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# Morphological characterization and study of zootechnical indexes of Berbere sheep in Eastern Algeria

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ABSTRACT

Knowledge of the phenotypic and morphological characteristics of animals is a prerequisite for the improvement and conservation of breeds. The present study contributed to the morphometric study of a total 100 adult Berbere breed of sheep, which is near to extinction (average age 3.24±1.25 years) and sparsely distributed in different zones of the El-Tarf region in Eastern Algeria. Fourteen (14) body measurements were used to calculate 11 zootechnical indexes with qualitative characteristics in order to determine an ethnic and functional classification of this breed. Significant differences in several body measurements were detected between regions, sexes and age groups. A principal component analysis was performed on body measurements, revealing two major components that make up 60.07 and 14.68% of total inertia. This analysis made it possible to establish differences between five classes which have implications to be taken into account in the breed conservation program. However, zootechnical indexes showed that the Berbere breed is a short-sighted breed (BI=0.84±0.08), light, close to the ground (DT=0.48±0.04), small, oblong (LI=1.14±0.11 and DCI=0.37±0.05), medium sized (eumetric) with a straight dorsal line (BR=0.99±0.02) and dolichocephalic heads (CI=0.56±0.05). The analysis of the qualitative characteristics showed a great phenotypic diversity in this breed.

**Key words**: Berbere, Body measurements, Breed, Characterization, Zootechnical index

Body measurements are the basis of score table in a given breed; some of them (heart girth, withers height, chest depth etc.) support estimation of live weights (Afolayan *et al.* 2006, Djaout *et al.* 2012, Dekhili and Aggoun 2013, Suhaila *et al.* 2013) which ultimately allows estimation of an animal's production potential (monitoring of growth, fattening etc.) (Jafari 2014) or determination of doses for veterinary treatment etc. Also, it can be used to estimate lamb carcass traits (Abdel-Moneim 2009) which in turn influences ovine performance (Abbasi and Ghafouri-Kesbi 2011).These are also helpful in estimation of genetic parameters for various live-body weights (Abbasi and Ghafouri-Kesbi 2011, Jafari 2014, Jafari *et al.* 2014) and especially for morphological and ethnic characterization (FAO 2013) of sheep breeds (Esquivelzeta *et al.* 2011, Handiwirawan *et al.* 2011, Melesse *et al.* 2013, Djaout *et al.* 2015) and other animal species like goats (Herrera *et al.* 1996, Rout *et al.* 2000, Chacón *et al.* 2011), equine (Nicks *et al.* 2006, Boujenane *et al.* 2008, Kefena *et al.* 2012), bovine (Yilmaz *et al.* 2012), dromedary (Adamou *et al.* 2013, Bedhiaf-Romdhani *et al.* 2014), porcine (FAO 2013) and poultry (Sponenberg *et al.* 2000, Melesse and Negesse 2011).

In addition, different body measurements were used for the calculation of zootechnical indexes, too. Alderson (1999) developed an index system for assessment of type and function in cattle. He also suggested the application of proposed system to other species. This investigation explores the possibility of extending the use of morphological indexes beyond the on-farm within-herd comparisons to determination of type and function between breeds within species (Salako 2006). The present study aimed at studying the phenotypic and morphological characteristics of Berbere sheep breed, which is near to extinction in the extreme east of Algeria, based on body measurements and zootechnical indexes.This work was carried out in seven different regions due to the availability of low numbers of Berbere animals/flock (not exceeding 20 head per breeder).

No studies have been carried out on the Berbere sheep breed and very little work has been done on the characterization of Algerian sheep breeds like Hamra (Benyoucef *et al.* 1995), Ouled Djellal (Dekhili and Aggoun 2013, Harkat *et al.* 2015), D'man (Boubekeur *et al.* 2013) and Rembi (Djaout *et al.* 2015, Laoun *et al.* 2015).

## MATERIALS AND METHODS

*Presentation of the Berbere sheep breed:* The Berbere

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sheep breed, popularly known as the *Azulai Wool Berbere* or *A'arbia*, is believed to be the oldest of the Algerian sheep breeds originating from this region.This breed is near to extinction and the flock size of this breed does not exceed 20 heads per breeder.The Berbere breed is distributed in the Algerian mountain range (Souk Ahras, Maghnia, Tlemcen, Jijel, Collo, Edough, Ouarsenis, and the Tiaret mountains) (Chellig 1992). However, the present study in the mountainous region of Jijel and the mountains of Tiaret showed that this breed is absent in these regions and is probably replaced by the Ouled Djellal and Hamra breeds. According to flockmen, Berbere breed is a good dairy breed whose milk is used for family consumption. Breeders prefer this breed for its rusticity with respect to parasitic pathologies and to the cold. The quality of the meat is poor.

