of the right foreleg, between the knee and the pastern
Tail Length[2]	TaL	Distance from the root of the tail to the tip

The numbers indicate the measuring tools: [1]: Portable electronic scales, [2]: Metric tapes, [3]: Measuring stick, [4]: Caliper. All the variables are taken in cm except the Body Weight, which is taken in kg

TABLE II
Qualitative parameters for morphological characterization of Algerian sheep in Djelfa province

Parameter	Symbol	Parameter classes
Horn Presence	HP	Present, Absent
Horn Shape	HS	Polled, Stumps, Curved, Spiral
Horn Orientation	HO	Polled, Stumps, Laterally
Ear Length	EL	Short, Medium, Long (relatively to labial commissure)
Ear Shape	ES	Erect, Semi–horizontal, Drooping
Face Profile	FP	Straight, Convex, Ultra convex
Tail Length	TL	Short (above the hocks), Medium (about the hocks), Long (below the hocks)
Tail Texture	TT	Fine, Greasy
Fleece Extente	FE	Invasive, Semi–invasive, Not invasive
Wattles	Wls	Present, Absent
Back Profile	BP	Straight, Sub–Concave
Head Colour	HC	White, White and Fawn
Fleece Colour	FC	Off–white (OW), White Chalk (WC), Pale Yellow (PY)
Limb Colour	LC	White, White and fawn
Body Skin Colour	BSC	Pigmented, Non–pigmented

errors (SE) were calculated. For qualitative data, the percentages of categories were determined. These analyses were performed using Excel 2013. Additionally, multivariate descriptive analyses were conducted to explore the formation of heterogeneous groups among the sheep in this region. Principal Component Analysis (PCA) was performed on quantitative data, and hierarchical clustering was conducted using the "ward.D2" method after centering and scaling the data. Initially, the number of clusters (k) was set to 4, representing the regions, and then adjusted it based on the average silhouette index to determine the optimal number of clusters. All statistical analyses and visualizations were carried out using R software version 4.3.3 [9].

RESULTS AND DISCUSSION

Univariate Descriptive Analysis

The results of the qualitative data are presented in TABLE III.

The predominant color in both sexes is light white, representing more than 50% of cases. Ewes are distinguished by hind limbs spotted with fawn in approximately 50% of cases. The fleece is mainly semi–invading in ewes, reaching approximately 75%, while it is both invading and semi–invading in rams, representing approximately 50% each. Sheep in this region have a thin tail that extends beyond the hock level in 100% of cases and do not possess wattles. The back silhouette is sub–concave in approximately 70% of cases for both sexes, but at the head level, it is arched in rams in about 90% of cases and slightly arched or straight in ewes in about 80% of cases. Ears droop in over 90% of cases and are short, not extending beyond the labial commissures in about 70% of cases. Horns are present in rams and absent in ewes, in over 95% of cases for both sexes.

The Algerian steppe, often termed as "sheep country," is primarily dedicated to sheep farming [10]. This farming practice plays a crucial role in supplying red meat to major urban areas in Algeria [6, 11]. The predominant breed in this region is the Ouled–Djellal. While debates persist about its origin, it remains one of the oldest and most significant breeds in Algeria, having evolved over centuries through

TABLE III
Statistics for qualitative parameters for morphological characterization of Algerian sheep in Djelfa province, according to sex

Parameter	Modalities	Rams	Ewes
HP	Absent	3.13%	95.59%
	Present	96.88%	4.41%
HS	Curved	0%	1.38%
	Polled	6.26%	96.70%
HO	Stumps	65.63%	1.65%
	Spiral	28.13%	0.28%
	Laterally	28.13%	1.38%
	Polled	3.13%	96.69%
ES	Stumps	68.75%	1.93%
	Semi–horizontal	3.13%	7.44%
	Drooping	96.88%	92.56%
EL	Long	3.13%	10.74%
	Medium	25.00%	27.27%
	Short	71.88%	61.98%
FP	Convex	90.88%	83.79%
	Ultra convex	3.13%	0%
	Straight	0%	16.53%
TL	Long	68.75%	45.18%
	Short	0%	11.57%
	Medium	31.25%	43.25%
TT	Fine	100%	100%
	Greasy	0%	0%
FE	Invasive	43.75%	8.54%
	Not invasive	0%	9.09%
	Semi–invasive	56.25%	82.37%
WLs	Absent	100.00%	97.52%
	Present	0%	2.48%
BP	Straight	37.50%	28.37%
	Sub–Concave	62.50%	71.63%
HC	White	96.88%	96.42%
	White and Fawn	3.13%	3.58%
FC	Off–white	62.50%	50.14%
	White Chalk	12.50%	26.99%
	Pale Yellow	25.00%	22.87%
LC	White	84.38%	51.79%
	White and Fawn	15.62%	48.21%
BSC	Non–pigmented	0%	3.58%
	Pigmented	100.00%	96.42%

