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# Osteo-morphometric Approach to the Heads of Dromedaries (*Camelus dromedarius*, L, 1758): Case of the Algerian Targui Population

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## ABSTRACT

**Background:** This study, conducted on a sample of 60 bones, provides an in-depth analysis of the main characteristics of dromedary skulls, their variability and the correlations between their various parts. These data have made it possible to isolate measurements that could provide a general overview in camel craniometry. This area lacks research and this work, by focusing on sexual dimorphism, which is an important diagnostic factor, aims to deepen the understanding of the Targui population in the Ouargla region of Algeria.

**Methods:** This study comprising a total of 30 males and 30 females Targui, organized into 4 groups: 15 young adult males (aged 5 to 9 years), 15 adult males (over 10 years), 15 young adult females (aged 5 to 9 years) and 15 adult females (over 10 years). The skulls are collected after slaughter. Each cranium was weighed and then measured using a caliper (15 linear measurements: 7 length measurements, 6 width measurements, 2 skull height measurements). The data underwent univariate, bivariate and multivariate statistical analysis.

**Results:** For each measured variable, males are larger than females. The lateral width of the neurocranium CL5 shows the highest level of sexual dimorphism with an index close to 55%, followed by weight, which reaches 28.74%. This dimorphism is clear in the skull: males not only have larger bones but also longer ones, as is the case with cattle. This is a significant difference compared to other ruminants such as sheep or goats, where bone length is not a dimorphic parameter.

**Key words:** *Camelus dromedarius*, Craniometry, Sexual dimorphism, Targui population.

## INTRODUCTION

This work is a continuation of several osteobiometric studies already published on native Algerian ruminants (cattle, sheep and dromedaries) (Adamou *et al*., 2013; Babelhadj *et al*., 2016; Guintard and Tekkouk-Zemmouchi, 2010; Guintard *et al*., 2018; Tekkouk and Guintard, 2007). While a considerable number of studies have focused on craniometry in cattle and sheep (Antonot, 2000; Fouché, 2006; Grigson, 1974, Guintard *et al*., 2001; Guintard and Fouché, 2008), very few have addressed dromedaries. Therefore, we conducted this study on cranial osteometry in the Targui population in Algeria, with an emphasis on sexual dimorphism in mature animals.

Osteometric studies in camels mainly involve the metapodials (Adamou, 2013; Babelhadj, 2016). This anatomical element has also been the most studied for assessing sexual dimorphism.

Sexual dimorphism in the skulls of different species has been of importance in archaeological, forensic and anatomical studies (Bornholdt *et al*., 2008). While classic differences can be observed in phenotypic skull features between sexes in some species (Olopade, 2006), they may be subtle in others, requiring precise morphometric examinations to distinguish them (Mazak, 2004; Virgl *et al*., 2003).

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In some species, specific adult cranial growth features are sexually dimorphic and may be related to distinct anatomical functions. These functions may involve enhanced auditory capacity, greater cranial muscle development and increased mandibular strength for chewing (Monterio *et al*., 2003). Therefore, in cases where a similarity in skull shape between sexes is observed, it has been associated with factors such as a similar diet (Virgl *et al*., 2003).

However, there is a scarcity of information regarding the effect of sex on the cranial morphometry of this species. To expand this knowledge, the present study examines various osteometric measurements in adult dromedaries from the Targui population in the northern Sahara of Algeria. The objective of this study is to:

- Establish a statistical database using a large sample of skulls from the Camelus dromedarius genus.
- Expand on previously published osteobiometric research on this species in Algeria (Adamou *et al*., 2013; Babelhadj *et al*., 2016).
- Identify variables with the strongest correlations within the bony head structure (specifically the upper bone mass or cranium).
- Deepen the analysis of sexual dimorphism within the camel species, as it has been relatively understudied so far.

## MATERIALS AND METHODS

### Animals

This study involves 60 adult Targui dromedaries, comprising a total of 30 males and 30 females, organized into 4 groups: 15 young adult males (aged 5 to 9 years), 15 adult males (over 10 years), 15 young adult females (aged 5 to 9 years) and 15 adult females (over 10 years). These animals were over 5 years old and were slaughtered at the Ouargla slaughterhouse in Algeria between January 2021 and September 2022.

