Iranian Journal of Veterinary Science and Technology

Received: 2025- Mar-18
Accepted after revision: 2025- Jul-22
Published online: 2025-Jul-23

RESEARCH ARTICLE

DOI: 10.22067/ijvst.2025.92718.1491

Osteo-Morphometry in Ouled-Djellal White Arab Sheep: Age-Related Correlations between Mandible, Skull and Body Measurements

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ABSTRACT

The Ouled Djellal White Arab sheep is the predominant breed in the Algerian steppes and high plains, known for its adaptability and meat production. This study examines correlations between mandibular, body, and craniometric measurements in two age groups to establish a reference dataset for archaeozoological applications. Thirty female Ouled Djellal sheep, evenly divided into young adults (2–4 years) and adults (>4 years), were examined. Eight body measurements were recorded pre-slaughter, followed by eight mandibular and sixteen craniometric measurements after bone preparation, with four indices subsequently calculated. Significant correlations were observed between mandibular and body measurements, and between mandibular and craniometric parameters. Correlations were more numerous and stronger in adults (ranging from 0.47 to 0.70) than in young adults (from 0.41 to 0.67). While differences in covariation strength were observed between age groups, some correlations, such as those between thoracic perimeter (TP) and mental foramen length (ML6), and between head length (hL) and aboral height of the ascending branch (MH1) persisted across age groups. Dentition-related measurements correlated more frequently in adults, reflecting skeletal maturity, whereas variability in young adults indicated ongoing growth. These findings highlight the importance of age considerations in morphometric analysis and provide reference data for estimating body size and cranial dimensions from mandible measurements, contributing to archaeozoological studies of North African ancient specimens.

Keywords

Archaeozoology, correlations, craniometry, sheep

Abbreviations

ANCOVA : Analysis of Covariance

Number of Figures: 7
Number of Tables: 6
Number of References:: 24
Number of Pages: 13

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Introduction

Algerian White Arab sheep, or Ouled Djellal, is the predominant sheep breed in the Algerian steppes and high plains, representing approximately 63% of the national flock, estimated at around 12 million head. Native to the Ouled Djellal region, this breed is characterized by its slim build, refined head, and high-quality white wool. It is well adapted to arid environments and suited to a nomadic lifestyle [1, 2].

Archaeological research in Algeria, despite being in its early stages, has led to the discovery of several sites, revealing animal bone remains from periods spanning the Paleolithic to the Neolithic. Notable examples include Oued Boucherit in Sétif (dated 2.4–1.7 million years ago) [3], Tighennif in Mascara (around 700,000 years ago) [4], and Gueldaman Cave GLD1 near Akbou, Béjaïa (dated to 5052-4885 B.C.) [5]. These sites have provided a variety of animal remains, including sheep mandibles and skull fragments. Such archaeozoological findings enable researchers to explore the attributes of ancient fauna. However one major challenge persists: the absence of robust reference database from living animals, particularly for body measurements. Estimation body measurements from archaeological bones relies on comparative datasets that include both body measurements and osteometric data from known specimens. Such reference datasets are scarce and currently absent for North African sheep populations.

This research is part of a series of osteobiometric studies on native Algerian ruminants, including sheep [6, 7], goats [8, 9], and camels [10, 11]. Building upon this work, the current study aims to examine correlations between the body measurements taken from live Ouled Djellal sheep and osteometric parameters of their skulls and mandibles. These correlations were compared between young adults and adults. The ultimate aim is to establish a reliable reference framework of one of the main breeds of Algeria, thereby enabling archaeozoologists to estimate body size and cranial dimensions from mandibular remains recovered in archaeological sites.

Result

Univariate analysis

The mandibular parameters MH1, MH7, MH8, and RM1 showed statistically significant differences between the age groups ($p < 0.05$; Table 1 and Figure 1). Average values for MH1 and MH8 were higher in adults, whereas MH7 and RM1 were higher in young adults. Notably, the average RM1 index was lower in adults than in young adults.

Bivariate analysis

Correlations by Age

Significant correlations between mandibular and body measurements, as well as between mandibular and craniometric parameters, were more numerous and stronger in adults than in young adults (Tables 2 and 3). When significant, correlation coefficient for adults ranged from 0.47 to 0.70, while for young adults they ranged from 0.41 to 0.67.

To evaluate whether age groups differed in their covariation patterns, a series of two-way ANCOVAs was conducted (Table 2). Some of these relationships remained stable across both age groups, such as those between thoracic perimeter (TP) and ML6, as well as between head length (hL) and MH1. However, 5 out of 20 mandibular body parameter pairs and and 10 out of 44 mandibular craniometric parameters pairs (Table 2) showed non homogeneous relationship between young adults and adults. In these case, correlation were analyzed separately. Examples include: Adults: correlations between head length (hL) and ML9, head width (hW) and MH9, as well as between MH8 and CL20, and MH9 and CL31. Young adults: correlations between scapulo-ischial length (SIL) and mandible weight (MW), as well as between CB8 and MB1. In general, measurements related to dentition (ML9, MH9, MH8) were more commonly observed in adults.

