

Morphological Assessment of Arab-Barb Horses in Algeria Based on Linear Measurements, Body Circumferences, and Morphometric Indices

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Abstract. The aim of this study was to define selected morphometric characteristics, namely linear measurements, body circumferences, and biometric indices, of Arab-Barb horses across different localities in Algeria. A total of twenty linear measurements were selected for morphometric analysis, and ten indices or body ratios were calculated from 49 Algerian Arab-Barb horses. The descriptive results indicated a relatively homogeneous population in northern Algeria based on the measured morphometric variables. Sex-related differences were observed mainly for neck length, neck circumference, and knee circumference ($P < 0.05$). Horses in the > 480 kg estimated body weight (BW) group showed greater total length, humero-iliac length, chest circumference, withers height, rump height, cannon circumference, fetlock circumference, and several mass-related indices. Significant differences were observed in 14 linear measurements of Algerian horses between two studied regions ($P < 0.05$). Most correlations among morphological variables exceeded 0.6, suggesting strong interrelationships and morphological consistency. The dactyl thorax index was significantly lower in females than in males ($P < 0.05$), whereas thoracic development was higher in females in the unadjusted comparison. Overall, the findings indicate relative morphometric homogeneity in Arab-Barb horses from northern Algeria, while also highlighting variation associated with sex, estimated body weight, and geographic origin. In the future, molecular analysis of Algerian horses will be essential for the preservation and management of this invaluable genetic resource, which constitutes an integral part of the nation's cultural and economic heritage.

Introduction

In Algeria, equestrian sports have developed considerably in recent years in terms of the number of horses and horse owners. According to the 2019 national inventory, the horse population was estimated at 312 000 heads nationwide (Ministry of Agriculture and Rural Development, 2019). Algeria thus ranks as the second-largest country in North Africa, after Morocco, in terms of horse population. Horses are distributed across many northern regions of Algeria, primarily in highland and mountainous areas. Two local horse breeds predominate in Algeria: the Barb and the Arab-Barb, alongside several imported breeds, including the Arabian Thoroughbred, English Thoroughbred, French Trotter, and Selle Français.

The Barb horse has played a significant role in North Africa's history, particularly in resistance wars, as well as in the economy through transport and agriculture. It is also used in the Fantasia – a traditional equestrian performance showcased during

cultural festivals. This breed has been exported for centuries because of its hardiness and exceptional endurance (Van der Merwe and Martin, 2002). The Arab-Barb horse originated at the Tiaret stud farm in western Algeria in 1877, when the local Barb breed was crossed with Arabian horses to meet the military cavalry's requirements and to improve certain characteristics of the Barb horse (Thompson, 1995). According to the studbook of the World Barb Horse Organization, horses resulting from these crossings are referred to as Arab-Barb horses (Rahal et al., 2009). As this breed spread throughout Algeria (Kabylie, Saoura, Sersou, Titteri, Dahra, El Hodna, and the Aurès region), variations in Barb morphology emerged. Therefore, it is important to continuously evaluate the morphometric characteristics of Algerian horse breeds in order to establish more accurate criteria for their definition and characterization.

The knowledge of morphometric measurements in horses is crucial for taxonomic classification, breed development, and the maintenance of genetic diversity. In Algeria, relatively few studies have been conducted on the morphometric characteristics of

Arab-Barb horses (Behamadi et al., 2017; Benia et al., 2022; Mebarki et al., 2018; Rahal et al., 2009), despite the numerous risks associated with genetic drift and breed modification. Therefore, the main objective of the present study was to improve knowledge of Algerian horse breeds. The investigation aimed to define certain morphological variables, including linear measurements, body circumferences, and biometric indices, in Arab-Barb horses from different regions of Algeria. In addition, Pearson correlation coefficients among the various linear measurements were evaluated.

Material and Methods

For animal experimentation, ethical review and approval were waived for this study because the morphometric measurements were performed with the consent of the horse owners. The data collection procedure was non-invasive and did not cause additional suffering to the animals.

Study region

The study was conducted from March to July 2022 in the Bejaia (36°45'N, 5°3'E) and Oran (35°41'N, 0°38'W) regions of Algeria. Both regions belong to the Mediterranean climatic zone, characterized by mild to warm and rainy winters, frequent precipitation mainly during autumn and winter, and

hot and dry in summers.

Animals and measurements

A total of 49 Algerian Arab-Barb horses aged 4 years or older were included. Linear measurements were performed in each stable on a level, and non-slip horizontal surface, using a specially graduated measuring tape. A total of twenty linear measurements were selected for morphometric characterization, as described below:

eye interval (EI): distance between the inner canthi of the eyes; head length (HL): distance between the neck and the tip of the nose; neck length (NL): distance between the middle of the anterior edge of the shoulder and the most noticeable part of the edge of the first cervical vertebra; neck circumference (NC): circumference measured at the base of the neckline; shoulder length (SL): distance between the summit and the tip of the shoulder; total length (TL): distance between the greater tubercle (tuberculum majus) of the humerus and the ischial tuberosity (tuber ischiadicum); humero-iliac length (HIL): distance between the greater tubercle of the humerus and the coxal tuber (tuber coxae) of the ilium; chest circumference (ChC): circumference around the chest behind the withers; withers height (WH): vertical distance from the highest point of the withers to the floor; rump height (RH): vertical distance from