Age was estimated by the camel herders based on their knowledge of the terrain (date of birth) and the eruption and wear of the teeth.

Only individuals that appeared healthy or had pathological lesions that did not affect the dimensions or general morphology of the bones were included. Bones with deformities or severe pathologies were excluded.

The Targui dromedary is a well-adapted animal, known for racing due to its large size, slender limbs and short, fine gray coat. Predominantly found in central Sahara, Hoggar and southern Algeria, especially Tamanrasset, it's used for breeding, racing, riding and load-carrying. Highly versatile. It is a highly versatile animal (Messaoudi, 1999) (Fig 1).

### Method

After slaughter, the head of each animal was retrieved and prepared to obtain the cranial bones. Following the dissection of the surrounding soft tissues, the bones were boiled in water for several hours. After boiling, they were cleaned with running water and left to air dry for several days. Following these manipulations, measurements were carried out in Higher Normal School (ENS Ouargla) during the mentioned period.

### Measurements

Linear measurements were taken using a caliper (Electronic Digital Caliper, with a precision of 1/100 mm reduced to 1/10 mm for statistical purposes).

Anatomical landmarks and the measurements taken (Fig 2) were inspired by "A Guide to the Measurement of Animal Bones" by Driesch (1976), from which we selected those most representative of cranial features, as shown in the works of Guintard, and Fouché, (2008): "Osteometric study of sheep cranial bones (*Ovis aries*, L.)" and Ridouh, R. (2021): "Craniometry and osteometry of indigenous goat metapodials."

For each cranium (dorsal part of the bony head), a total of 15 linear measurements were taken. These measurements provide a comprehensive view of this bone piece, including length, width and height measurements at various levels of the skull. Measurements for the cranium were noted with a C before, "L" for length, "B" for width

**Fig 1:** Male and female Targui dromedary, Algeria.

and “H” for height. For example, CL1 represents the first length measurement (Table 1).

From these measurements, it was possible to calculate a CR ratio, as in osteometry, this approach allows for an assessment of the morphological type of the individual, independent of size (measurement units).

For each parameter, a sexual dimorphism index called “D.S” was calculated to gain insight into sexual dimorphism for the various linear parameters measured.

The weight of each animal’s cranium was determined using a precision scale with an accuracy of one gram.

### Statistical analysis

The data was entered into Microsoft Office Excel 2019® software and the statistical analysis was conducted using EXCELSTAT 2014, with a significance threshold of p= 0.05. The statistical analyses were carried out in three major steps: univariate analysis, followed by bivariate analysis and finally multivariate analysis.

## RESULTS AND DISCUSSION

### Univariate analyses

The results of osteometric parameters are grouped in Table 2 according to gender and age.

The differences in means observed between males and females are consistently significant. The results obtained show that the values recorded in males are higher than those in females for all measured variables, with highly significant differences ($p<0.0001$). Sexual dimorphism is thus already visible at this level.