The four strongest and most significant correlations are illustrated in Figure 2, showing examples from both mandibular and body parameter pairs (Figures 2A,2B), as well as mandibular and craniometric parameters (Figures 2C,2D) for both age groups.

Correlations in the total population

Most correlations between mandiblar and body measurements were consistent between the two age groups (Table 2 and Table 3). Out of 99 correlations, only 14 differed significantly between age groups (Table 4). These correlations were considered low, with coefficients ranging from 0.10 to 0.39 or moderate from 0.40 to 0.59.

Analysis of mandible and skull measurements revealed several significant correlations between mandibular and craniometric parameters (Table 5). The strongest correlation was between mandible weight (MW) and skull weight (SW), with a correlation coefficient of 0.85.

The mental foramen length (ML6) and the aboral height of the ascending branch (MH1) were most frequently correlated with craniometric parameters. ML6 showed the strongest correlations with both skull lengths and height CH6, while MH1 was primarily correlated with cranial widths, but also with certain lengths and height CH6.

Table 1.
Descriptive statistics of mandibular parameters

Groups	Statistical parameters	ML6	ML8	ML9	MB1	MH1	MH7	MH8	MH9	MW	RM1	RM2
Young adults N=15	m	165,05	58,50	24,22	61,71	82,97	41,33	24,26	19,71	83,20	25,10	74,45
	Min	155,36	52,68	19,43	52,44	76,88	37,36	21,41	16,57	70,00	22,19	59,66
	Max	180,15	62,66	28,24	68,18	88,35	47,37	26,06	22,15	94,00	30,18	82,58
	σ	6,99	3,05	1,95	5,00	3,47	2,92	1,45	1,81	6,56	2,26	6,10
	CV%	4,23	5,21	8,04	8,10	4,18	7,07	5,99	9,20	7,88	9,00	8,19
Adults N=15	m	166,74	57,09	24,12	62,16	88,54	38,88	25,55	20,65	85,80	23,35	70,33
	Min	152,66	51,27	21,66	52,82	83,34	35,79	23,70	18,04	67,00	21,31	62,69
	Max	178,39	63,10	26,52	70,35	96,88	42,50	27,63	24,19		26,61	83,59
	σ	6,62	3,28	1,40	5,02	4,26	1,93	1,19	2,01	14,17	1,48	6,46
	CV%	3,97	5,74	5,81	8,07	4,81	4,95	4,64	9,72	16,51	6,35	9,18
total Population N=30	m	165,89	57,79	24,17	61,94	85,76	40,10	24,90	20,18	84,50	24,22	72,39
	Min	152,66	51,27	19,43	52,44	76,88	47,37	21,41	16,57	67,00	21,31	59,66
	Max	180,15	63,10	28,24	70,35	96,88	2,73	27,63	24,19		30,18	83,59
	σ	6,74	3,19	1,67	4,93	4,75	35,79	1,46	1,94	10,93	2,08	6,52
	CV%	4,06	5,52	6,90	7,95	5,54	6,81	5,86	9,61	12,93	8,58	9,00
p YA-A		0,389	0,25	0,885	0,87	0,001	0,033	0,033	0,325	0 ,95	0,019	0,067

m: mean, Min: minimum, Max: maximum, σ: standard deviation, CV%: coefficient of variation in %.
p YA-A corresponds to the p-value for the Wilcoxon-Mann-Whitney test comparing young adults and adults.