natural selection and traditional breeding practices, endowing it with remarkable adaptability [12]. Sheep in this area are typically white, with variations in shade depending on the breeding and environmental conditions, although these variations are minimal. Our findings support previous conclusions by Chellig [4], Khelifi [13], and Djaout [14], who described these sheep as having white, non-evasive fleece, long and drooping ears, and a thin tail. They also noted that these characteristics are similar between males and females, with very slight differences. According to Craplet and Thibier [7], sweat glands produce fluids that, combined with foreign particles, can slightly influence the intensity of fleece color, although this modification is temporary. All authors working on phenotypic diversity, like Chellig [4], Khelifi [13], and Djaout [14], agree that sheep in Algeria are characterized by a thin-tailed breed, while the fat-tailed sheep only exist in Tunisia, Libya, and the Middle East in arid regions.

The quantitative data findings are shown in TABLE IV, delineating distinct characteristics between the sexes across most parameters. Rams exhibit an average weight of 94.16 kg, categorizing them as hypermetric, while ewes have an average weight of 58.47 kg, hence classified as eumetric. Both sexes have slender heads, with HdL/HdW ratios of 2.46 for rams and 2.47 for ewes. Ear length is relatively consistent across sexes, averaging around 17 cm, although rams have slightly broader ears. Rams also possess longer necks compared to ewes; measuring 38.28 cm versus 34.70 cm. Body length is roughly three times greater than width, with TrL/ChW and TrL/RpW ratios of 3.31 and 3.51 for rams, and 3.48 and 3.54 for ewes. Both sexes have long, somewhat slender legs, with estimated heights of around 80 cm for ewes and approximately 90 cm for rams, alongside a cannon circumference of roughly 9 cm. Rams have a longer hip structure relative to width compared to ewes, with RpW/RpL ratios of 0.80 and 0.90, respectively. Finally, there is a minor discrepancy in tail length between the sexes, measuring 50.72 cm for rams and 43.42 cm for ewes.

The findings support those of Traoré [15], Laoun *et al.* [16], and Harkat *et al.* [17], which indicate that males are generally heavier and exhibit superior morphological parameters compared to females beyond the growth stage, except for ear measurements (ErL and ErW), which are similar ($P>0.05$). Chellig [4] and Djaout [14] describe that sheep in this region are distinguished by two varieties: heavy and light. The heavy varieties are larger, while the light variety is smaller and predominates in the eastern region of the central steppe. These observations are based solely on direct observations and morphological measurements and are not inferential.

Principal Components Analysis (PCA)

The correlation matrix for the ewes shows that all correlation coefficients are positive (FIG. 1).

Various strengths of correlation are observed, ranging from very strong (r = 0.80 to 0.99) between BkH and ScH, indicating high correlation, to weak correlations (0.10 < r < 0.39). Bartlett's test results indicate a significant departure of the correlation matrix from the identity matrix, with a highly significant p-value ($P<0.05$). Thus, we reject the null hypothesis and confirm the suitability of Principal Component Analysis (PCA) for exploring the data structure. The Kaiser-Meyer-Olkin (KMO) coefficient of 0.92 and Measures of Sampling Adequacy (MSA) for each variable (ranging from 0.82 to 0.97) demonstrate very good sampling adequacy, indicating that each variable significantly contributes to the data structure and is suitable for factor analysis. The Kaiser-Guttman test and the elbow

TABLE IV
Statistics for quantitative parameters for morphological characterization of Algerian sheep in Djelfa province, according to sex

Parameter	Ewes			Rams		
	M	SD	SE	M	SD	SE
BdW	58.47	13.69	0.72	94.16	17.95	3.17
HdL	24.19	1.51	0.08	28.05	1.93	0.34
HdW	9.83	1.03	0.05	11.56	0.89	0.16
ErL	17.60	1.91	0.10	17.31	1.99	0.35
ErW	8.85	0.82	0.04	9.46	0.74	0.13
NkL	34.70	4.15	0.22	38.28	4.14	0.73
TrL	74.29	5.26	0.28	84.98	5.97	1.05
BdL	115.27	8.63	0.45	127.80	10.53	1.86
ChW	21.33	3.27	0.17	26.02	3.97	0.70
RpL	24.50	3.08	0.16	29.16	4.70	0.83
RpW	21.04	2.66	0.14	24.41	3.04	0.54
IsW	19.04	2.47	0.13	20.94	3.14	0.56
ChG	97.08	10.12	0.53	114.08	8.55	1.51
ChD	36.56	2.52	0.13	42.69	3.87	0.68
WtH	80.60	5.52	0.29	92.39	4.68	0.83
BkH	78.00	3.55	0.19	87.97	4.31	0.76
ScH	79.23	3.76	0.20	89.27	4.23	0.75
CnP	8.54	0.67	0.03	10.36	0.80	0.14
TaL	43.20	6.16	0.32	50.72	6.50	1.15