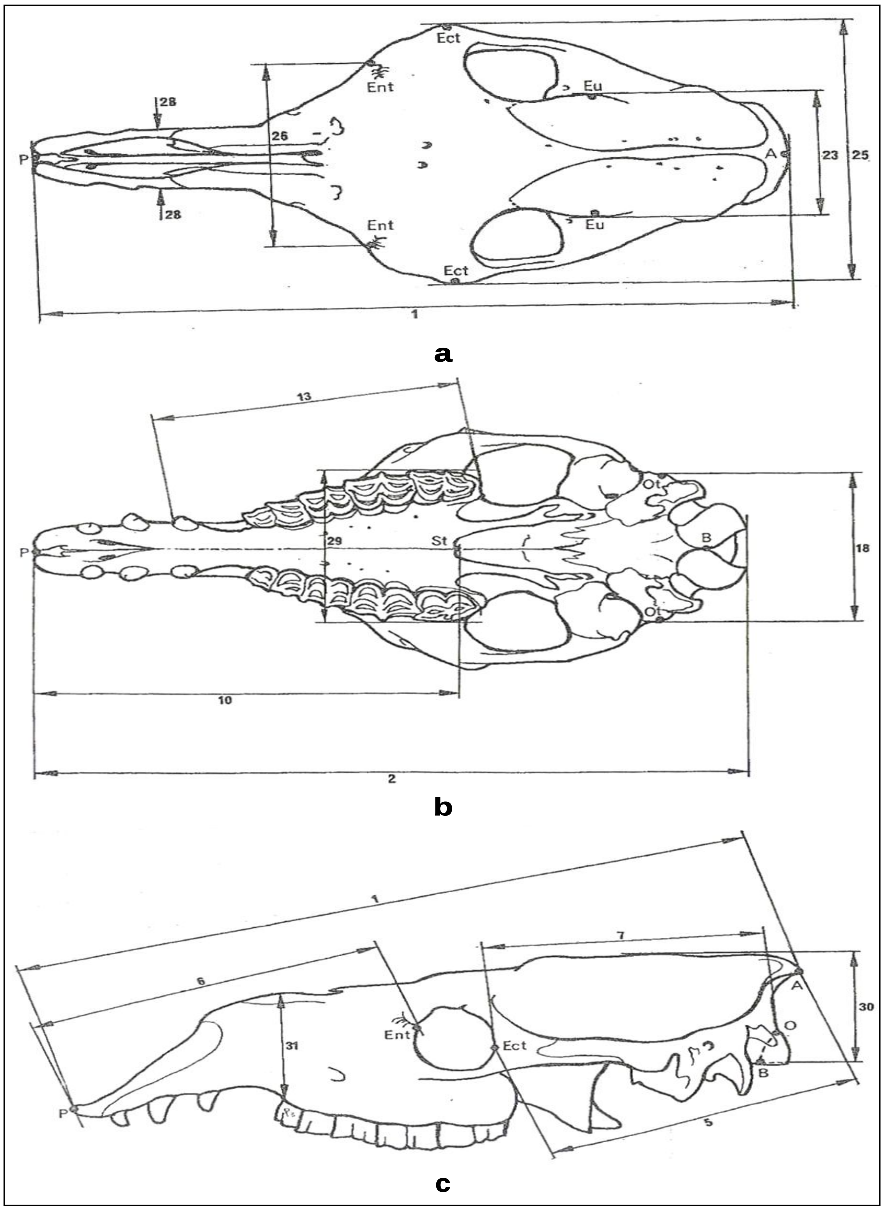


**Fig 2:** Anatomical landmarks and measurements on the cranial; (a) Dorsal view, (b) Ventral view, (c) Lateral view.

For both age classes, we observed that the measurements for both sexes are higher in adults compared to young adults, except for parameter CL13 and weight, which are higher in young adults. The CL13 measurement represents the row of jugal teeth (molars and premolars) and decreases with age due to bone remodeling affecting the maxillary bone once the roots of the molars and premolars have disappeared with age. This finding is in line with what was observed by Ridouh (2021) in a craniometric study on goats.

The weight of the bone pieces is influenced by the phenomenon of osteoporosis (which intensifies with age). As the female ages, the bone framework's density decreases due to the mobilization of bone calcium during repeated pregnancies.

Beyond the mean values, the overall variability expressed by the coefficient of variation is relatively significant for linear parameters, with the coefficient ranging from 8.22% to 1.29%, respectively for the great width of the premaxilla CB28 and the great palatine width CB29. However, it is moderately low for the calculated ratio RC (from 0.07% to 0.13%) and weight (from 9% to 11.58%). Weight is the parameter with the highest CV value, equal to 11.58.

The parameters in the nasal region (CB28 and CH31) are the most variable, with coefficients of variation exceeding 5.62%.

The CV values for linear parameters vary for both males (from 2.10% to 8.22%) and females (from 1.29% to 7.26%). For all the variables, the coefficient of variation does not exceed 12%, which means that the measurements of the studied parameters are very close among individuals and the population is more homogeneous.

It is possible to visualize the overall variability of the sample by bounding the variability of females and that of males for all parameters. To highlight the maximum variability in the studied sample, the skulls of extreme individuals were photographed (Fig 3). Sexual dimorphism is already evident at this level.

This camel population demonstrates clear sexual dimorphism at this stage, which is practically observed in almost all mammalian species.

**Bivariate analyses**

The correlation coefficients between the variables are listed in Table 3.