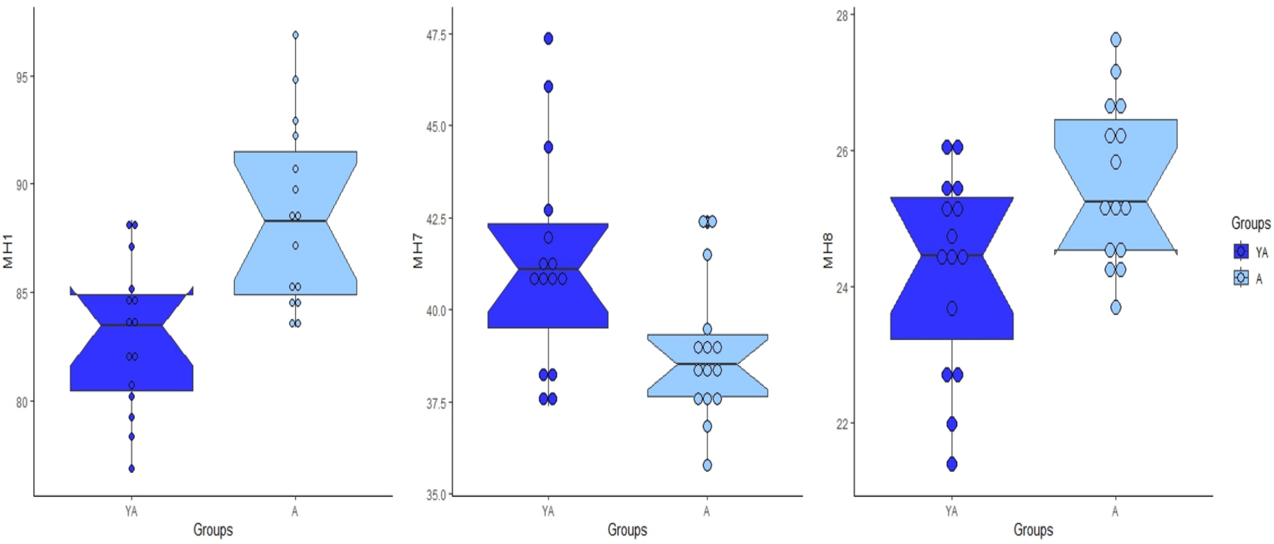

Figure 1.
Boxplots illustrating the variation in the mandibular variables MH1 (left), MH7 (middle), and MH8 (right) between Young Adults (YA) and Adults (A). Descriptions of these variables can be found in Table 6.

Table 2.
Correlations between mandibular and body parameters by age.

VAR 1	VAR 2	Total population	Adults	Young adults	p-value
LW	MH1	0.28	0.66	0.20	0.208
LW	MH8	0.29	0.17	0.65	0.335
SIL	MW	-0.07	0.20	-0.55	0.026
WH	MH8	0.13	0.73	0.16	0.137
TP	ML6	0.51	0.46	0.60	0.973
TP	MH1	0.38	0.66	0.30	0.298
TP	MH8	0.33	0.18	0.62	0.44
CP	MH1	0.48	0.64	0.35	0.292
CP	MH9	0.42	0.52	0.25	0.335
CP	MW	0.41	0.63	-0.26	0.042
hL	ML6	0.48	0.45	0.58	0.575
hL	ML9	0.34	0.61	0.09	0.02
hL	MH1	0.54	0.65	0.46	0.226
hW	MH9	0.20	0.57	-0.33	0.016
hW	MH1	0.48	0.50	0.52	0.912
hW	MW	0.50	0.63	0.52	0.679
eL	MH1	0.22	0.52	0.19	0.43
eW	MH1	0.29	0.62	0.29	0.516
eW	MH8	0.31	0.51	0.33	0.48
eW	MW	0.16	0.47	-0.40	0.033

p-value represent the difference between the young adults and the adults using two-way ANCOVA test.

Table 3.
Correlations between mandibular and craniometric parameters by age.

VAR 1	VAR 2	Total population	Adults	Young adults	p-value
CL1	ML6	0.76	0.80	0.72	0.352
CL1	MH1	0.63	0.77	0.56	0.538
CL2	ML6	0.81	0.82	0.80	0.481
CL2	MH1	0.63	0.76	0.57	0.621
CL7	ML6	0.75	0.76	0.76	0.24
CL7	MH1	0.58	0.50	0.60	0.952
CL10	ML6	0.55	0.51	0.56	0.917
CL10	ML9	0.32	0.50	0.21	0.231
CL10	MH1	0.42	0.28	0.56	0.378
CL20	MB1	0.45	0.50	0.39	0.616
CL20	MH8	-0.001	-0.38	0.48	0.032

Table 3 cont.

VAR 1	VAR 2	Total population	Adults	Young adults	p-value
CL31	ML6	0.46	0.60	0.52	0.779
CL31	ML8	0.65	0.57	0.68	0.577
CL31	MH7	0.47	0.53	0.27	0.273
CL31	MH9	0.04	0.54	0.28	0.033
CL31	MW	0.34	0.65	0.04	0.364
CL34	ML6	0.44	0.61	0.31	0.305
CL34	MB1	0.25	0.53	0.04	0.115
CB2	MH1	0.29	0.19	0.69	0.15
CB2	MH7	0.26	0.54	0.10	0.096
CB2	MH9	0.29	0.51	0.04	0.192
CB3	MH1	0.56	0.34	0.62	0.128
CB8	MH1	0.34	0.51	0.22	0.769
CB8	MB1	-0.23	0.21	0.57	0.024
CB8	MW	-0.04	0.19	0.46	0.044
CB8	RM2	-0.41	0.07	0.67	0.037
CB10	MH1	0.65	0.67	0.82	0.203
CB10	MH7	0.06	0.56	0.14	0.045
CB10	MH9	0.38	0.65	0.07	0.148
CB10	MW	0.33	0.61	0.20	0.087
CB14	MH1	0.68	0.56	0.69	0.453
CB14	MW	0.39	0.70	0.28	0.026
CB18	MH1	0.55	0.35	0.52	0.307
CB18	MW	0.09	0.32	0.41	0.049
CB19	MH1	0.60	0.62	0.60	0.947
CB19	MW	0.37	0.50	0.04	0.455
CH5	MH1	0.04	0.02	0.67	0.127
CH6	ML6	0.76	0.71	0.83	0.944
CH6	MB1	0.59	0.67	0.49	0.426
CH6	MH1	0.39	0.36	0.60	0.43
SW	ML8	0.14	0.45	0.53	0.02
SW	MH1	0.49	0.64	0.28	0.074
SW	MH7	0.19	0.63	0.16	0.003
SW	MW	0.85	0.92	0.50	0.062

p-value represent the difference between the young adults and the adults using two-way ANCOVA test.