Table 1. Description of herds and number of animal measured in each flock

| Region | Wilaya | Herd size | Measured rams | Measured ewes | Total |
|---|---|---|---|---|---|
| Bouhadjar | El-Tarf | 40 | 0 | 13 | 13 |
| Matroha | | 10 | 0 | 7 | 7 |
| AïnAssel | | 25 | 3 | 13 | 16 |
| Lake of Birds | | 25 | 1 | 13 | 14 |
| El-Kala | | 45 | 10 | 21 | 31 |
| Om Etboul | | 30 | 3 | 16 | 19 |
| Total | | 175 | 17 | 83 | 100 |

Table 2. Zootechnical indexes studied

| Particular | Indexes | Calculation |
|---|---|---|
| Head shape | Cephalic index (CI) | HW/HL |
| Format of animal | Body index (BI) | SIL/HG |
| | Length index (LI) | SIL/WH |
| | Relative depth of thorax (DT) | CD/WH |
| | Body ratio (BR) | WH/RH |
| | Width slope (WS) | RW/SW |
| | Thoracic development (TD) | HG/WH |
| Performance of the animal | Weight (BW1) | [SIL × CD × (RW+SW)/2]/1050 |
| | Weight (BW2) | $HG^3 \times 50.7$ |
| Skeleton | Dactylo-costal index (DCI) | CP/SW |
| | Dactylo-thoracic index (DTI) | CP × 100/HG |

Scapular-ischiallength (SIL), Withers height (WH), Rump height (RH), Heart girth (HG), Chest depth (CD), Shoulder width (SW), Rump width (RW), Pelvis length (PL), Trochanter width (TW), Head length (HL), Head width (HW), Ear length (EL), Ear width (EW) and Cannon perimeter (CP).

Table 3. Qualitative variables studied

| | |
|---|---|
| Colour of the head and legs | White, Black, Red pie, Black pie, Brown |
| Wool Colour | White, Red pie, Black pie |
| Fleece cover | Semi-invasive wool, Invasive wool, Non-invasive wool |
| Fleece density | Open, semi-open, closed or semi-closed |
| Ear shape | Horizontal, slightly drooping, drooping |
| Cephalic profile | Concave, rectilinear |

*Animals studied:* The study examined the analysis of zootechnical indexes based on body measurements and phenotypic description of 100 Berbere sheep with average age of 3.24±1.25 years (between October 2013 and May 2014) in six different regions (Bouhadjar, Matroha, AinAssel, Lake of Birds, El-Kala and Om Etboul, Table 1).

*Body measurements and zootechnical indexes:* Different body measurements were taken by the same operator in the morning. Fourteen (14) measurements were used for each animal (body lengh or scapular-ischial length (SIL), withers height (WH), rump height (RH), heart girth (HG), chest depth (CD), shoulder width (SW), rump width (RW), pelvis length (PL), trochanter width (TW), head length (HL), head width (HW), ear length (EL), ear width (EW) and cannon perimeter (CP)). From these measurements, 11 zootechnical indexes were calculated according to the work of Miller *et al.* (1964), Sotillo and Serrano (1985), Santos *et al.* (1995), Alderson (1999), Salako (2006), Sarma (2006) and Chacón *et al* (2011) (Table 2). The calculation and analysis of the various zootechnical indexes make it possible to classify the ethnology of the Berbere breed studied.

*Qualitative traits studied:* Other phenotypic variables studied were head color, leg color, wool color, fleece cover, fleece density, ear shape and cephalic profile (Table 3).

*Statistical analysis:* Body measurements were analyzed according to the following linear model:

$$Y_{ijk} = \mu + Region_i + Sex_j + Age_k + £_{ijk}$$

with $Y_{ijkl}$, the dependent phenotypic characters; μ, the general mean of the population; $Region_i$, effect of the ith region; $Sex_j$, effect of the jth sex; $Age_k$, effect of the kth age; and $£_{ijk}$, residual error of mean = 0 and of constant variance.

The effect of region, sex and age were compared by the one-way ANOVA test followed by the Student Newman-Keuls multiple comparison test. All these data were analyzed using the statistical analysis software SAS (version 9.1.3).A principal component analysis (PCA) was performed based on the zootechnical indexes. Multiple factorial analysis (MCA) was used for the qualitative variables to differentiate the sheep and to construct a typology which consisted of identifying individuals who are fairly similar to each other in order to present common qualitative characteristics.Finally, to obtain the optimal number of groups, an ascending hierarchical classification (CHA) was used. These tests were processed by the SPSS software (version 19).