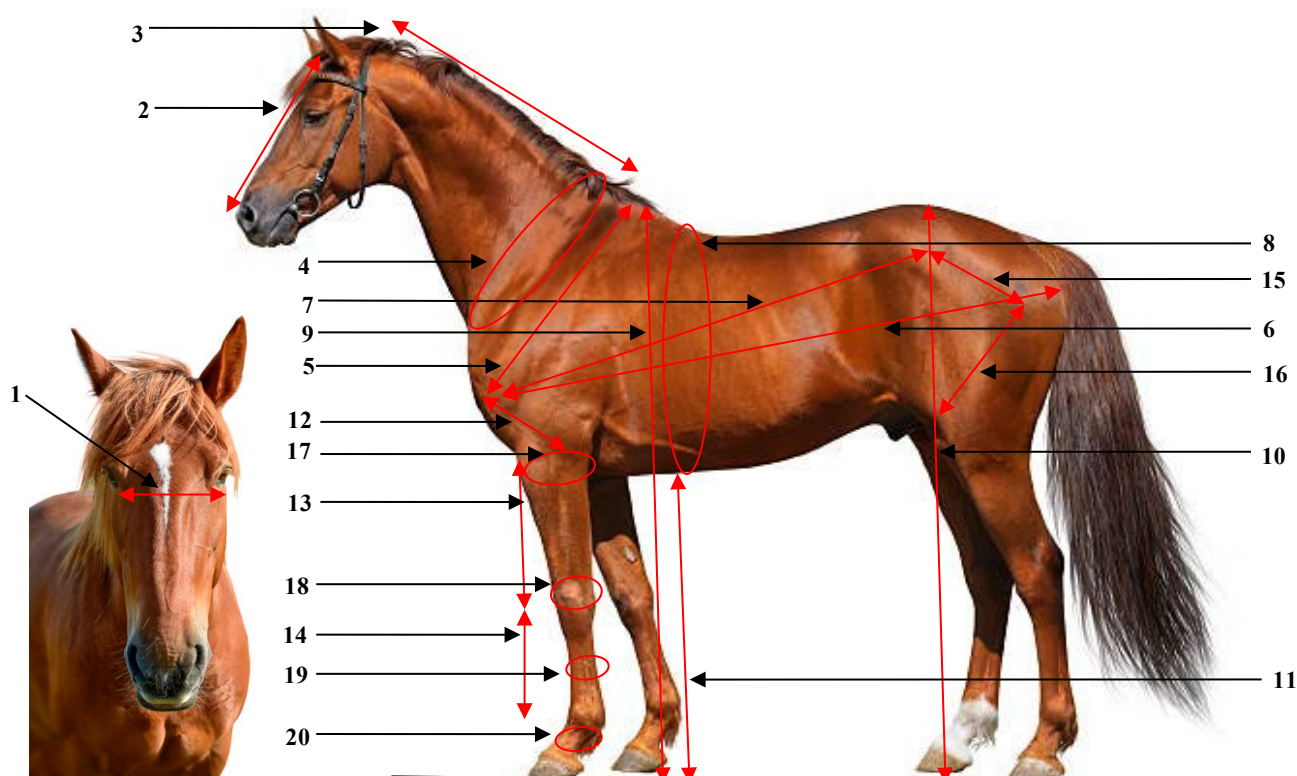


Fig. 1. The different linear measurements performed in horses.

1 – eye interval (EI); 2 – head length (HL); 3 – neck length (NL); 4 – neck circumference (NC); 5 – shoulder length (SL); 6 – total length (TL); 7 – humero-iliac length (HIL); 8 – chest circumference (ChC); 9 – withers height (WH); 10 – rump height (RH); 11 – space under the chest (SC); 12 – arm length (AL); 13 – forearm length (FoL); 14 – cannon length (CL); 15 – ilium length (IL); 16 – femur length (FeL); 17 – forearm circumference (FoC); 18 – knee circumference (KC); 19 – cannon circumference (CC); 20 – fetlock circumference (FeC)

the highest point over the sacral tuberosity to the floor; space under the chest (SC): distance between the sternum and the floor; arm length (AL): distance from the central area of the scapulo-humeral joint to the central area of the humero-radial joint; forearm length (FoL): distance from the central area of the humero-radial joint to the lateral middle third of the carpal joint; cannon length (CL): distance from lateral middle third of the carpal joint to middle third of lateral face of the metacarpo-phalangeal joint of right forelimb; ilium length (IL): distance between the greater trochanter of femur and the coxal tuber of ilium; femur length (FeL): distance between the greater trochanter of femur and the patella; forearm circumference (FoC): midpoint between the distance from the central area of the humero-radial joint and the lateral middle third of the carpal joint; knee circumference (KC): circumference of the central region of the carpus; cannon circumference (CC): circumference of the cannon bone at the middle point of its length; fetlock circumference (FeC): circumference of the middle third of the lateral face of the metacarpo-phalangeal joint.

From the measured morphological variables, body indices and ratios were calculated following established methods (Cabral et al., 2004; Hill et al. 2020; Marcenac and Aubert, 1974; Mariante et al., 2002; McManus et al., 2008; Rezende et al. 2015), as detailed below:

- Body index (BI) = TL/ChC; if BI > 0.90, they are longiline, suited for speedy animals; between 0.86 and 0.88, mediline with midway ratios has intermediate abilities and <0.85, breviline, more apt for force or strength.
- Body ratio (BR) = WH/TL; if the WH is less than the TL, the animal is considered low in front and vice versa, which is considered as defects. This inequality in heights may hinder both gait and resistance.
- Compact index 1 (CI1) = BW/WH; it indicates how compact the horse is. Animals used as saddle horses have CI1 < 2.20, animals suited for light traction have $2.60 \leq CI1 \leq 3.15$, and horses used for heavy pulling/traction have CI1 > 3.15.
- Dactyl thorax index (DTI) = CC/ChC; DTI > 0.105 for light small horses, up to 0.108 in intermediary horses, up to 0.110 in light traction animals, and up to 0.115 in heavy traction and riding horses. This index also indicates thoracic development.
- Relative body index (RBI) = TL/WH; it indicates useful indices in assessing functionality in horses. If > 110 in RBI, animals are overweight with poor gait; meanwhile, animals with an RBI lower than < 90 show poor gait and emaciated muscular appearances.
- Tare index 1 (trot or gallop) (TI1) = $ChC^2 \times 56/WH$; this index indicates weight in kilograms that the animal can withstand without excessive stress on the back, which can be carried working at a trot or gallop.