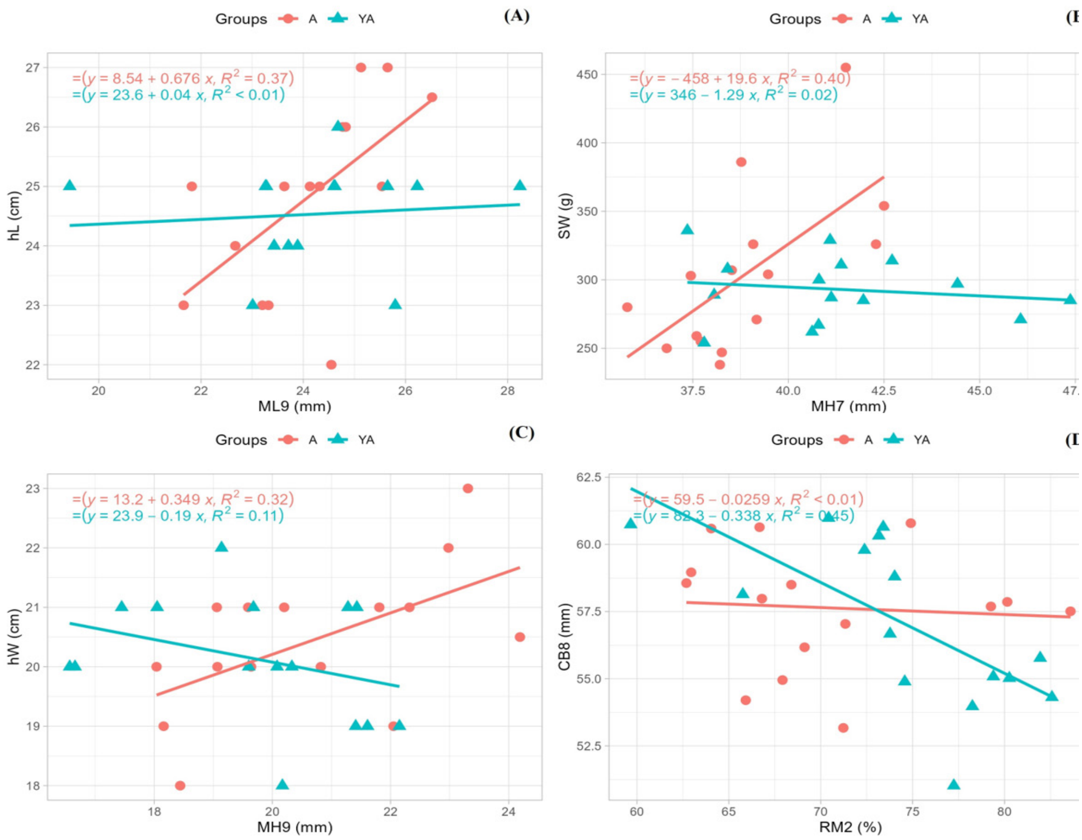

Figure 2.
Example of a scatter plots with linear regression between mandibular and body parameters: A. hL=f(ML9), B. hW=f(MH9) and between mandibular and craniometric parameters: C. SW = f(MH7), D. CB8 = f(RM2) for adults and young adults. Only the strongest correlations are shown.

Table 4.
Correlations between mandibular and body measurement for all specimens. Only the significant correlations ($p < 0.05$) are shown.

Body measurements	Mandibular measurements	Coefficient (r)	p-value
Head length	MH1	0.54	0.0022
Thoracic Perimeter	ML6	0.51	0.0042
Head width	MW	0.50	0.0044
Cannon perimeter	MH1	0.48	0.0068
Head length	ML6	0.48	0.0073
Head width	MH1	0.48	0.0066
Cannon perimeter	MH9	0.42	0.021
Scapulo-ischial length	RM1	0.41	0.022
Cannon perimeter	MW	0.41	0.024
Cannon perimeter	ML6	0.39	0.032
Live weight	ML9	0.38	0.038
Thoracic Perimeter	MH1	0.38	0.040
Scapulo-ischial length	MH7	0.38	0.038
Live weight	MH7	0.37	0.043

p-value represent the difference between the young adults and the adults using two-way ANCOVA test.

The four strongest and most significant correlations are illustrated in Figure 3, showing pairs of mandibular-body (Figure 3A,3B), and mandibular-craniometric relationships (Figure 3C,3D).

Table 5.
Correlations between mandibular and craniometric measurement for all specimens. Only the significant correlations ($p < 0.05$) are shown.