M: Mean, SD: Standard Deviation, SE: Standard Error

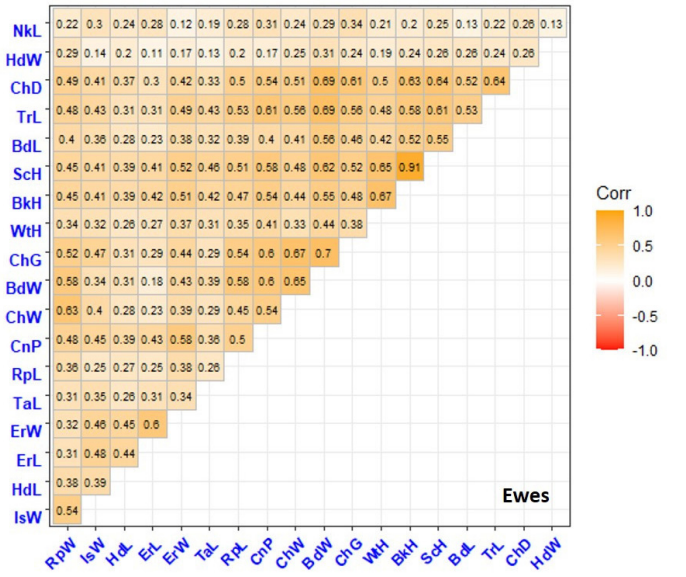

FIGURE 1. Correlation matrix for quantitative traits on ewe morphological data of Algerian sheep in Djelfa province

method suggest selecting two components. These two components collectively explain 53% of the variance, with the first component explaining 45% and the second approximately 8%. Together, they offer a substantial understanding of the data structure.

The variables BdW, ScH, TrL, ChD, BkH, ChG, ErW, CnP, and ChW show notable characteristics with elevated cos^2 values, indicating strong correlation and contribution with the primary component. Conversely, the variable ErL demonstrates significant correlation and contribution with the second component (FIG. 2). In contrast, variables NkL, HdW, and TaL exhibit poor representation across both components ($cos^2 \leq 0.30$).

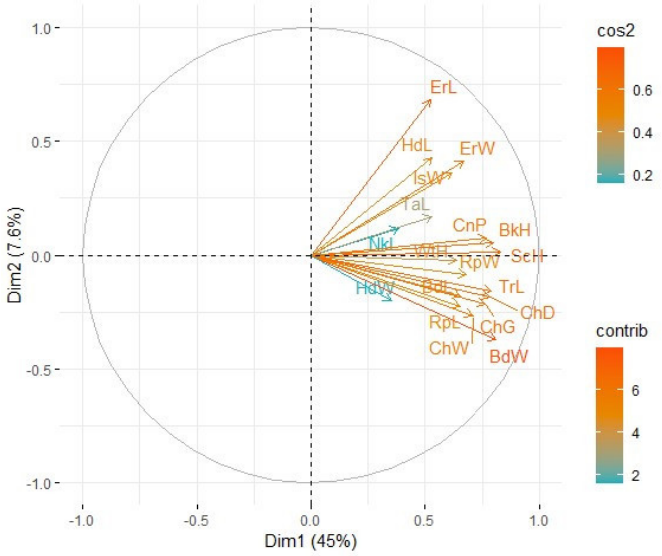

FIGURE 2. Correlation circle showing the correlation (cos^2) and contribution (contrib) of variables for ewes

The biplot demonstrates a clear distinction between two clusters of individuals (FIG. 3).

One cluster comprises individuals with significant stature and weight, mainly from Birine (BR) and Hassi Bahbah (HB), correlating with larger and heavier morphological traits. Conversely, the other cluster consists of smaller individuals in terms of stature and weight, primarily from Sidi Ladjal (SL) and Aïn Oussera (AO), associated with smaller and lighter morphological characteristics. Notably, individuals from both clusters exhibit both long and short ears, which does not correspond to regional distribution. This separation suggests substantial differentiation between the two groups based on overall morphological traits.

The correlation analysis for rams data reveals varying degrees of correlation among different variables (FIG. 4).