## RESULTS AND DISCUSSION

*Body measurements and zootechnical indexes:* Means, standard deviations, minimum, maximum and coefficients of variation of body measurements and zoo technical indexes of Berbere sheep breed are shown in Tables 4 and 5.

*Format of head:* Cephalic measurements were used for the identification of breed, origin and relationship between species (Jewel 1963).The cephalic index (CI) is an ethnological index, particularly because its value is not influenced by environmental factors and by the animal's management (Cerqueira *et al.* 2011). In our study, the head of the Berbere animals was short and fine. It was dolichocephalic, length greater than width, CI=0.56±0.05) with a length of 26.64±1.84 cm and width as 14.89±1.37 cm.The ears are short (EL: 13.96±1.34 cm) and fine (EW: 7.25±0.73 cm, Tables 4 and 5).

*Body size:* The length of the body is the scapulo-ischial length (SIL). It was taken from the tip of the shoulder to the tip of the ischium. It was 76.55±6.47 cm with a CV of 8.45. The height at the withers (WH) and the height at the sacrum (RH) were 67.03±3.47 and 67.62±3.42 cm, respectively. The shoulder width (SW) was 21.67±2.78 cm with the highest CV (12.80) compared to the other measurements. The heart girth (HG) taking the top of the withers as a marker appeared more relevant than that established behind the withers by being more correlated with other body measurements. In practice, taking measurements at the back of the withers is more prone to variations due to the respiratory activity of animals (inspiration/exhalation) than the measure at the withers.This measurement accounts for the development of the chest and the muscles that cover it (Nicks *et al.* 2006). In the studied population, the HG was 92.10±8.05 cm. The chest depth (CD) was 32.17±3.40 cm; it gives information on the development of the thoracic cavity. It is influenced by the length and degree of inclination of the spinous processes of the first dorsal vertebrae (Nicks *et al.* 2006). Berbere animals were found to be longer than the Ouled Djellal breed (Dekhili and Aggoun 2013) and shorter than the Rembi breed (Djaout *et al.* 2015). These are smaller and narrower than the Ouled Djellal (Dekhili and Aggoun 2013) and Rembi breed (Djaout *et al.* 2015) with lesser chest circumference (HG) and chest development (CD) (Tables 4 and 5).

Table 4. Descriptive analysis of body measurements in Berbere breed

| Trait | Mean | SD | ES | Var | CV | Min | Max |
|---|---|---|---|---|---|---|---|
| SIL | 76.55 | 6.47 | 0.65 | 41.85 | 8.45 | 65 | 95 |
| WH | 67.03 | 3.47 | 0.35 | 12.03 | 5.17 | 61 | 75 |
| RH | 67.62 | 3.42 | 0.34 | 11.69 | 5.06 | 60 | 74 |
| HG | 92.10 | 8.05 | 0.80 | 64.78 | 8.74 | 82 | 114 |
| CD | 32.17 | 3.40 | 0.34 | 11.54 | 10.56 | 27 | 41 |
| SW | 21.67 | 2.78 | 0.28 | 7.70 | 12.80 | 17 | 28 |
| RW | 17.13 | 1.24 | 0.12 | 1.55 | 7.26 | 14 | 19 |
| PL | 24.85 | 2.70 | 0.27 | 7.28 | 10.86 | 21 | 33 |
| TW | 24,57 | 2,71 | 0,27 | 7,32 | 11,01 | 19 | 29 |
| HL | 26.64 | 1.84 | 0.18 | 3.38 | 6.91 | 23 | 30 |
| HW | 14.89 | 1.37 | 0.14 | 1.88 | 9.20 | 12 | 19 |
| EL | 13.96 | 1.34 | 0.13 | 1.80 | 9.60 | 11 | 16 |
| EW | 7.25 | 0.73 | 0.07 | 0.53 | 10.07 | 6 | 10 |
| CP | 7.90 | 0.63 | 0.06 | 0.39 | 7.94 | 7 | 9 |

Scapular-ischial length (SIL), Withers height (WH), Rump height (RH), Heart girth (HG), Chest depth (CD), Shoulder width (SW), Rump width (RW), Pelvis length (PL), Trochanter width (TW), Head length (HL), Head width (HW), Ear length (EL), Ear width (EW) and Cannon perimeter (CP).