- Tare index 2 (walk) (TI2) = $ChC^2 \times 95/WH$; this index indicates the weight in kilograms that the animal can carry at a walking pace without excessive stress on its back while working at a walking speed.
- Thoracic development (TD) = ChC/WH; the values > 1.2 indicate animals with good TD or massiveness. Poor TD is associated with a lack of good musculature and deficiencies in the cardiovascular system. A horse with an excessively large thorax is also not desirable as the centre of gravity moves to the front of the horse.
- Relative thickness of the cannon bone index (RTCI) = CC/WH; higher values indicate harmony between the body conformation and bone development, and vice versa.
- Front-back height in (FBH) = WH/RH; FBH ≤ 1: straight back (no overload), or FBH > 1: the anterior region is higher than the posterior (overload).

The estimated body weight (BW) for each animal was calculated using the equation proposed by Eley and French (1993):

$$BW = (WH^{0.24}) \times (ChC^{2.576}) \times 0.000252$$

As this equation was originally developed for donkeys and has not yet been specifically validated in Arab-Barb horses, the resulting body weight (BW) estimates were considered as operational morphometric indicators rather than precise measures of actual live weight. Consequently, all BW-related analyses were interpreted in terms of comparisons among estimated body mass categories and were used primarily for relative group allocation, rather than as assessments based on exact body weight values.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, Version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics for all morphometric variables are presented as mean ± standard deviation (SD), minimum and maximum values, median, and coefficient of variation (%). Two-level comparisons of linear measurements and morphometric indices according to sex, estimated body weight group (≤ 480 kg vs > 480 kg), and region (Bejaia vs Oran) were performed using independent-samples t-tests, with Welch's correction when variances were unequal. Each morphometric index or ratio was analyzed separately as the dependent variable in a univariate general linear model (GLM). The model included the morphometric index as the dependent variable. Sex (male vs female), body weight Group (≤ 480 kg vs > 480 kg), and region (Bejaia vs Oran) were entered as fixed factors. The assumptions of the model homogeneity of variance and normality of residuals were checked. Statistical significance was set at P < 0.05, and GLM P values were obtained from Type III Sum of Squares F-tests. Pearson correlation coefficients (r) were calculated to evaluate the linear

relationships between linear measurements, estimated body weight, and morphometric indices. Model selection was based on predefined biological and geographic sources of variation. Interaction terms were not retained to preserve degrees of freedom given the modest sample size. Model fit, and effect magnitude were summarized using R^2 , and 95% confidence intervals were calculated for key descriptive estimates.

Results and Discussion

In general, the use of body morphometric descriptions as a means of comparing different animal breeds is a valuable approach (Ayad et al., 2019; Lomillos et al., 2020), as it provides important information on variation in form. This linear morphological assessment methodology is essential in animal biology and can be used in genetic analysis. It has been observed that animal genetic resources demonstrate significant heterogeneity with respect to breed in the natural environment, particularly with respect to body morphology and production potential. The Algerian horse population is predominantly composed of Barb and Arab-Barb horses, accounting

for 90% of the total, with the remaining 10% comprising a combination of other breeds (FAO, 2021). A clear distinction in the morphometric difference among horse breeds has been demonstrated (Brooks et al., 2010). The overall objective of this study was to highlight a series of morphometric characteristics in horses. These included linear measurements, body circumferences, and body biometric indices of Arab-Barb horses from two Algerian localities.

The results in Table 1 provide a comprehensive overview of the descriptive statistics of morphological variables, including mean, standard deviation, minimum and maximum values, median, and coefficient of variation, from linear measurements taken from Algerian Arab-barb horses. The findings of this study demonstrate that the descriptive analysis of horse linear measurements in northern Algeria exhibits relatively homogeneous patterns, as evidenced by coefficient of variation (CV) that does not exceed 0.23. Measurements of withers height, hind limb length, heart girth, body length, and rump length have been shown to provide valid estimates of total body size (Birteeb et al., 2012). This is because they

Table 1. Descriptive analysis of horse linear measurements in northern Algeria

Linear measures	Mean \pm SD	Min-Max	Median	CV (%)	95% CI
BW (kg)	485.0 \pm 66.9	336.1–631.6	493.9	13.8	465.7–504.1
EI (cm)	14.5 \pm 3.5	6–17	16	24.1	13.5–15.5
HL (cm)	58.9 \pm 3.4	50–66	60	5.8	57.9–59.9
NL (cm)	62.7 \pm 5.4	53–80	62	8.6	61.1–64.3
NC (cm)	108.7 \pm 12.0	93–150	107	11.1	105.3–112.1
SL (cm)	60.7 \pm 3.5	55–69	60	5.7	59.7–61.7
TL (cm)	145.8 \pm 7.9	134–169	145	5.5	143.5–148.1
HIL (cm)	109.2 \pm 6.7	95–124	110	6.1	107.3–111.1
ChC (cm)	171.9 \pm 9.1	151–190	173	5.3	169.3–174.5
WH (cm)	151.5 \pm 6.8	136–162	153	4.5	149.6–153.4
RH (cm)	150.4 \pm 5.7	138–160	152	3.8	148.8–152.0
SC (cm)	83.1 \pm 5.7	70–99	84	6.9	81.5–84.7
AL (cm)	30.0 \pm 5.2	21–46	28	17.5	28.5–31.5
FoL (cm)	40.3 \pm 3.2	31–47	40	8.0	39.4–41.2
CL (cm)	26.4 \pm 2.1	22–31	26	8.1	25.8–27.0
IL (cm)	38.4 \pm 8.6	26–55	35	22.3	35.9–40.9
FeL (cm)	38.9 \pm 6.6	26–53	38	17.1	37.0–40.8
FoC (cm)	45.5 \pm 4.0	40–54	44	8.7	44.4–46.6
KC (cm)	29.6 \pm 2.2	25–34	30	7.3	29.0–30.2
CC (cm)	19.3 \pm 1.2	17–22	19	6.0	19.0–19.6
FeC (cm)	24.1 \pm 4.0	15–30	25.5	16.7	23.0–25.2