In general, almost all the lengths are strongly correlated with each other (r>0.8), as well as with the majority of the widths. On the other hand, the heights and the calculated ratio are not as correlated or may not be correlated at all.

The great width of the neurocranium CB23 is not correlated with any measurement, in contrast to what was found in the Malha population in Saudi Arabia (Al-Sagair and ElMougy, 2002), where this measurement showed a strong positive correlation with other skull measurements.

It's observed that weight is only correlated with the great length of the skull CL1, which differs from the findings in the Malha population, where weight showed a weak correlation (r = 0.29) with this measurement.

**Multivariate analysis**

The results of the Principal Component Analysis (PCA) are presented in Fig 4 (variable graph) and Fig 5 (individual projection).

**Table 1:** List of measurements taken.

| Skull measurement | Number according to von den driesch (1976) | Measurement definition |
|---|---|---|
| CL1 | 1 | Profile length - total length: Acrocranion (A) - Prosthion (P). |
| CL2 | 2 | Condylobasal length: aboral border of the occipital condyles - Prosthion |
| CL5 | 5 | Lateral neurocranium length: Acrocranion - Ectorbitale (Ect) on one side |
| CL6 | 6 | Short lateral facial length: Entorbitale (Ent) - Prosthion |
| CL7 | 7 | Opisthion (O) - Ectorbitale |
| CL10 | 10 | Median palatal length: Staphylion (St) - Prosthion |
| CL13 | 13 | Length of the cheektooth row, M3-P2 (measured along the alveoli) |
| CB18 | 18 | Greatest mastoid breadth: Otion (Ot) - Otion |
| CB23 | 23 | Greatest neurocranium breadth = greatest breadth of the braincase: Euryon (Eu) - Euryon |
| CB25 | 25 | Greatest breadth of the skull = greatest breadth across the orbits = greatest frontal breadth: Ectorbitale - Ectorbitale |
| CB26 | 26 | Least breadth between the orbits: Entorbitale - Entorbitale |
| CB28 | 28 | Greatest breadth of the premaxilla: measured in the region of the bony nostril |
| CB29 | 29 | Greatest palatal breadth: measured across the outer borders of the alveoli |
| CH30 | 30 | Basion height: Basion (B) - the highest point of the skull in projection |
| CH31 | 31 | Height of the horizontal part of the maxilla: from the front border of the alveoli of P3 at right angles to the most dorsal point of the maxilla on one side |
| RC | CB29/CL1 | Greatest palatal breadth/Profile length |

The inertia carried by the first factorial plane I-II amounts to 80.15% of the total inertia, which represents a good level of study reliability (greater than 80%).

Fig 4 revealed strong positive correlations between the measured variables and between these variables and the first axis. In morphometry, this axis, referred to as F1, is considered a size axis. It integrates lengths and widths. Brugal (1985) describes F1 as an indicator of the overall size of the bone. Moving to the right on axis F1 corresponds to an increase in the overall size of the skull.

Axis F2 primarily involves the ratio RC and, to a lesser extent, CB29 (the measurement used in calculating this ratio). Therefore, F2 is a general shape axis for the bone. It is not surprising to see the ratios projecting onto this axis.

Strong positive correlations exist between the variables, except for CB29, which is only correlated with RC. Furthermore, parameter CB23 (neurocranium width) is not associated with the other length parameters.

We observed a sex effect on the studied parameters, which are positively correlated with males and negatively correlated with females, except for parameters CB29 and CB23, which are independent of sex.

The scatterplot visualizing the dispersion of individuals of both sexes in the first factorial plane shows a continuous spread of males and females along axes I and II.

**Table 2:** Means, minimum and maximum values and coefficients of variation of the measured variables by age and gender.