Table 5. Descriptive analysis of zootechnical indexes in Berbere breed

| Zoo technical index | Mean | SD | ES | Variance | CV | Min | Max |
|---|---|---|---|---|---|---|---|
| CI | 0.56 | 0.05 | 0.00 | 0.002 | 8.28 | 0.44 | 0.65 |
| BI | 0.84 | 0.08 | 0.01 | 0.01 | 10.02 | 0.68 | 1.13 |
| LI | 1.14 | 0.11 | 0.01 | 0.01 | 9.60 | 1.00 | 1.51 |
| DT | 0.48 | 0.04 | 0.00 | 0.004 | 8.56 | 0.41 | 0.57 |
| BR | 0,99 | 0.02 | 0.00 | 0.00 | 2.02 | 0.94 | 1.03 |
| WS | 0.80 | 0.11 | 0.01 | 0.01 | 14.28 | 0.59 | 1.00 |
| TD | 1.37 | 0.09 | 0.01 | 0.01 | 6.52 | 1.19 | 1.60 |
| BW1 | 46.00 | 10.00 | 1.00 | 100.10 | 21.75 | 30.53 | 71.32 |
| BW2 | 40.54 | 11.52 | 1.15 | 132.66 | 28.41 | 27.95 | 75.11 |
| DCI | 0.37 | 0.05 | 0.00 | 0.00 | 12.43 | 0.29 | 0.47 |
| DTI | 8.61 | 0.73 | 0.07 | 0.53 | 8.47 | 7.10 | 10.00 |

The cephalic, thoracic, pelvic and corporeal indexes are ethnological, give general information on the characteristics of the breed in terms of describing the structure of the animal and its proportions (i.e. compactness, height, length and weight). The remaining indexes are functional, providing information on the performance of the animal (type, fitness and production, Esquivelzeta *et al.* 2011). It may be in order to suggest that the indexes that are produced from the body measurements that are more closely associated with bone growth such as forearm length, height and length index are more suitable for evaluation of the animal's type (Salako 2006). The lower body index values (BI) indicate that the animal is closer to being of rectangular shape which is an indicator of a better conformation for meat (Cerqueira *et al.* 2011). However, according to the zootechnical indexes, the Berbere breed studied can be classified as a breviline breed (body index: BI=0.84±0.08), i.e. near the earth (relative depth of thorax: DT=0.48±0.04) with an oblong body because the length of the body is greater than the height (length index: LI=1.14±0.11).The dorsal line of the animal was straight (body ratio: BR=0.99±0.02). The reasons for a superiority of the size at the rump compared to that at the withers can be multiple, depending both on the length of the different bone rays but also on the angulations of the joints of the cannonball, the elbow, shoulder, hock and stifle. Excessive deviations should be avoided in one direction or the other (Nicks *et al.* 2006).The Berbere animal is little developed in front because the width at the shoulders is greater than the width at the hips (width slope: WS=0.80±0.11).Compared to its small size, the animal has significant thoracic development (thoracic development: TD =1.37±0.09).

*Dimensions of the pelvis:* The distance between the two points of the hip (ilions, RW) is 17.13±1.24 cm, while the distance between the ilium tip and the ischium tip (PL) is 24.85±2.70 cm.The pelvis width of animals is shorter than its length. The pelvis in the Berbere sheep is less broad and shorter than that of the Rembi breed (Djaout *et al.* 2015).

Table 6. Body measurements of Berbere sheep according to regions

| Region | Bouhadjar | Matrouha | AïnAssel | Lake of birds | El-Kala | Om Etboul | p |
|---|---|---|---|---|---|---|---|
| | 13 | 7 | 16 | 14 | 31 | 19 | |
| SIL | 78.54$^{a}$±7.89 | 77.43$^{a}$±4.89 | 71.50$^{b}$±5.24 | 75.29$^{ab}$±5.17 | 77.71$^{a}$±6.68 | 78.16$^{a}$±5.66 | * |
| WH | 66.46±2.50 | 69.86±2.54 | 66.13±2.00 | 66.57±4.01 | 67.35±4.09 | 66.95±3.55 | NS |
| RH | 67.00±2.83 | 69.29±2.81 | 65.88±1.67 | 67.36±4.22 | 68.32±3.82 | 67.95±3.42 | NS |
| HG | 90.62±6.55 | 96.29±13.09 | 87.38±3.16 | 93.36±7.26 | 92.32±8.12 | 94.26±8.94 | NS |
| CD | 31.23±3.35 | 34.00±5.00 | 31.00±2.19 | 32.86±3.84 | 32.00±3.17 | 32.89±3.48 | NS |
| SW | 22.00$^{a}$±3.03 | 22.43$^{a}$±3.64 | 19.56$^{b}$±1.32 | 21.79$^{a}$±2.97 | 22.00$^{a}$±2.83 | 22.32$^{a}$±2.41 | * |
| RW | 17.54±1.51 | 17.00±1.29 | 17.69±0.79 | 16.57±1.60 | 17.06±1.18 | 16.95±1.03 | NS |
| PL | 25.62±3.07 | 25.29±2.14 | 24.75±1.81 | 25.00±3.68 | 24.87±2.91 | 24.11±2.13 | NS |
| TW | 25.38±2.69 | 24.43±3.51 | 23.25±2.11 | 23.86±3.01 | 24.77±2.72 | 25.37±2.36 | NS |
| HL | 26.62$^{a}$±1.85 | 27.29$^{a}$±1.70 | 25.19$^{b}$±1.87 | 27.43$^{a}$±1.56 | 26.97$^{a}$±1.87 | 26.53$^{a}$±1.47 | ** |
| HW | 14.23±1.48 | 14.86±0.38 | 14.75±0.58 | 14.86±1.35 | 15.26±1.77 | 14.89±1.20 | NS |
| EL | 13.69±0.86 | 14.71±1.25 | 13.19±0.91 | 13.93±1.49 | 14.13±1.43 | 14.26±1.49 | NS |
| EW | 7.23±0.60 | 7.29±0.76 | 7.38±1.03 | 7.14±0.86 | 7.26±0.63 | 7.21±0.63 | NS |
| CP | 8.08±0.28 | 8.14±0.69 | 7.50±0.52 | 7.86±0.77 | 8.00±0.63 | 7.89±0.66 | NS |