Estimated body weight (BW); eye interval (EI); head length (HL); neck length (NL); neck circumference (NC); shoulder length (SL); total length (TL); humero-iliac length (HIL); chest circumference (ChC); withers height (WH); rump height (RH); space under the chest (SC); arm length (AL); forearm length (FoL); cannon length (CL); ilium length (IL); femur length (FeL); forearm circumference (FoC); knee circumference (KC); cannon circumference (CC); fetlock circumference (FeC); coefficient of variation (CV); standard deviation (SD), CI, 95% confidence interval around the whole-sample mean.

include key linear measurements that are indicative of body conformation and overall mass. To enhance the reporting of estimate precision, 95% confidence intervals (95% CI) were calculated for the principal morphometric and body weight variables across the entire study population. The corresponding intervals were 465.7–504.1 kg for BW, 169.3–174.5 cm for ChC, 149.6–153.4 cm for WH, 143.5–148.1 cm for TL, and 19.0–19.6 cm for CC.

The study results demonstrated that the size of the horses, based on height at the withers, overall length, and cannon bone circumference, was consistent with the results obtained in previous studies of different localities in Algeria (Rahal et al., 2009; Mebarki et al., 2018; Madani et al., 2024). The significant contribution of withers height and rump dimensions underscores the importance of the general skeletal framework in distinguishing breeds. The configuration of the horse's physique is indicative of its robustness. It is noteworthy that Arab-Barb horses are distinguished by their robustness and high adaptability, which enables their use across diverse activities such as ceremonial parades, field work, and

training applications. Additionally, they are used as a component of fantasias that constitute a conventional exposition of equestrian expertise in the Maghreb, which is performed during cultural festivals. As Denoix (2002) notes, the neck of the racehorse must be of sufficient length to ensure effective balance function, particularly during galloping, without overloading the front hand.

The data regarding the average weight and size of the animals' withers indicate a small body format, as noted by Benia et al. (2022). Moreover, it has been demonstrated that during gallop races, larger body surfaces require the use of enhanced thermoregulatory mechanisms (Metayer et al., 2003). On the other hand, Giontella et al. (2024) have reported higher values for wither height and cannon bone circumference (164.31 ± 0.20 and 20.78 ± 0.06 , respectively). In a recent study performed on Algerian fantasia horses, the values of withers height and body length were lower than those reported by Chaabi et al. (2025) (155.2 ± 2.76 and 154.3 ± 4.38 cm, respectively). The measurement of cannon circumference is indicative of the thickness of the bones and limb strength,

Table 2 Values of morphometric linear measurements of Algerian horses according to sex

Linear measures	Female (n = 27) (Mean \pm SD)	Male (n = 22) (Mean \pm SD)	P Value
BW (kg)	497.3 \pm 71.7	470.0 \pm 58.6	0.158
EI (cm)	14.6 \pm 3.2	14.2 \pm 3.9	0.679
HL (cm)	58.2 \pm 3.4	59.7 \pm 3.2	0.125
NL (cm)	60.6 \pm 2.8	65.2 \pm 6.6	0.005
NC (cm)	104.4 \pm 6.9	113.9 \pm 14.8	0.01
SL (cm)	60.6 \pm 3.1	60.8 \pm 3.9	0.823
TL (cm)	146.3 \pm 8.6	145.2 \pm 7.2	0.63
HIL (cm)	108.8 \pm 7.1	109.6 \pm 6.2	0.673
ChC (cm)	173.6 \pm 9.8	169.9 \pm 8.0	0.155
WH (cm)	151.0 \pm 6.3	152.1 \pm 7.4	0.592
RH (cm)	150.5 \pm 5.0	150.4 \pm 6.5	0.965
SC (cm)	82.5 \pm 5.3	83.8 \pm 6.3	0.437
AL (cm)	29.2 \pm 5.0	30.9 \pm 5.5	0.267
FoL (cm)	40.1 \pm 3.2	40.5 \pm 3.4	0.644
CL (cm)	26.0 \pm 2.0	26.8 \pm 2.2	0.183
IL (cm)	38.3 \pm 8.1	38.5 \pm 9.3	0.909
FeL (cm)	38.7 \pm 6.1	39.1 \pm 7.4	0.841
FoC (cm)	45.0 \pm 3.8	46.2 \pm 4.2	0.305
KC (cm)	28.7 \pm 1.9	30.7 \pm 2.0	< 0.001
CC (cm)	19.0 \pm 1.1	19.7 \pm 1.1	0.054
FeC (cm)	23.8 \pm 4.0	24.5 \pm 4.1	0.537

Estimated body weight (BW); eye interval (EI); head length (HL); neck length (NL); neck circumference (NC); shoulder length (SL); total length (TL); humero-iliac length (HIL); chest circumference (ChC); withers height (WH); rump height (RH); space under the chest (SC); arm length (AL); forearm length (FoL); cannon length (CL); ilium length (IL); femur length (FeL); forearm circumference (FoC); knee circumference (KC); cannon circumference (CC); fetlock circumference (FeC).

traits which are essential for structural soundness and adaptability in rough terrains, particularly in mountainous regions (Yakubu and Ibrahim, 2011). The observed disparities might be related to environmental and management practices, as well as to breed factors or crossbreeding that has occurred over time (Adinata et al., 2023).