Mandibular measurements	Craniometric measurements	Coefficient (r)	*p*-value
MW	SW	0.85	2.17e-09
ML6	CL2	0.81	5.90e-08
ML6	CH6	0.76	9.46e-07
ML6	CL1	0.76	1.14e-06
ML6	CL7	0.75	2.20e-06
MH1	CB14	0.68	3.30e-05
ML8	CL31	0.65	0.00011
MH1	CB10	0.65	9.74e-05
MH1	CL1	0.63	0.00016
MH1	CL2	0.63	0.00021
MH1	CB19	0.60	0.00041
MB1	CH6	0.59	0.00065
MH1	CL7	0.58	0.00086
MH1	CB3	0.56	0.0013
MH1	CB18	0.55	0.0015
ML6	CL10	0.55	0.00181
MH1	SW	0.49	0.00578
MH7	CL31	0.48	0.00805
ML6	CL20	0.47	0.00802
MB1	CL7	0.46	0.00985
ML6	CL31	0.46	0.0100
MB1	CL20	0.45	0.0137
ML6	CB10	0.44	0.0139
MH9	CB10	0.38	0.0384
MW	CB19	0.37	0.0451
MB1	CL2	0.37	0.0445

Discussion

This study examined the correlations between mandibular and craniometric osteometric measurement, and body measurements on the living animals in Ouled Djellal sheep, focusing on age-related effects, it revealed that the average mandibular height behind M3 (MH7) was greater in young adults. This can be attributed to the association of MH7 with the eruption of third molar (M3): after M3 eruption is complete in adults, the mandibular body tends to lower (Figure 4). Similar findings were noted by Ridouh [12] in the native Algerian goat and by Dib, Babelhadj [11] in the Tergui dromedary. In contrast, the higher value of MH8 in adults may relate to the eruption of premolars prier to adulthood.

When comparing the Ouled Djellal sheep with other breeds, the mental foramen length (ML6) in our sample (165.89 mm) is greater than that in other sheep breeds, including Yankassa (165 mm) [13], Konya Merino (163.44 mm) [14], Barbados Black Belly (160.9 mm), Awassi Females (155.22 mm) [15], French breeds (152 mm) [16], Mehraban (137.4 mm) [17], Morkaraman (122.29 mm), Tuj (118.85 mm) [18], and Iranian Native sheep (112.9 mm) [19]. This indicates that Ouled Djellal females have relatively longer mandibles compared to most other breeds.

Regarding mandibular angle width (MB1), the Ouled Djellal (61.94 mm) exhibits a mean value close to that of Sharri females (61.64 mm) [20] and Awassi females (60.22 mm) [15]. yet exceeded values reported for Norduz females (45.14 mm) [21], Konya Merino (56.88 mm) [14], Tuj (43.61 mm), Morkaraman (43.2 mm) [18], and French breeds (58 mm) [16]. This suggests broader mandibles in Ouled Djellal females.

The height of the ascending branch (MH1) is particularly higher in Ouled Djellal females (85.76 mm), than French breeds (80 mm) [16], Mehraban (77.5 mm) [22], Konya Merino (76.11 mm) [14], Barbados Black Belly (70.8 mm) [23], Zell sheep females (69.81 mm) [24], Iranian native sheep (62.6 mm) [19], Morkaraman (62.08 mm) [18], Norduz females (61.98 mm) [21], and Tuj (60.86 mm) [18]. This further supports the Ouled Djellal females are distinguished by the greater height of their mandibular branches.

Comparing our findings with to Ami's [6] results on Ouled Djellal from the same region, the mean values of ML6 (153.20 mm), MB1 (59.6 mm) and MH1 (79.86 mm) were lower in Ami's study. This difference may be due to the presence of juvenile individuals in Ami's dataset.

Since these three parameters (ML6, MB1, MH1) represent the mandibular dimensions along its main