Strong to very strong positive correlations ($0.60 < r < 0.99$) are evident, such as between BdW and ChG ($r = 0.83$), indicating significant associations. Additionally, moderate positive correlations ($0.40 < r < 0.59$) are observed, for instance, between ChW and RpL ($r = 0.58$), suggesting relevant but less intense relationships. Conversely,

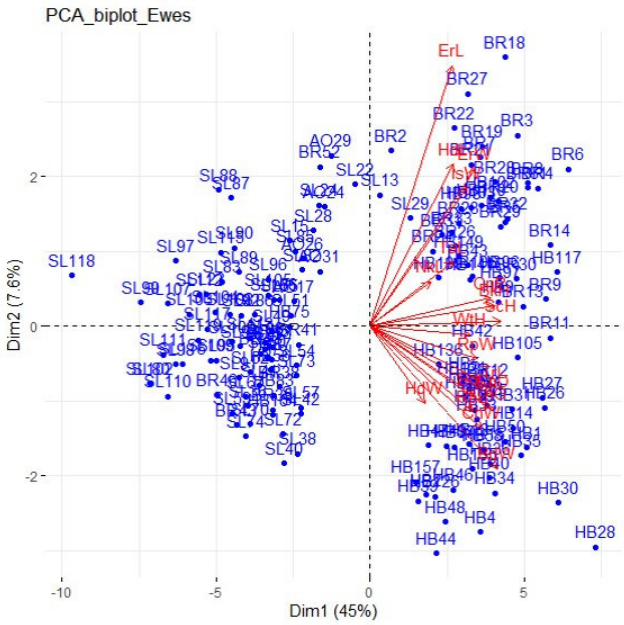

FIGURE 3. PCA biplots for ewes

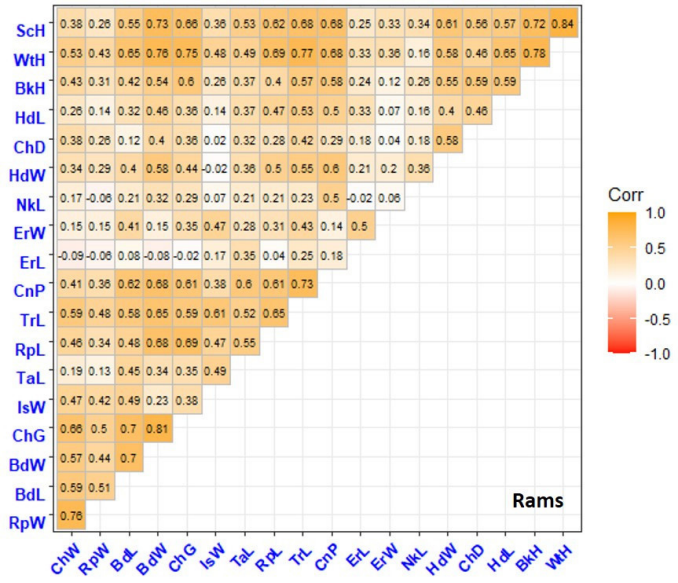

FIGURE 4. Correlation matrix for quantitative traits on ram morphological data of Algerian sheep in Djelfa province

weak to very weak positive correlations ($0.1 < r < 0.39$) are noted, including between NkL and TrL ($r = 0.21$), indicating less pronounced connections. Furthermore, a few practically weak correlations, both positive and negative ($-0.09 < r < 0.09$), such as between BdW and ErL ($r = -0.09$), highlight weaker yet present relationships. These findings support the utilization of PCA for revealing underlying data structures, as Bartlett's test yields a very low p-value ($P<0.05$), justifying the rejection of the null hypothesis H_0 The overall Kaiser–Meyer–Olkin (KMO) coefficient, indicating the sampling adequacy for

Principal Component Analysis (PCA), is 0.66, suggesting a good fit for the analysis. Most variables have KMO values ranging from 0.59 to 0.92, indicating their significant contribution to the data structure and suitability for factor analysis. However, variables ErL, ErW, and bkL exhibit lower contributions, with KMO values ranging from 0.30 to 0.45. The Kaiser–Guttman test, along with the elbow method, suggests two components, explaining approximately 57% of the total variance. The first component captures around 47%, and the second component around 10%, providing insight into a substantial portion of the data structure.

According to the correlation circle, the majority of variables (BdW, HdL, HdW, TrL, ChW, BdL, RpL, RpW, IsW, ChG, ChD, BkH, CnP, and TaL) are well-correlated with the first principal component of the PCA, with r > 0.50 and a *P*-value < 0.05 (FIG. 5).