Number (n), Scapular-ischial length (SIL), Withers height (WH), Rump height (RH), Heart girth (HG), Chest depth (CD), Shoulder width (SW), Rump width (RW), Pelvis length (PL), Trochanter width (TW), Head length (HL), Head width (HW), Ear length (EL), Ear width (EW), Cannon perimeter (CP), *P≤0.05 and **P≤0.01.

Table 7. Body measurements of Berbere sheep according to sex

| Sex | Male | Female | p |
|---|---|---|---|
| | 17 | 83 | |
| SIL | 72.94±3.50 | 77.29±6.70 | * |
| WH | 68.82±3.58 | 66.66±3.35 | * |
| RH | 69.76±3.27 | 67.18±3.30 | ** |
| HG | 90.88±5.69 | 92.35±8.46 | NS |
| CD | 31.18±2.10 | 32.37±3.58 | NS |
| SW | 20.94±2.14 | 21.82±2.88 | NS |
| RW | 17.65±1.22 | 17.02±1.23 | NS |
| PL | 24.59±1.58 | 24.90±2.88 | NS |
| TW | 24.00±2.09 | 24.69±2.81 | NS |
| HL | 27.24±2.14 | 26.52±1.76 | NS |
| HW | 16.00±1.90 | 14.66±1.12 | *** |
| EL | 14.29±1.26 | 13.89±1.35 | NS |
| EW | 7.59±0.62 | 7.18±0.74 | * |
| CP | 8.29±0.59 | 7.82±0.61 | ** |

Number (n), Scapular-ischiallength (SIL), Withers height (WH), Rump height (RH), Heart girth (HG), Chest depth (CD), Shoulder width (SW), Rump width (RW), Pelvis length (PL), Trochanter width (TW), Head length (HL), Head width (HW), Ear length (EL), Ear width (EW), Cannon perimeter (CP). *P≤0.05, **P≤0.01and ***P≤0.001.

*Frame:* The dactylo-thoracic index (DTI) indicates the degree of skeletal fineness, allowing us to correlate the individual mass of the animal with its limbs to determine whether the body volume corresponds to bone development (Cerqueira *et al.* 2011). The DTI is 8.61±0.73 in the Berbere breed studied, which showed that these animals are light and have a very fine bone structure (DCI=0.37±0.05), contrary to the Rembi breed (Djaout *et al.* 2015). In addition, the perimeter of the upper 1/3$^{rd}$ of the bone of the canon (CP) is 7.90±0.63 cm (Table 8).

*Performance of animal:* Weight (BW) and balance are important in determining the functionality of an animal, so we say that its performance is influenced by the environment (Salako 2006). The weight of these animals was calculated according to two formulas: BW1= [SIL×CD×(RW+SW)/2]/1050 (Alderson 1999) and BW2= (HG$^{3}$*50.7, Djaout *et al.* (2012). The respective values for BW1and BW2 were 46.00±10.00 and 40.54±11.52 kg. These values show that these animals are of medium size (eumetric).We cannot compare these zootechnical indexes with that of other authors because of the absence of the studies on the ethnology of this breed or other Algerian sheep.