Mean values of morphological variables of the Algerian horse population according to sex group are presented in Table 2. Neck length, neck circumference, and knee circumference differed significantly according to sex ($P < 0.05$). These differences indicate limited sexual dimorphism for selected neck and limb measurements. In contrast, estimated BW, head length, chest circumference, most other linear measurements did not differ significantly between females and males in the corrected analysis. The phenotypic differences in body size between the sexes are well documented and are associated with sexual dimorphism, which is driven by hormones that influence growth rates in mammalian taxa (Okpeku et al., 2011). However, in the present data set, sex-related differences should be interpreted cautiously

because the sample size was modest and body weight was estimated rather than directly measured. Values of linear measurements of horses in Algeria according to the estimated BW group are depicted in Table 3. Horses in the > 480 kg estimated BW group showed higher total length, humero-iliac length, chest circumference, withers height, rump height, cannon circumference, and fetlock circumference than horses in the ≤ 480 kg estimated BW group ($P < 0.05$). These results suggest that estimated BW was generally associated with larger thoracic, height, and selected support-structure dimensions. This interpretation must be cautious because BW was estimated partly from WH and ChC, which can strengthen statistical associations between estimated BW group and these measurements.

The estimated BW values obtained using this equation differ from values reported in previous investigations in Algeria (Benhamadi et al., 2017; Guedaoura et al., 2011; Rahal et al., 2009; Kacem et al., 2024). It has been reported that using chest girth and body length as linear measurements provides useful parameters for predicting body weight in cows

Table 3. Values of morphometric linear measurements of Algerian horses according to estimated body weight group

Linear measures	Estimated BW group (≤ 480 kg) (n = 22) (Mean \pm SD)	Estimated BW group (> 480 kg) (n = 27) (Mean \pm SD)	P Value
BW (kg)	426.3 \pm 46.8	532.9 \pm 34.6	< 0.001
EI (cm)	14.0 \pm 3.9	14.8 \pm 3.1	0.412
HL (cm)	58.4 \pm 2.9	59.2 \pm 3.8	0.409
NL (cm)	62.5 \pm 5.3	62.8 \pm 5.6	0.882
NC (cm)	105.2 \pm 8.0	111.4 \pm 14.0	0.071
SL (cm)	60.4 \pm 4.0	60.9 \pm 2.9	0.608
TL (cm)	143.1 \pm 7.0	148.0 \pm 8.1	0.033
HIL (cm)	106.7 \pm 6.3	111.2 \pm 6.3	0.016
ChC (cm)	164.0 \pm 6.7	178.4 \pm 4.5	< 0.001
WH (cm)	148.5 \pm 7.3	154.0 \pm 5.2	0.005
RH (cm)	148.0 \pm 5.9	152.4 \pm 4.7	0.006
SC (cm)	82.5 \pm 7.2	83.5 \pm 4.2	0.594
AL (cm)	30.6 \pm 6.1	29.5 \pm 4.5	0.467
FoL (cm)	39.7 \pm 3.8	40.8 \pm 2.7	0.262
CL (cm)	26.9 \pm 2.0	26.0 \pm 2.2	0.142
IL (cm)	40.8 \pm 8.1	36.4 \pm 8.6	0.078
FeL (cm)	39.7 \pm 6.4	38.2 \pm 6.9	0.449
FoC (cm)	45.3 \pm 3.9	45.7 \pm 4.1	0.766
KC (cm)	29.0 \pm 2.1	30.1 \pm 2.1	0.057
CC (cm)	18.9 \pm 0.8	19.6 \pm 1.3	0.016
FeC (cm)	22.7 \pm 4.4	25.2 \pm 3.4	0.034

Estimated body weight (BW); eye interval (EI); head length (HL); neck length (NL); neck circumference (NC); shoulder length (SL); total length (TL); humero-iliac length (HIL); chest circumference (ChC); withers height (WH); rump height (RH); space under the chest (SC); arm length (AL); forearm length (FoL); cannon length (CL); ilium length (IL); femur length (FeL); forearm circumference (FoC); knee circumference (KC); cannon circumference (CC); fetlock circumference (FeC).

(Paputungan et al., 2013). The differences between the average weight values could be explained by the condition of the horses at the time of measurement, but also by the formulas used to estimate body weight. The body morphometric results of horses by region from the regions of Oran and Bejaia in Algeria are presented in Table 4. Fourteen linear body parameters differed significantly between Oran and Bejaia regions ($P < 0.05$). The observed variation in the size and morphology of horses could be attributed to the geographical environments in which they are found (e.g., coastal plains, mountainous regions, or semi-desert areas). Furthermore, temperature and rainfall have been demonstrated to influence vegetation, which in turn indirectly affects animal development. The species-specific origin of the BW equation should be considered when interpreting these values. Differences in thoracic conformation, body condition, and breed type may influence the accuracy of field-based BW estimates. Moreover, because ChC and WH are included in the equation, analyses involving estimated BW, ChC, or WH are partly mathematically linked and should be interpreted as morphometric

associations rather than independent validation of live weight.

Body indices are important for understanding proportionality, conformation, and breed type and may also indicate environmental adaptations. It has been noted that they play a significant role in the selection of productive and reproductive traits. The most essential aspects for hard work are function, aptitude, disposition, and training (Folla et al., 2020). The results of various indices and ratios derived from linear measurements taken from Algerian Arab-Barb horses are summarized in Table 5. The results of body biometric indices according to sex, estimated body weight, and region are summarized in Tables 6, 7, and 8, respectively. In the unadjusted sex comparison, females showed higher thoracic development (TD), whereas DTI was lower in females than in males ($P < 0.05$). CI1, T11, TI2, RTCI, and the remaining indices did not differ significantly between sexes in the corrected unadjusted comparison.