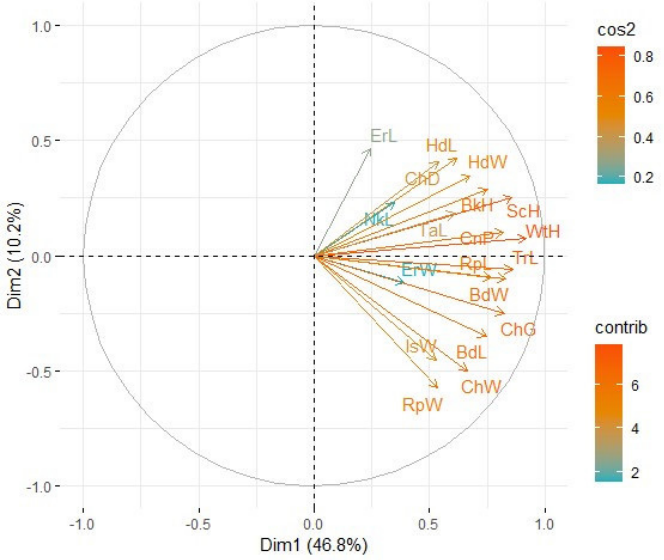

FIGURE 5. Correlation circle showing the correlation (cos^2) and contribution (contrib) of variables for rams

It is also observed that the variable RpW is correlated with the second component with r = -0.59 and a *P*-value < 0.05. However, the variables (ErL, NkL, ErW) are correlated with the third component with r > 0.50. In terms of contribution, the variables that contribute the most to the first component are BdW, TrL, and RpL, with contribution values of 8.414, 0.784, and 6.844 respectively. For the second component, the most contributive variables are ErL, HdL, and ChW, with contribution values of 11.456, 8.332, and 13.695 respectively (FIG. 5). The biplot highlights three distinct groups of individuals (FIG. 6). The first group, mainly represented by rams from Hassi Bahbah (HB), stands out due to their large size and high weight, suggesting significant morphological characteristics. The second group, composed of rams from Aïn Oussera (AO) and Birine (BR), exhibits average dimensions in terms of size and weight. Lastly, the third group, consisting of rams from Sidi Ladjal (SL), is characterized by smaller size and weight, indicating lighter morphological traits.

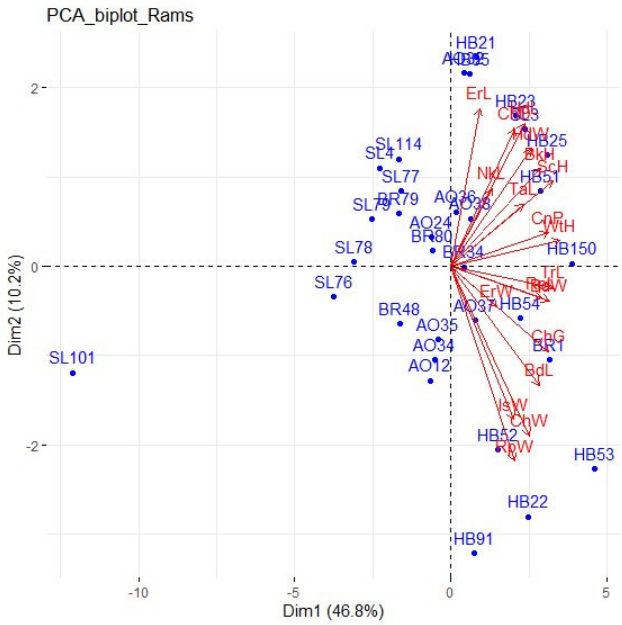

FIGURE 6. PCA biplots for rams

Hierarchical Cluster Analysis (HCA)

The results obtained from the analysis of dissimilarity among individuals, assessed using the average silhouette index, reveal a clear distinction between the groups. Indeed, after testing various configurations, the highest silhouette score is 0.35 for ewes and 0.36 for rams, both occurring at K=2 clusters (FIG. 7 and 8). In this configuration, two distinct groups of individuals were clearly identified. On one side, we observe a set of individuals characterized by their lightness and small size, primarily represented by sheep from the locales of Sidi Laadjel (SD) and Aïn Oussera (AO). On the other side, a group stands out with heavier and larger individuals, mainly from the locales of Birine (BR) and Hassi Bahbah (HB) (TABLE V and VI). The percentage of assignment to groups is shown in TABLE VII. Most ewes from Hassi Bahbah (HB) and Birine (BR) are placed in group 2, while those from Sidi–Ladjel (SD) and Aïn Oussera (AO) are mainly assigned to group 1. However, this pattern differs for rams; rams from HB are predominantly in group 2, while those from BR and SL are in group 1. Rams from AO show an even distribution across both groups.

From this standpoint, researchers like Chellig [4] and Djaout [14] have identified two distinct varieties within the Ouled-Djellal sheep breed: a large-sized type predominant in the eastern steppe, particularly in regions like M'sila, Biskra, and Sétif, and a small-sized variety more common in the central steppe, notably in Djelfa and Tiaret. These observations align with our study's findings in Djelfa province, where sheep are categorized into large and small types. The central and eastern parts of the province are mainly represented by large sheep varieties like Birine (BR) and Hassi Bahbah (HB), while smaller sheep types, such as those from Sidi Laadjel (SL) and Aïn Oussera (AO), are more prevalent in the west. It's interesting to note that Chellig [4] referred to the small-sized variety as the "Chellalia white breed", derived from its origin near Sidi Laadjel in Djelfa province, close to Ksar Chellala in Tiaret province.