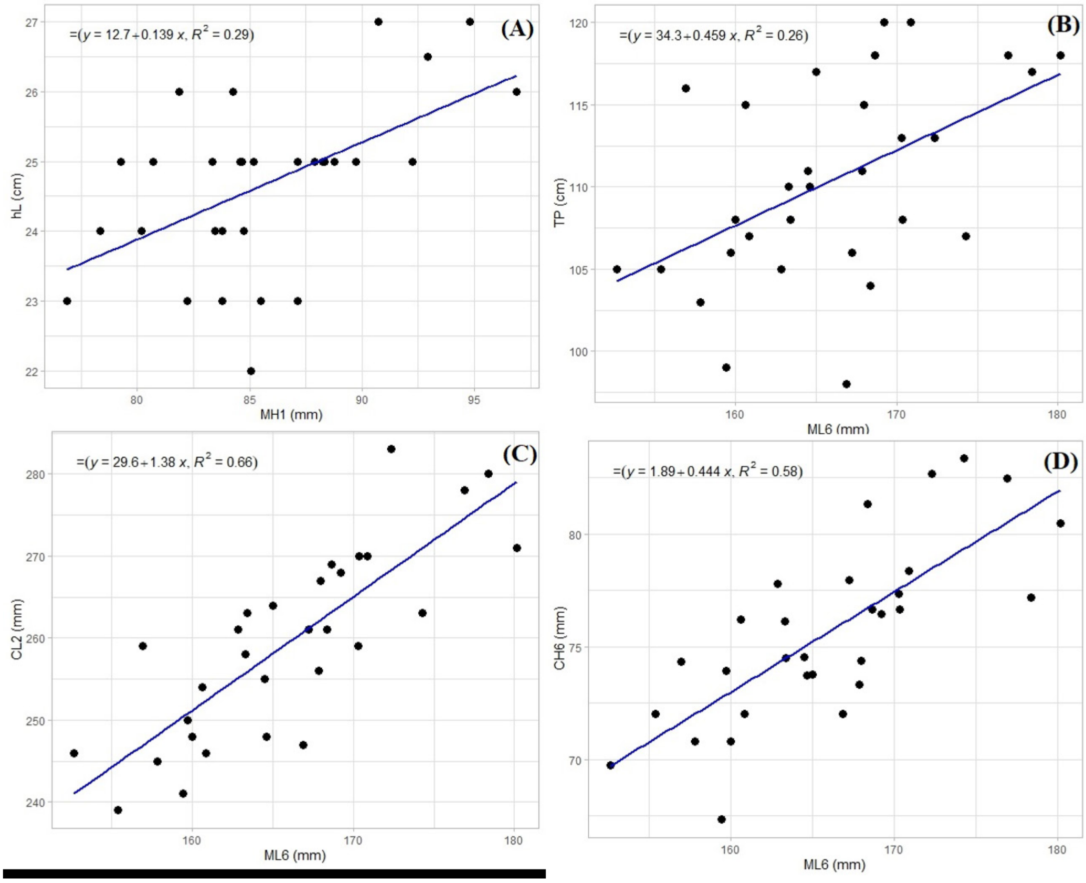

Figure 3.
Example of scatter plots with linear regression between mandibular and body parameters: A. hL=f(MH1), B. TP=f(ML6) and between mandibular and craniometric parameters: C. CL2 = f(ML6), D. CH6 = f(ML6) for all specimens. Only the strongest correlations are shown.

Figure 4.
Mandibular corpus height behind the third molar (MH7) in young adults (top) and adults (bottom)

axes, our results suggest that the mandibles in our study population are overall relatively larger than other sheep breeds.

The lower RM1 values in adults, suggest thinner mandibular bodies compared to young adults. Additionally, both RM1 (24.22%) and RM2 (72.39%) in our study were lower than those reported by Ami [6] for Ouled Djellal (26.06% and 74.63%), and by Guintard and Fouché [16] for French breeds (25% and 73%). These findings indicate that the mandibles in our study possess more slender bodies.

Moreover, the correlation patterns were stronger and more consistent in adults than young adults. In young adults, varying growth rates between zootechnical and bone parameters suggest that osteological development is still ongoing. In contrast, adults exhibit a stable and fully mature form across both zootechnical and osteological measures, which likely explains the stronger consistency in correlations at this stage.

Furthermore, the relatively weak correlations in the total population can be attributed to several factors, such as age, dentition stage, nutrition, and environmental conditions, all of which influence the growth and development of sheep in uneven ways, thereby leading to differences in mandible morphology. Despite these variations, certain mandibular measurements (especially MH1 and ML6) show significant correlations with body parameters. For example, the strongest correlations were observed between the head length and the height of the ascending branch (MH1), and between the thoracic perimeter and the mental foramen length (ML6) (Figure 3).

Regarding the correlations between the mandibular and craniometric parameters, the results indicate that ML6 reflects the linear skull dimensions, while mandibular height (MH1) is more closely associated with cranial widths. These results suggest that the mandibular axes (ML6, MH1, MB1) showing significant correlations with the three main skull dimensions (length, width, and height). This reflects harmonious growth between mandibular and cranial structures, confirming that the mandible and skull may develop in an interdependent manner.

The results indicate that the mandibles of Ouled Djellal females are both larger and more slender than those of other breeds, with adults exhibiting even greater size and slenderness compared to young adults. Across the population, significant correlations were observed between body and mandibular measurements. Additionally, the three axes of the mandible are significantly correlated with skull measurements, reflecting the harmonious growth between the mandible and skull. Most correlations between mandibular, craniometric, and body parameters remain consistent across age groups, while others vary. Significant correlations are more frequent in adults, suggesting that they have reached a stable, mature form in both zootechnical and osteological aspects, whereas young adults exhibit differential growth patterns. The identified correlations highlight the importance of taking into account the age of the specimens when mandibular measurements are used for estimating body and craniometric dimensions. This study paves the way for age-specific predictive models in archaeozoology.

Materials and Methods

This study was conducted on 30 female Ouled Djellal sheep obtained from the slaughterhouses in Aïn Fakroun and Télaghma, northeastern Algeria, between March 2022 and May 2023. All animals appeared healthy and were over two years old. They were divided into two age groups: young adults (YA) aged 2 to 4 years, and adults (A) over 4 years.

Body Measurements

Before slaughter, eight body measurements (Figure 5) were recorded using a tape measure (cm): withers height (WH), scapulo-ischial length (SIL), thoracic perimeter (TP), cannon perimeter (CP), head length (hL), head width (hW), ear length (eL), and ear width (eW). Live weight (LW) was estimated using body weight prediction formulas: LW= 0.635 TP - 23.026 and LW = 0.7536 SIL - 19.2234 [13].