*Factors of variation*

*Effect of region:* Body measurements of Berbere animals in different regions in the Wilaya of El-Tarf are presented in the Table 6. The animals studied showed no significant difference (P>0.05) for all body measurements in different regions except for body length (SIL), shoulder width (SW) and length of head (HL) for which the animals have significant differences (P<0.05). The animals in the Om Etboul region are longer (SIL, P<0.05) than other animals, as well as animals in the Bouhadjar region have a scapulo-ischial length (SIL) of 78.54±7.89 (P<0.05) with short heads (HL) compared to the other animals in the different regions of study (Table 6).

*Effect of sex:* There were significant differences between the two sexes (P<0.05, Table 7). The males were shorter in length (SIL) and expressed higher values for WH, RH, HW, EW and CP than females (Table 7). Chellig (1992) reported higher measurements of height (WH) and length (SIL), with a lower depth of chest (CD). On the other hand, they reported comparatively smaller depth of chest than Ouled Djellal (Harkat *et al.* 2015) and D'man breed (Boubekeur *et al.* 2013).

*Effect of age:* Animals aged 2 years expressed lesser

length (SIL) and width (SW, RW and TW) than other animals with a lower HG and WH and a shorter head (HL). They also have a shorter pelvis (PL, Table 8).

*Diversity of individuals according to body measurements*

*Analysis of variables:* A principal component analysis (PCA) was carried out, on all the variables in the beginning which revealed 59.40% of the total inertia on both axes.It is relatively very low. In order to obtain more significant representation, 7 variables with very high variances were used (SIL, WH, HG, CD, SW, TW and PL). The cumulative share of information returned in this case is 74.75% (Table 9). The analysis of the studied parameters showed that the two axes respectively presented 60.07 and 14.68% of the total inertia. Axis 1 (60.07%) was represented by variables WH, HG, CD, SW, TW and PL. Whereas, Axis 2 (14.68%) was represented by SIL and WH (Table 10).

*Analysis of individuals:* The principal component analysis (PCA) and the hierarchical ascending classification allowed the determination of following five classes:

*Class 1:* This class consisted of 65 animals (majority of the population) characterized by a less developed chest than that of other animals. They have HG and CD lower than the average and those of the other classes.They were also the shortest in length among all (SIL, Table 11).

*Class 2:* Compared to animals of other classes, animals of this class (11 animals) possessed a highly developed chest (HG: 109.27±3.98, CD: 38.27±1.95 and WH: 71.55±3.14 cm) with a wider (TW: 26.82±1.47 cm) and longer pelvis (PL: 29.18±3.52 cm). They have a body length higher than the average (SIL: 82.36±3.80 vs. 76.55±6.47 cm, Table 11).

*Class 3:* This group of animals (4 animals) consisted of the longest (SIL: 95 cm) and the smallest ones (WH: 63 cm) with the least developed chest (HG: 84 and CD: 30.25±0.50 cm) and shortest pelvis (PL: 22, Table 11).

*Class 4:* Only 2 animals constituted this class and these were the widest (SW: 26.00±1.41 cm) with a fairly developed chest (HG: 91.00 and CD: 35.50±0.71 cm, Table 11).

*Class 5:* Eighteen (18) animals of this group were characterized by a developed chest (HG: 99.00±2.59 and CD: 34.61±2.43 cm) with a depth of 70.72±2.32 cm above average. They have a very larder pelvis compared to that of other animals (TW: 26.33±1.85 cm, Table 11).

*Diversity of individuals according to morphological characteristics:* Individuals studied have a fine and medium tail; they have short ears of different lengths. They have different colors of head and legs; only 15% of the animals were horned all rams; the horns have an average length of 33.07±9.10 cm.The qualitative characteristics which have been studied for the description of these animals were the colour of skin (head and legs) and wool, the fleece cover and density, ears shape and the cephalic profile.The analysis carried out on 100 Berbere animals showed that the first two factorial axes 1 and 2 expressed 32.08 and 24.49% of the inertia, respectively (of the total inertia 56.58%, Table