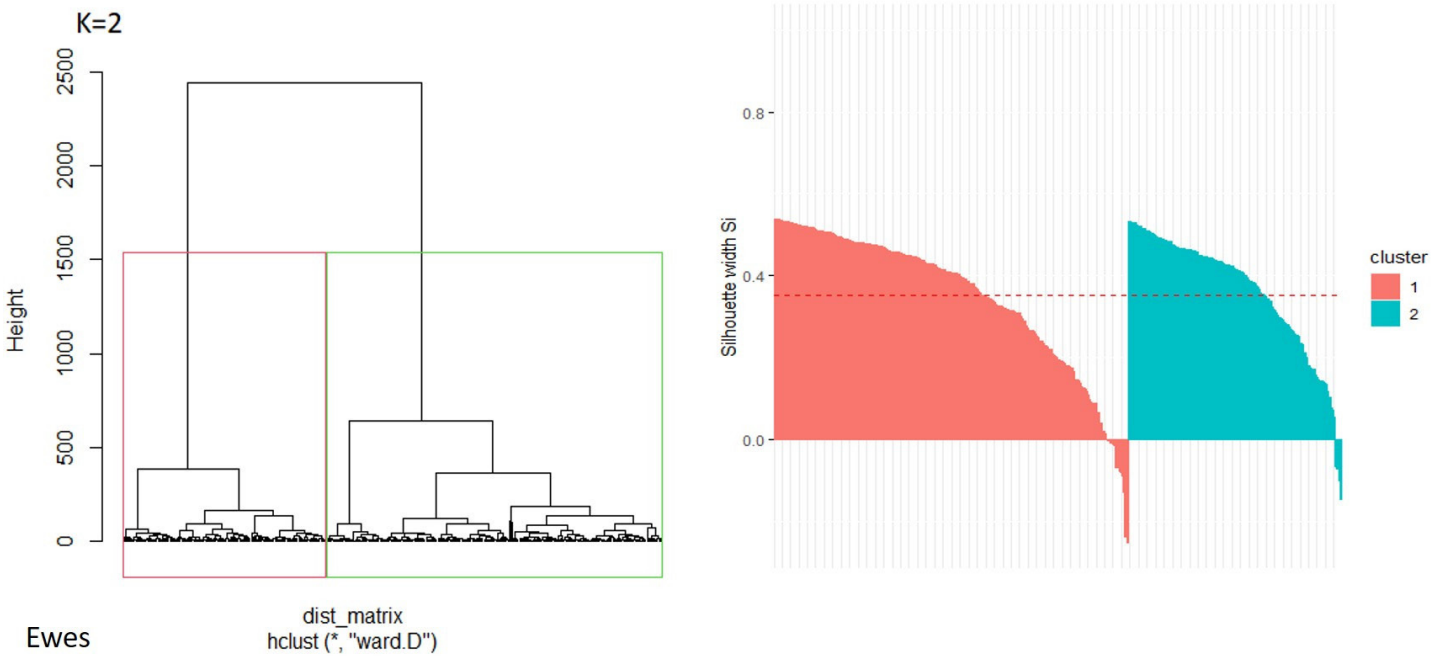

FIGURE 7. Dendrogram of Hierarchical Ascendant Classification (HAC) and silhouette index graph for ewes