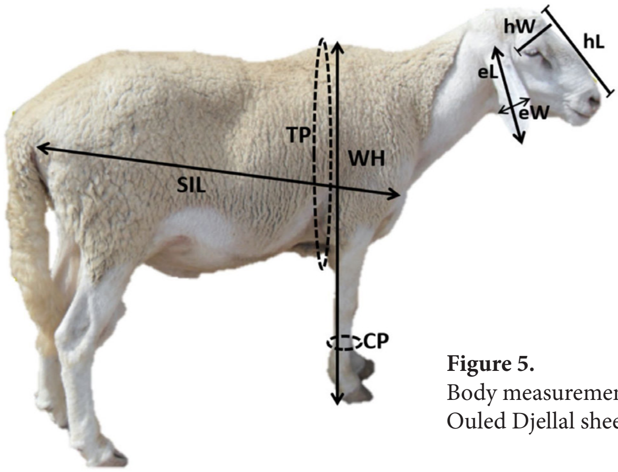

Figure 5.
Body measurements on Ouled Djellal sheep

Specimen Preparation

After slaughter, each head was collected, labeled with identification number, and linked to its corresponding body measurement data. Soft tissues were removed, and the bones were cleaned by boiling for several hours, rinsing in running water, and air-drying. Each skull and mandible (right side) were labeled accordingly. Mandible weight (MW) and skull weight (SW) were recorded in grams using a precision scale.

Osteometric Measurements

Eight mandibular and sixteen cranial measurements were taken in millimeters using a caliper (accuracy ± 0.02 mm), a ruler for linear dimensions (e.g., CL1, CL2), and a thickness compass for specific parameters (e.g., CH6). Measurement protocols followed Ridouh's [14] methodology (Figures 6 and 7, Table 6). Additionally, four indices (RM1, RM2, RC5, and RC7), were selected based on criteria proposed by Guintard [15], then were calculated to provide further morphometric insights.

Statistical Analysis

All statistical analyses were conducted using R (version 4.3.1) with the RStudio interface. Descriptive statistics, including mean (m), minimum (min), and maximum (max) values, were calculated for each age group and the total population (TP). Variability was assessed using the standard deviation (σ) and coefficient of variation (CV% = (σ/m) × 100).

The Wilcoxon-Mann-Whitney test was applied to compare univariate measurements between age groups, with significance set at $p < 0.05$. Pearson correlation coefficients (r) were calculated for each variable pair, interpreted as: 0–0.10 for no correlation, 0.10–0.39 for low correlation, 0.40–0.59 for moderate correlation, 0.60–0.79 for strong correlation, and 0.80–1 for very strong correlation. Additionally, p-values were also used to assess the significance of the correlations. Two-way ANCOVAs was used to evaluate the homogeneity of correlations between young adults and adults.

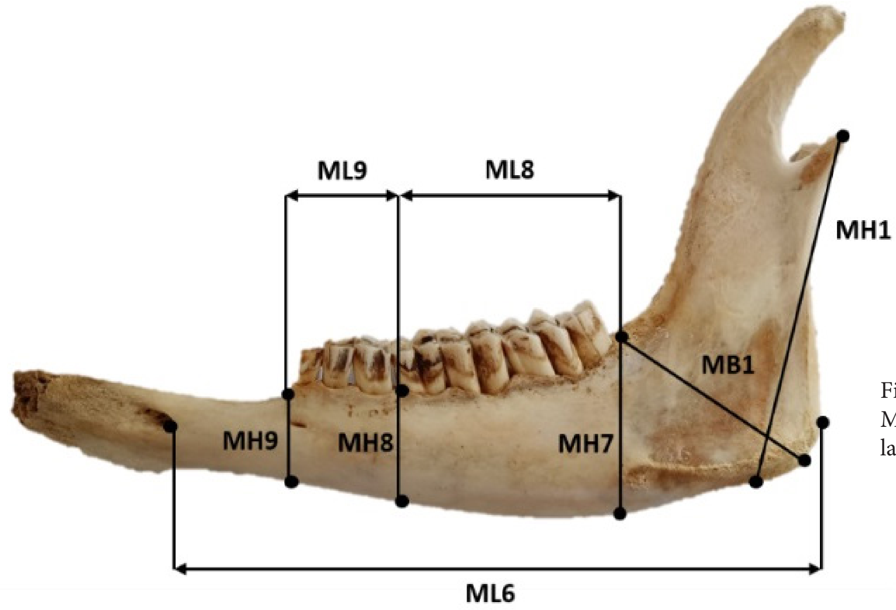

Figure 6.
Measurements of the right mandible in lateral view.

Table 6.
Denomination of mandibular measurements (variable names starting with M) and craniometric measurements (variable name starting with C), and indices (variable name starting with R).