Table 8. Variation of body measurements of Berbere sheep according to age

| Age<br>n | 1 year<br>10 | 2 years<br>16 | 3 years<br>33 | 4 years<br>25 | ≥5 years<br>16 | p |
|---|---|---|---|---|---|---|
| SIL | $77.6^{a}$±4.67 | $71.50^{b}$±3.35 | $77.64^{a}$±7.66 | $77.92^{a}$±6.57 | $76.56^{a}$±4.91 | * |
| WH | $66.60^{ab}$±2.12 | $65.31^{b}$±2.36 | $66.64^{ab}$±4.16 | $68.52^{a}$±3.72 | $67.50^{ab}$±2.13 | * |
| RH | 67.50±2.27 | 66.50±3.29 | 67.06±4.18 | 68.84±3.39 | 68.06±1.69 | NS |
| HG | $96.80^{a}$±10.59 | $87.75^{c}$±4.42 | $93.82^{ab}$±9.66 | $91.92^{abc}$±6.27 | $90.25^{bc}$±5.80 | * |
| CD | 34.20±3.85 | 30.44±1.41 | 32.73±4.33 | 31.72±2.39 | 32.19±3.04 | NS |
| SW | $22.60^{ab}$±2.72 | $19.50^{c}$±2.13 | $22.82^{a}$±3.19 | $21.36^{b}$±2.08 | $21.38^{ab}$±2.13 | ** |
| RW | $16.00^{b}$±1.05 | $16.94^{ab}$±0.77 | $17.03^{a}$±1.19 | $17.68^{a}$±1.25 | $17.38^{a}$±1.41 | ** |
| PL | $25.30^{a}$±2.36 | $23.13^{b}$±1.54 | $25.73^{a}$±3.40 | $24.88^{a}$±2.62 | $24.44^{ab}$±1.21 | * |
| TW | $24.20^{abc}$±2.20 | $22.31^{c}$±2.63 | $25.48^{a}$±2.39 | $25.40^{ab}$±2.12 | $23.88^{bc}$±3.18 | *** |
| HL | $26.90^{a}$±1.20 | $25.00^{b}$±1.90 | $27.09^{a}$±1.55 | $26.76^{a}$±2.07 | $27.00^{a}$±1.55 | ** |
| HW | $14.40^{b}$±0.70 | $14.69^{b}$±1.30 | $14.61^{b}$±1.03 | $15.64^{a}$±2.04 | $14.81^{ab}$±0.40 | * |
| EL | 14.80±1.55 | 13.69±0.95 | 13.85±1.48 | 14.20±1.26 | 13.56±1.21 | NS |
| EW | 6.90±0.32 | 7.44±0.89 | 7.24±0.71 | 7.44±0.65 | 7.00±0.82 | NS |
| CP | 7.90±0.32 | 7.75±0.45 | 8.03±0.68 | 7.96±0.79 | 7.69±0.48 | NS |

Number (N), Scapular-ischial length (SIL), Withers height (WH), Rump height (RH), Heart girth (HG), Chest depth (CD), Shoulder width (SW), Rump width (RW), Pelvis length (PL), Trochanter width (TW), Head length (HL), Head width (HW), Ear length (EL), Ear width (EW), Cannon perimeter (CP), *P≤0.05, **P≤0.01 and ***P≤0.001.

Table 9. Eigen values

| Component | Initial Eigen values | | | Extraction of the sums of the squares of the selected factors | | |
|---|---|---|---|---|---|---|
| | Total | % of variance | % Cumulative | Total | % of variance | % Cumulative |
| 1 | 4.20 | 60.07 | 60.07 | 4.20 | 60.07 | 60.07 |
| 2 | 1.03 | 14.68 | 74.75 | 1.03 | 14.68 | 74.75 |

12). Axis 1 (32.08%) was represented by the variables wool color, fleece cover, fleece density, ear shape and cephalic profile. Whereas, the Axis 2 (24.49%) was represented by the variables head color, leg color and fleece density (Table 12). The analysis identified four classes as follows:

*Class 1:* The 56 animals of the population (36%) had white heads (41.07%), whereas 41.07 and 17.86% were red and black pied, respectively. Legs were mostly white (80, 36%) or red pied (19.64%). Wool was white (96.43%) and semi-invasive in 87.50% of animals.It was either open (69.64%) or semi-open (30.36%). These animals had horizontal ears in 85.71% of the individuals with rectilinear cephalic profile in a majority of animals (78.57%), while 21.43% of the animals had a concave chamfer (Table 12).

*Class 2:* This class consists of only 3 animals (14%), of which 2 animals have black heads and legs and one individual with red pied head and brown legs. The wool is semi-open and semi-invasive; it is white in two individuals, whereas only one animal had black wool. These animals have a rectilinear cephalic profile and horizontal ears (Table 12).

*Class 3:* Only 12 animals make up this class, 75% of which have black heads and 25% have brown heads. The members were black pied (58.33%), brown (25.00%) and black (16.67%). In most animals of this class, the wool was white (41.67%), red pied (50%) and black pied (8.33%). Wool was semi-invasive (83.33%) and open (91.67%), whereas it was invasive in 16.67% and semi-open in 8.33% of the animals. Most of the animals have horizontal ears (91.67%) and a rectilinear cephalic profile (75%), while only 25% of the animals have a concave cephalic profile (Table 12).