According to DTI values, the body structure of female horses corresponds to that of light-traction categories, whereas male horses correspond

Table 4. Values of morphometric linear measurements of Algerian horses according to region

Linear measures	Oran region (n = 34) (Mean \pm SD)	Bejaia region (n = 15) (Mean \pm SD)	P Value
BW (kg)	497.2 \pm 46.4	457.2 \pm 95.4	0.141
EI (cm)	16.3 \pm 0.5	10.3 \pm 3.8	< 0.001
HL (cm)	60.1 \pm 2.1	56.1 \pm 4.1	0.002
NL (cm)	64.2 \pm 5.4	59.3 \pm 3.5	0.002
NC (cm)	109.4 \pm 13.0	106.9 \pm 9.6	0.512
SL (cm)	59.4 \pm 2.1	63.5 \pm 4.2	0.002
TL (cm)	144.9 \pm 6.6	147.7 \pm 10.5	0.352
HIL (cm)	108.4 \pm 5.5	110.9 \pm 8.7	0.313
ChC (cm)	173.6 \pm 6.2	168.2 \pm 13.1	0.146
WH (cm)	153.9 \pm 4.1	146.1 \pm 8.4	0.004
RH (cm)	152.4 \pm 3.9	146.0 \pm 6.6	0.002
SC (cm)	84.6 \pm 3.9	79.5 \pm 7.4	0.021
AL (cm)	27.0 \pm 2.4	36.7 \pm 3.5	< 0.001
FoL (cm)	41.5 \pm 2.6	37.5 \pm 2.8	< 0.001
CL (cm)	26.0 \pm 1.9	27.2 \pm 2.4	0.068
IL (cm)	33.4 \pm 4.2	49.6 \pm 4.1	< 0.001
FeL (cm)	35.3 \pm 3.7	47.0 \pm 4.0	< 0.001
FoC (cm)	43.9 \pm 2.9	49.3 \pm 3.6	< 0.001
KC (cm)	30.2 \pm 2.0	28.3 \pm 2.1	0.003
CC (cm)	19.2 \pm 1.1	19.5 \pm 1.2	0.527
FeC (cm)	26.5 \pm 1.7	18.7 \pm 1.9	< 0.001

Estimated body weight (BW); eye interval (EI); head length (HL); neck length (NL); neck circumference (NC); shoulder length (SL); total length (TL); humero-iliac length (HIL); chest circumference (ChC); withers height (WH); rump height (RH); space under the chest (SC); arm length (AL); forearm length (FoL); cannon length (CL); ilium length (IL); femur length (FeL); forearm circumference (FoC); knee circumference (KC); cannon circumference (CC); fetlock circumference (FeC).

Table 5. Morphometric indices and ratios of Algerian horses

Index/Ratio Horses Total (n = 49) (Mean ± SD)			
BI	0.85 ± 0.05	TI1	109.53 ± 10.14
BR	1.04 ± 0.06	TI2	185.82 ± 17.21
CI1	3.20 ± 0.39	TD	1.14 ± 0.06
DTI	0.112 ± 0.007	RTCI	0.128 ± 0.008
RBI	0.96 ± 0.05	FBH	1.01 ± 0.02

Body index (BI); body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

Table 6. Morphometric index and ratio of the horses in Algeria according to sex

Index/Ratio	Female (n = 27) (Mean ± SD)	Male (n = 22) (Mean ± SD)	P Value
BI	0.84 ± 0.04	0.86 ± 0.06	0.371
BR	1.03 ± 0.06	1.05 ± 0.06	0.38
CI1	3.29 ± 0.42	3.09 ± 0.33	0.075
DTI	0.110 ± 0.007	0.116 ± 0.005	0.001
RBI	0.97 ± 0.05	0.96 ± 0.06	0.406
TI1	112.03 ± 10.85	106.48 ± 8.46	0.056
TI2	190.04 ± 18.41	180.63 ± 14.36	0.056
TD	1.15 ± 0.06	1.12 ± 0.05	0.046
RTCI	0.126 ± 0.008	0.129 ± 0.009	0.143
FBH	1.00 ± 0.02	1.01 ± 0.02	0.151

Body index (BI); body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

Table 7. Morphometric index and ratio of Algerian horses according to estimated body weight

Index/Ratio	Estimated BW (≤ 480 kg) (n = 22) (Mean ± SD)	Estimated BW (> 480 kg) (n = 27) (Mean ± SD)	P Value
BI	0.87 ± 0.04	0.83 ± 0.04	< 0.001
BR	1.04 ± 0.06	1.04 ± 0.06	0.784
CI1	2.87 ± 0.24	3.46 ± 0.27	< 0.001
DTI	0.115 ± 0.006	0.11 ± 0.007	0.006
RBI	0.97 ± 0.05	0.96 ± 0.06	0.794
TI1	101.58 ± 6.06	116.01 ± 7.95	< 0.001
TI2	172.33 ± 10.28	196.81 ± 13.49	< 0.001
TD	1.11 ± 0.04	1.16 ± 0.06	< 0.001
RTCI	0.127 ± 0.007	0.128 ± 0.009	0.917
FBH	1.01 ± 0.02	1.01 ± 0.02	0.135

Body index (BI); body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

more closely to heavy-traction and riding horses, respectively. This index may also suggest that thoracic development is more pronounced in male horses than in female horses. Furthermore, CII refers to conformation category, and indicates the type of exercise traditionally associated with the index. The dactyl-thorax index reflects the relationship between body mass of individuals and the limbs that support it. Bone development may be indicated by the dactyl-thorax index and relative thickness of the cannon bone index. The DTI values obtained demonstrated that the horses exhibited sex-related differences in limb-to-thorax proportionality and bone development. These indices are best understood as indirect descriptors of proportionality and support structure. They may help generate hypotheses about functional aptitude, whereas confirmation of athletic performance, endurance capacity, or biomechanical efficiency would require direct measurements of locomotion, physiological, or performance measurements. These results are comparable with those reported in Spain (Solé et al., 2013) and Brazil (de Siqueira and Cordeiro, 2024).

Furthermore, our results revealed that the CII, TI1, TI2, and TD values of horses in the > 480 kg estimated BW group were significantly higher ($P < 0.05$) than those of horses in the ≤ 480 kg estimated BW group. In contrast, BI and DTI showed higher values in the ≤ 480 kg estimated BW group. This pattern appears to reflect the contribution of estimated BW and chest circumference to these indices. Therefore, the observed differences are more appropriately considered morphometric patterns associated with estimated mass than direct indicators of muscularity, endurance capacity, or physical activity exhibited by horses. Likewise, it has been reported that linear measurements and morphometric indices can be used to predict body weight in goats (Putra and Ilham, 2019).