Mandibular Measurements	Denominations	Craniometric Measurements	Denominations
ML6	Mental foramen length	CL1	Total length
ML8	Molar tooth row length	CL2	Condylobasal length
ML9	Premolar tooth row length	CL7	Oblique length of the muzzle
MB1	Width at the mandib-ular angle	CL10	Median frontal length
MH1	Aboral height of the ascending branch	CL20	Orbit base to jugular process length
MH7	Mandibular height behind M3	CL31	Naso-dental oblique length
MH8	Mandibular height in front of M1	CL34	Temporal fossaLength
MH9	Mandibular height in front of P1	CB2	Greatest breadth of the occipital condyles
RM1	MH7 / ML6 × 100	CB3	Greatest breadth at the bases of the paraoccipital processes
RM2	MB1 / MH1× 100	CB8	Least frontal breadth
		CB10	Least breadth between the orbits
		CB14	Greatest palatal breadth
		CB18	Greatest breadth across the premaxillae
		CB19	Zygomatic breadth
		CH5	Least height of the occipital
		CH6	Splanchnocranial height
		RC5	CB8 / CL1 × 100
		RC7	CH5 / CL1 × 100

M3: Third molar, M1: First molar, P1: First premolar.

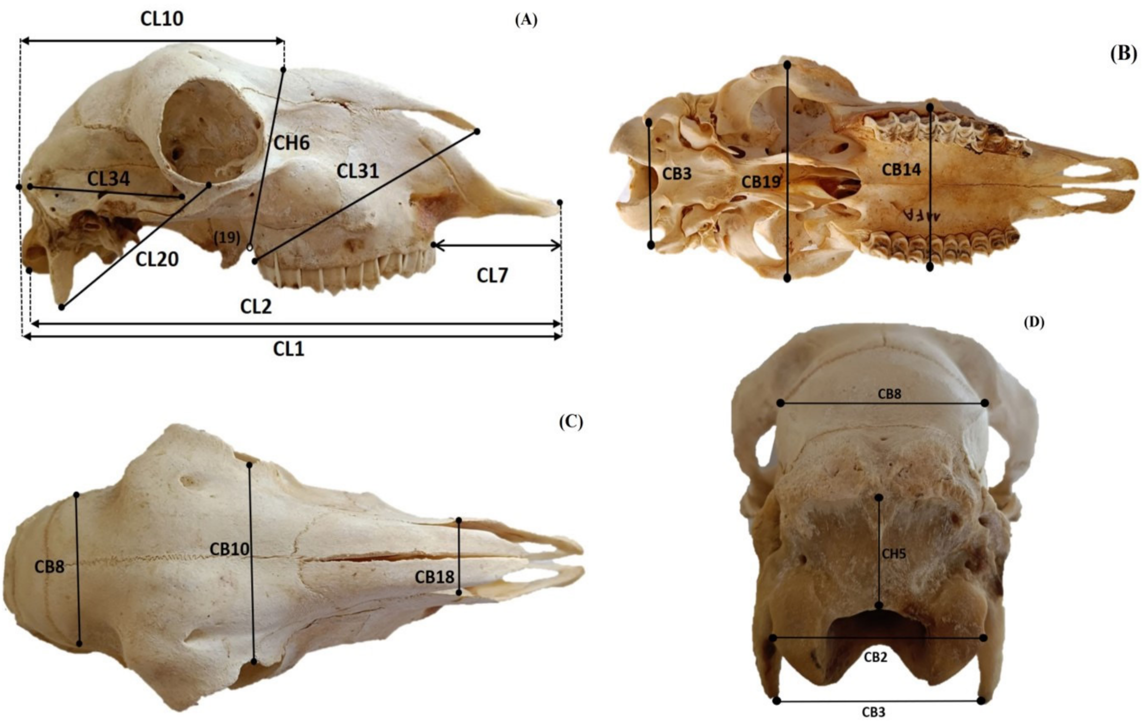

Figure 7.
Skull measurements: (A) lateral view, (B), ventral view (C) dorsal view, (D) caudal view.

Authors' Contributions

MB contributed to the collection of the specimens, methodology, statistical analysis, and writing the first draft. RR contributed to the interpretation of the results, the writing of the discussion and revised the first draft. AED worked on the methodology. FTZ revised the final draft. BB revised the final draft. AE was involved in statistical analysis, writing, review, and editing. CG provided the original idea and revised the final draft. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Acknowledgements

We would like to thank Dr. Abderrahmane Boukerrou for his assistance in sample collection, Dr. Hafida Koutchoukali for her support in specimen preparation, and Pr. El Hacene Brerhi for his invaluable guidance. We also thank the staff of the Ain Fakroun and Teleghma slaughterhouses for their cooperation.

AE work is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Grant Agreement No. 852573).

Competing Interests

The authors declare that there is no conflict of interest.

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How to cite this article
Boukerrou M,Ridouh R , DjegharAE, Tekkouk - Zemmouchi F, BabelhadjB, Evin A, Guintard C. Osteo-Morphometry in Ouled-Djellal White Arab Sheep: Age-Related Correlations between Mandible, Skull and Body Measurements. Iran J Vet Sci Technol. 2025; 17(3): 8-20.
DOI: https://doi.org/10.22067/ijvst.2025.92718.1491
URL:https://ijvst.um.ac.ir/article_47051.html