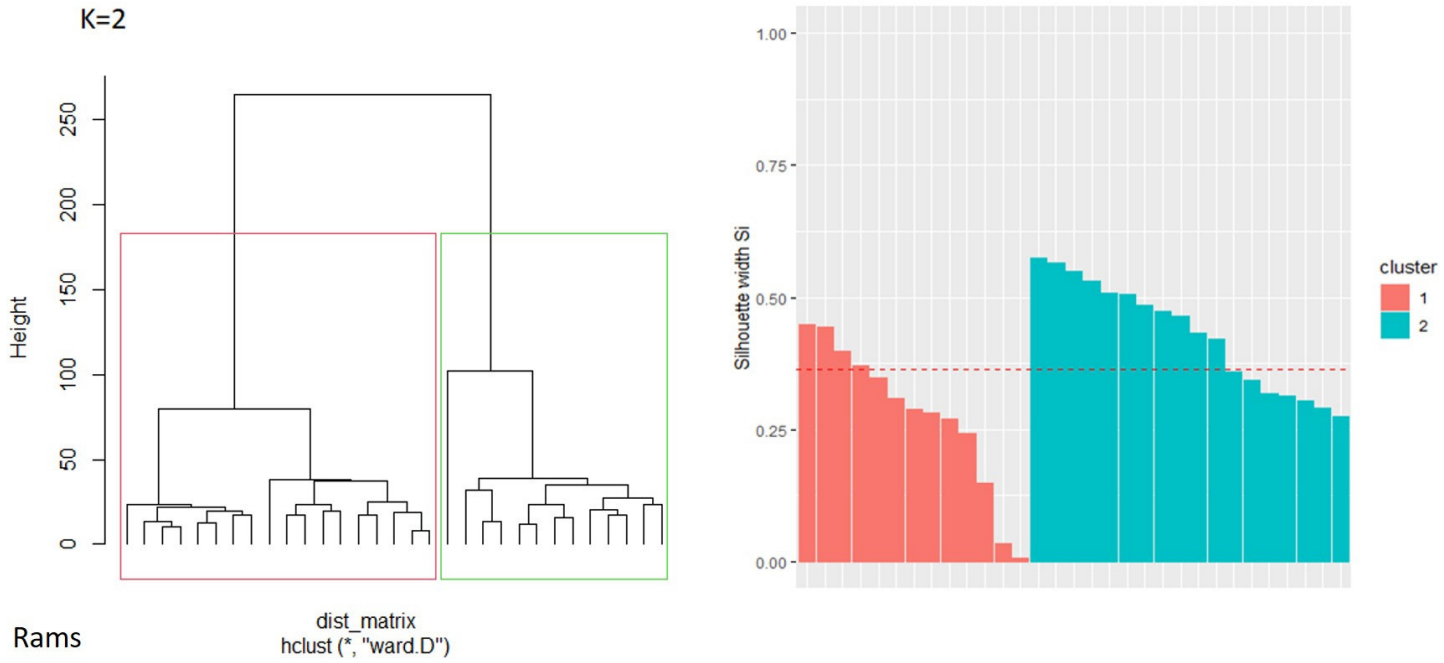

FIGURE 8. Dendrogram of hierarchical ascendant classification (HCA) and silhouette index graph for rams

Renard [18] emphasizes that the genetic makeup of domestic species depends on both biological and economic forces. Regarding the biological aspect, he suggests that the genetic heritage of domestic species is constantly reshaped, benefiting from a high capacity for adaptation and variation due to frequent mechanisms of mutation and sexual reproduction. As for the economic aspect, Renard [18] observed that the selection of breeders has evolved from natural selection to systematic human selection. Initially, the most capable breeders were chosen for their ability to provide food and labor, leading to the creation of locally adapted breeds.

TABLE V
Results of quantitative parameters among HCA groups for rams. G1:group 1; G2: group 2

Parameter	Mean		Median		Min		Max	
	G1	G2	G1	G2	G1	G2	G1	G2
BdW	77.28	106.80	80.00	105.00	41.00	96.00	96.00	121.50
HdL	27.50	28.42	27.50	28.00	23.00	26.00	31.00	32.50
HdW	10.95	12.01	11.10	12.10	8.90	10.20	11.90	12.90
ErL	17.69	17.07	17.00	17.25	15.00	14.50	21.50	22.00
ErW	9.28	9.57	9.50	9.60	7.80	8.50	10.50	10.50
NkL	37.62	38.61	38.50	38.25	31.00	29.00	45.00	46.00
TrL	81.12	87.33	80.00	86.50	68.00	80.00	89.50	95.00
BdL	120	132.70	122	132.00	98	120.00	133	153.00
ChW	24.12	27.22	24.50	26.00	17.00	22.50	30.50	38.50
RpL	25.81	31.53	29.00	32.25	15.00	23.50	30.50	36.00
RpW	23.31	25.06	24.00	24.50	20.00	20.00	26.00	31.50
IsW	20.27	21.03	20.50	20.75	15.50	17.00	25.00	26.00
ChG	106.90	118.90	108.00	120.00	86.00	112.00	121.00	126.00
ChD	41.38	43.53	41.50	44.50	33.00	27.50	43.00	47.00
WtH	89.23	94.47	91.00	95.00	74.00	91.00	95.00	99.00
BkH	86.15	89.06	87.00	90.00	71.50	83.00	97.00	93.00
ScH	86.50	91.03	87.50	91.75	73.00	82.00	91.00	94.00
CnP	9.86	10.68	10.00	10.65	7.80	9.50	10.60	11.90
TaL	48.12	51.97	47.00	51.25	35.00	43.00	65.00	65.00

TABLE V
Results of quantitative parameters among HCA groups for ewes. G1:group 1; G2: group 2