The comparison between horses from the two regions of Algeria showed no significant differences in BI, BR, DTI, and RTCI ($P < 0.05$) was higher in horses from Bejaia region than in Oran region, whereas BR values were lower in Bejaia horses. The horses from the Bejaia area (Kabylie mountains) exhibited ration values closer to the mediline category, whereas Oran horses were closer to the breviline conformation category. These categories should be interpreted as morphological descriptors rather than as direct indicators of strength, traction ability, gait quality, or endurance capacity. This finding is consistent with the observations reported by Madani et al. (2024), who noted significant differences in body indices between horse populations in Algeria. A similar observation has been reported in Algerian Arab-Barb horses, in which body index values vary in different regions (coastal plains, high plateaus, desert, and mountains) (Mebarki et al., 2018). This may be explained by environmental factors, as climatic conditions and

farming systems differ between regions, likely because of their geographical separation.

Separate univariate GLMs were fitted for each morphometric index or ratio to assess the effects of sex, estimated BW group, and region on horse morphometric indices and ratios, as presented in Table 9. Estimated BW group emerged as the primary determinant of compactness and mass-related indices, with horses in the > 480 kg estimated BW group exhibiting significantly higher CII, TI1, TI2, and TD values ($P < 0.001$), independent of sex or region. Region also influenced body proportions, as evidenced by significant differences in BI, BR, DTI, RBI, and RTCI between regions ($P < 0.05$), suggesting environmental or sub-population effects on skeletal conformation. Sex had a comparatively limited impact after controlling for estimated body weight group and region, with DTI remaining significantly associated with sex ($P = 0.003$). Model R^2 values ranged from 0.157 for FBH to 0.593 for CII, indicating variable explanatory capacity depending on the index. The strongest model fit was observed for estimated BW-dependent indices, especially CII, TI1, and TI2, which is expected because several indices include estimated BW or chest measurements in their calculation.

It is well established that selection criteria during marketing and breeding are determined by breeders and breeding associations. The health status and intended use of horses are also taken into consideration (Jönsson et al., 2014). Evaluating correlations between morphometric indices and ratios is important for determining genetic potential, describing breed standards, and supporting breed management and conservation programs aimed at increasing meat production (Younas et al., 2013). The correlation coefficients (r) among the 31 variables, including morphometric characteristics, estimated body weight, biometric indices, and ratios, are presented in the heatmap, with the corresponding values displayed within the cells (Fig. 2). Overall, most correlations in Algerian horses exceeded 0.6 ($P < 0.002$, $P < 0.0001$), indicating strong relationships and a high degree of homogeneity among linear measurements.

The results of the present study demonstrated a high degree of positive correlation among the examined horses. This may indicate that an increase in linear measurements is accompanied by a corresponding increase in estimated BW. This may be attributed to factors such as the availability of feed resources and the quality of management practices. The calculation of the correlation coefficients indicated that body weight exhibited a high correlation with ChC, compared with other measurements. This finding clearly suggests that chest circumference is the most reliable measurement for predicting the live weight of horses. The analysis of the correlation coefficients between the biometric indices and the ratios of the Algerian horse population revealed both negative and positive correlations ($P < 0.001$). Because ChC

is one of the input variables in the BW equation, its strong association with estimated BW is expected and should be interpreted as internal consistency within the estimation framework rather than as independent validation of ChC against directly measured live weight.

The present study indicates that morphometric analysis can support the description of animals with different body conformation indices. In this study, the results obtained are in close agreement with those reported by Guyo et al. (2024). The correlations observed for body conformation indices varied considerably, ranging from highly positive to markedly negative associations with the functional characteristics under investigation. Correlation results may help identify morphometric variables useful

for future selection or conservation programs, but they should not be considered sufficient evidence for advanced selection strategies without larger data sets, pedigree or molecular information, and direct functional assessment. This is achieved through the use of morphological variables employed in body conformation analysis (Ribeiro et al., 2024).

The present study has several limitations that should be acknowledged when interpreting the findings. First, the sample size was relatively modest ($n = 49$), which may have reduced statistical power and limited the generalizability of the results. Second, the study population was drawn from only two regions of Algeria; therefore, caution should be exercised when extrapolating these findings to the broader Arab-Barb horse population across the country. Third, BW was

Table 8. Morphometric index and ratio of the horses in Algeria according to area

Index/Ratio	Oran area (n = 34) (Mean \pm SD)	Bejaia area (n = 15) (Mean \pm SD)	P Value
BI	0.84 \pm 0.04	0.88 \pm 0.04	0.002
BR	1.06 \pm 0.05	0.99 \pm 0.05	< 0.001
CI1	3.23 \pm 0.29	3.12 \pm 0.57	0.473
DTI	0.111 \pm 0.006	0.116 \pm 0.007	0.012
RBI	0.94 \pm 0.04	1.01 \pm 0.05	< 0.001
TI1	109.83 \pm 7.65	108.86 \pm 14.63	0.811
TI2	186.32 \pm 12.98	184.67 \pm 24.83	0.811
TD	1.13 \pm 0.04	1.15 \pm 0.08	0.287
RTCI	0.125 \pm 0.007	0.133 \pm 0.007	< 0.001
FBH	1.01 \pm 0.02	1.00 \pm 0.02	0.102

Body index (BI); body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

Table 9. General linear model (GLM) analysis of the effect of sex, estimated body weight and region on morphometric index and ratios of Algerian horses

Index/ratio	Sex (P Value)	Estimated BW (P Value)	Region (P Value)	R ² (Model Fit)
BI	0.839	0.003	0.006	0.343
BR	0.296	0.714	< 0.001	0.362
CI1	0.526	< 0.001	0.844	0.593
DTI	0.003	0.08	0.017	0.367
RBI	0.323	0.678	< 0.001	0.371
TI1	0.379	< 0.001	0.339	0.530
TI2	0.379	< 0.001	0.339	0.530
TD	0.196	< 0.001	0.018	0.354
RTCI	0.063	0.18	< 0.001	0.294
FBH	0.057	0.092	0.175	0.157