*Class 4:* It contained 32% of the population (29 individuals), with brown (48.28%) and black heads (51.72%), white legs (75.86%) and red pied legs (24.14%). The wool was white (65.52%), red pied (31.03%) and black pied (3.45%). It was semi-invasive in majority of animals (82.76%) with 10.34% invasive and 6.90% non-invasive type. It was mainly open (72.41%) and partly semi-open (27.59%). The ears were horizontal (96.55%). This class had animals mainly with rectilinear cephalic profile (82.76%) with 17.24% concaviline ones (Table 12).

Apart from the documents of Chellig (1992), scanty literature is available on the phenotypic and morphological characterization of this breed. It should be noted that the movement of herds on the national territory has evolved considerably. Sheep have fixed their racial characteristics following crossbreeding in a few decades. Probably, these have undergone changes following the evolution of breeding methods (mainly extensive), the free circulation of animals throughout the national territory and uncontrolled modes of reproduction, especially in the El Tarf region where this breed has been replaced by the Hamra breed in recent years, hence the appearance of individuals who bear the criteria

Table 10. Presentation of the variables by PCA in the Berbere breed

| Traits | Components | |
|---|---|---|
| | 1 | 2 |
| SIL | 0.53 | 0.70 |
| WH | 0.70 | –0.48 |
| HG | 0.90 | –0.15 |
| CD | 0.89 | –0.07 |
| SW | 0.88 | 0.14 |
| TW | 0.80 | 0.35 |
| PL | 0.65 | –0.36 |

Scapular-ischiallength (SIL), Withers height (WH), Heart girth (HG),Chest depth (CD), Shoulder width (SW),Trochanter width (TW) and Pelvis length (PL).

Table 11. Classification of Berbere breed animals with PCA

| | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 |
|---|---|---|---|---|---|
| n | 65 | 11 | 4 | 2 | 18 |
| HG | 87.82± 3.02 | 109.27± 3.98 | 84.00± 0.00 | 91.00± 0.00 | 99.00± 2.59 |
| TW | 23.63± 2.71 | 26.82± 1.47 | 25.00± 0.00 | 26.00± 0.00 | 26.33± 1.85 |
| SW | 20.42± 1.97 | 25.64± 2.80 | 20.00± 0.00 | 26.00± 1.41 | 23.67± 1.50 |
| WH | 65.49± 2.21 | 71.55± 3.14 | 63.00± 0.00 | 67.00± 0.00 | 70.72± 2.32 |
| CD | 30.48± 2.02 | 38.27± 1.95 | 30.25± 0.50 | 35.50± 0.71 | 34.61± 2.43 |
| PL | 24.42± 2.05 | 29.18± 3.52 | 22.00± 0.00 | 26.00± 0.00 | 24.28± 2.02 |
| SIL | 73.77± 4.53 | 82.36± 3.80 | 95.00± 0.00 | 87.00± 0.00 | 77.78± 3.46 |

Number (n), Heart girth (HG), Trochanter width (TW), Shoulder width (SW), Withers height (WH), Chest depth (CD), Pelvis length (PL) and Scapular-ischiallength (SIL).

Table 12. Variance explained

| Dimension | Total (Eigen values) | Inertia | Percentage of variance explained |
|---|---|---|---|
| 1 | 2.25 | 32.08% | 32.08 |
| 2 | 1.71 | 24.49% | 24.49 |
| Total | 3.96 | 56.58% | |

Table 13. Measures of discrimination of qualitative variables in the Berbere breed.

| Traits | Dimension | |
|---|---|---|
| | 1 | 2 |
| Color of the head | 0.63 | 0.74 |
| Color of the legs | 0.47 | 0.63 |
| Wool color | 0.66 | 0.14 |
| Fleece cover | 0.29 | 0.07 |
| Fleece density | 0.09 | 0.09 |
| Ears shape | 0.06 | 0.01 |
| Cephalic profile | 0.05 | 0.04 |

different from the others (brown eyes with a semi-open wool). Following uncontrolled crosses with the Ouled Djellal and Hamra breeds, we are losing this breed which has a strong resistance to cold, humidity and several parasitic pathologies.

The study of body measurements and zootechnical, ethnological and functional indexes has made it possible to define the Berbere breed studied as a breviline breed, close to land, hypometric to eumetric of medium size, with a very fine musculature.These animals have a dolichocephalic head, very short, fine with short, thin and horizontal ears. The skin (head and legs) is usually white, may be brown, black or white pigmented either black or red. Wool is long and white, sometimes mixed with brown and black, unfurled, shiny (Azoulaï), open fleece largely falling. The ewes of this breed are hornless, while the rams are horned.

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