Parameter	Mean		Median		Min		Max	
	G1	G2	G1	G2	G1	G2	G1	G2
BdW	50.37	71.9	50.40	70.7	32.00	50.0	73.50	100.0
HdL	23.84	24.76	24.00	25.00	20.50	20.00	32.50	29.00
HdW	9.65	10.14	9.70	10.20	7.10	7.30	19.90	19.00
ErL	17.15	18.34	17.00	18.00	12.00	12.60	22.50	23.00
ErW	8.57	9.32	8.500	9.20	6.50	8.00	10.50	11.00
NkL	33.54	36.62	33.00	37.00	21.50	22.50	51.50	49.00
TrL	71.99	78.09	72.50	78.50	58.00	57.50	83.00	89.00
BdL	111.5	121.5	112.0	121.0	72.0	108.0	180.0	140.00
ChW	19.84	23.8	20.00	23.0	10.50	10.9	28.00	34.50
RpL	23.3	26.49	23.0	26.50	14.5	21.00	31.0	39.00
RpW	19.96	22.84	20.00	22.50	14.00	15.50	27.00	33.50
IsW	18.24	20.35	18.50	20.00	14.00	16.00	24.00	28.00
ChG	92.01	105.9	92.50	105.0	73.00	91.0	105.00	134.00
ChD	35.41	38.41	35.50	38.50	21.50	31.00	40.00	44.50
WtH	78.96	83.79	79.50	84.00	67.50	76.00	88.50	90.00
BkH	76.42	80.57	77.00	80.50	67.00	70.50	83.50	88.00
ScH	77.41	82.26	77.50	82.00	68.50	73.50	85.50	90.00
CnP	8.24	9.02	8.20	9.00	6.200	8.00	10.00	10.50
TaL	41.42	46.69	41.00	47.00	25.00	34.50	54.00	59.00

Socio-cultural and economic influences play a significant role in the preservation and evolution of animal genetic heritage, particularly through breeding practices, cultural preferences, and economic pressures. Breeding practices reflect the techniques and resources used in production, aiming to fully exploit the potential of the raised breed. The choice of a breed to raise is guided by its productive and adaptive capacities. The production and reproductive performances of the Djellalia and Hodnia varieties (large-sized varieties) of the Ouled-Djellal breed have sparked the interest of breeders, thus explaining their widespread distribution throughout the national territory)[19]. However, climatic constraints have been highlighted by Chellig [4], limiting this expansion; the Djellalia and Hodnia varieties, although large-sized and robust, do not tolerate cold weather. In contrast, the "Chellalia" variety, smaller in size, adapts better to the cold climates of Djelfa. With the evolution of sheep farming systems and the increasing trend towards sedentarization, as well as the shift from extensive to semi-extensive and intensive farming methods, where environmental conditions are controlled to some extent [20, 21], this climatic constraint could decrease in importance as a limiting factor, thus promoting the expansion of these two varieties.

Sheep play a central and diverse role in Algerian societies, encompassing various aspects including economic, social, cultural, and symbolic dimensions [22]. The act of sacrificing sheep during Eid al-Adha holds significant importance for Muslims, symbolizing the faith of Ibrahim, submission to God, gratitude, and solidarity. It is crucial to select high-quality sheep for this purpose to demonstrate respect and prosperity. This ritual not only strengthens community ties and preserves cultural traditions but also imparts values of generosity and sharing to the younger generation [23, 24]. Hadbaoui *et al.* [25] highlight the significant potential of the steppe for producing sheep meat intended for Eid al-Adha, underscoring the socio-cultural importance of breeding large-sized sheep possessing the necessary qualities for sacrifice.

TABLE VII
Percentages of assignment to groups from HCA for ewes and rams G1: group 1; G2: group 2

Locality	Ewes		Rams	
	G1	G2	G1	G2
Birine (BR)	47.37	52.63	100.00	0.00
Ain Oussara (AO)	87.10	12.90	50.00	50.00
Sidi Ladjel (SL)	99.09	0.91	88.89	11.11
Hassi Bahbah (HB)	36.73	63.27	0.00	100.00

In Algeria, breeding the Ouled-Djellal breed goes beyond mere meat production. It is also a conspicuous practice that allows breeders to showcase their prestige and social status. Festivals, community gatherings, and religious celebrations such as Eid al-Adha provide opportunities to exhibit these exceptionally high-quality animals, thereby strengthening social bonds and respect within the community [26].

CONCLUSION

The data on the morphological characteristics of sheep in the studied region reveal significant diversity, suggesting specific adaptations to different local environments and lifestyles. This morphological diversity is a valuable asset for herd resilience in the face of changing environmental challenges and selective pressures. In-depth analysis of individuals, particularly through techniques such as Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA), highlights the presence of distinct groups of sheep based on their morphological characteristics. These results underscore the importance of genetic variability within sheep populations, as well as the influence of human selection in shaping these traits. Indeed, the diversity observed in the herds reflects a complex interplay of biological, environmental, and economic factors.

Conflicts of interest

The authors declare no conflict of interest

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