Body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

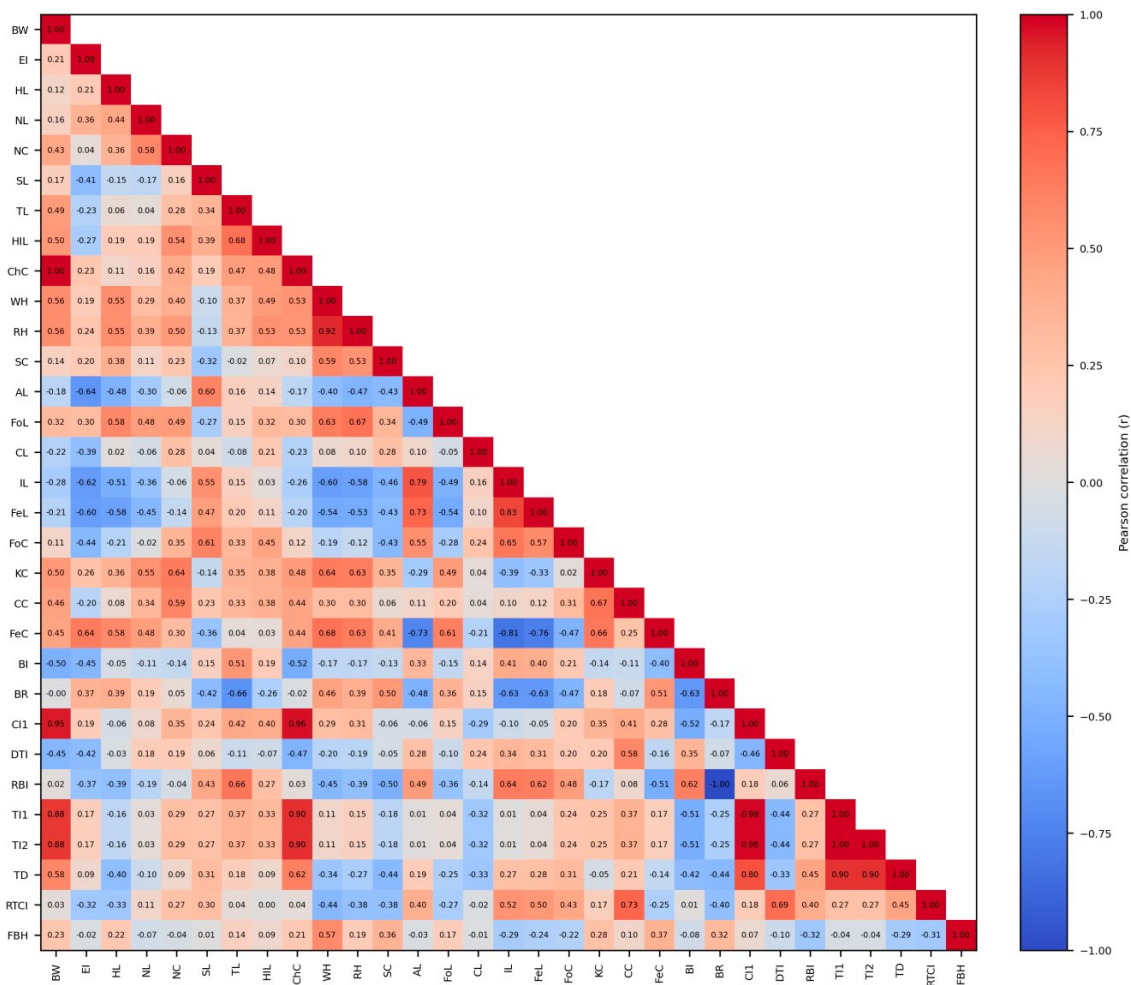


Fig.2. Phenotypic correlation coefficients (r) between 31 variables, including morphometric characteristics, estimated body weight, biometric indices, and ratios in Algerian horses

Estimated body weight (BW); eye to eye space (EI); head length (HL); neck length (NL); neck circumference (NC); shoulder length (SL); total length (TL); humero-iliac length (HIL); chest circumference (ChC); withers height (WH); rump height (RH); space under the chest (SC); arm length (AL); forearm length (FoL); cannon length (CL); ilium length (IL); femur length (FeL); forearm circumference (FoC); knee circumference (KC); cannon circumference (CC); fetlock circumference (FeC). Body index (BI); body ratio (BR); compact index 1 (CI1); dactyl thorax index (DTI); relative body index (RBI); tare index 1 (trot or gallop) (TI1); tare index 2 (walk) (TI2); thoracic development (TD); relative thickness of cannon bone index (RTCI); front-back height in (FBH).

estimated using an allometric equation originally developed for donkeys. Although this approach provides a practical alternative under field conditions where weighing facilities are unavailable, the equation has not yet been formally validated for Arab-Barb horses. Consequently, the derived BW values should be regarded as operational morphometric proxies rather than exact live-weight measurements. Accordingly, BW-based classifications and associated analyses should be interpreted as comparisons among estimated body mass categories rather than absolute weight-based assessments. Finally, athletic performance, endurance capacity, gait quality, and biomechanical function were not directly measured; consequently, functional interpretations based on morphometric indices should remain inferential.

Conclusion

The present study provides an updated morphometric profile of Algerian Arab-Barb horses from two northern regions and confirms a broadly homogeneous conformation, with measurable variation related to sex, estimated body weight, and geographic origin. The combination of linear measurements and body indices indicates a predominantly compact and breviline morphotype, offering a useful phenotypic reference for breed description, management, and conservation planning. Regional differences suggest that local environmental conditions, management systems, and population structure may contribute to conformational variability within Algerian Arab-Barb horses. These findings strengthen the morphometric basis for characterizing this national equine resource and highlight the importance of continued phenotypic monitoring combined with broader regional and molecular investigations.

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