| Variables (mm) | Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | Adults | | Young adults | | Adults | | Young adults | |
| | Mean Min-max | CV% | Mean Min-max | CV% | Mean Min-max | CV% | Mean Min-max | CV% |
| CL1 | 500.77<br>483-529 | 3.62 | 495.60<br>471-529.5 | 2.91 | 464.90<br>445-483.5 | 2.56 | 454.53<br>429-472.5 | 2.61 |
| CL2 | 477.86<br>445.5-508 | 3.38 | 469.26<br>411-499.5 | 4.33 | 448.13<br>425-464.5 | 2.82 | 438.46<br>417.5-466 | 2.81 |
| CL5 | 245.80<br>236.5-264.5 | 2.72 | 239.10<br>226-264 | 4.32 | 225.10<br>214.5-234 | 2.70 | 216.93<br>200.5-226.5 | 3.38 |
| CL6 | 259.56<br>243.5-279 | 3.65 | 257.63<br>236-270.5 | 3.42 | 242.33<br>228-251 | 2.68 | 237.33<br>223-260 | 4.21 |
| CL7 | 216.20<br>203-225 | 2.54 | 210.43<br>197-228 | 3.86 | 201.63<br>194.5-212 | 2.80 | 195.23<br>183-204 | 2.84 |
| CL10 | 287.16<br>266.5-316 | 4.59 | 285.53<br>265.5-302 | 3.53 | 272<br>259.5-285.5 | 2.91 | 267.33<br>253-291 | 3.88 |
| CL13 | 200.73<br>192-217 | 3.38 | 201.66<br>191.5-211 | 3.01 | 188.83<br>175.5-200.5 | 3.68 | 192.10<br>182-200 | 2.51 |
| CB18 | 141.23<br>130.5-150.5 | 3.46 | 136.80<br>124.5-144.5 | 4.31 | 131.00<br>124-137.5 | 3.68 | 124.86<br>113.5-132.5 | 3.57 |
| CB23 | 99.33<br>94-104.5 | 2.50 | 98.40<br>92-105 | 3.18 | 98.03<br>94-102.5 | 2.58 | 94.46<br>90.5-99.5 | 2.73 |
| CB25 | 231.06<br>216.5-242.5 | 2.73 | 223.86<br>208.5-238.5 | 3.69 | 218.06<br>203-227.5 | 2.90 | 210.00<br>197.5-219 | 2.81 |
| CB26 | 181.33<br>163-193 | 3.72 | 176.40<br>164-193 | 5.17 | 168.66<br>155-175 | 3.30 | 160.63<br>148-170 | 3.78 |
| CB28 | 60.20<br>53.5-65.5 | 5.82 | 57.03<br>50-65 | 8.22 | 48.46<br>42.5-56.5 | 7.26 | 44.40<br>39-48 | 5.16 |
| CB29 | 131.60<br>128.5-138.5 | 2.10 | 128.33<br>122-135 | 3.12 | 127.03<br>123.5-129.5 | 1.29 | 123.53<br>117-130.5 | 3.04 |
| CH30 | 119.20<br>111-125 | 3.28 | 119.30<br>111.5-127 | 3.59 | 113.23<br>105.5-122 | 4.30 | 109.33<br>100.5-117.5 | 4.38 |
| CH31 | 107.43<br>95-120 | 6.30 | 102.20<br>91.5-114.5 | 5.89 | 93.06<br>82-101.5 | 6.81 | 90.66<br>86-96 | 3.49 |
| RC | 26.29<br>24.57-27.72 | 3.41 | 25.90<br>24.55-27.30 | 3.13 | 27.33<br>26.31-28.50 | 2.48 | 27.18<br>25.60-28.64 | 3.43 |
| Weight | 2000.33<br>1691-2423 | 9.00 | 2002.86<br>1774-2414 | 10.03 | 1550.40<br>1204-1787 | 10.59 | 1559.06<br>1156-1852 | 11.58 |

In the middle of the diagram (Fig 5), an observation reveals a mixture of male and female individuals, with larger females moving right on the vertical axis, while smaller males stay on the left.

As is typical in morphometry within a breed, there is biological continuity between the measured values for males and females (the common area between the two circles in Fig 5).

Due to sexual dimorphism, the abscissa of the mean point for males is higher than that of females.

**Sexual dimorphism index (D.S)**

Meniel (1984) suggests a factor called D.S. (for Sexual Dimorphism: D.S.= [(male mean - female mean)/female mean]) that is straightforward. We have calculated this index (Table 4) to gain an understanding of sexual dimorphism for the various linear parameters measured.

This ratio appears moderately strong at 11.63% for the 15 linear parameters, ranging from 2.72% for CB23 to 54.94% for CL5.

According to the Table 4, the parameter with the highest Sexual Dimorphism Index (D.S) is the lateral length of the neurocranium CL5, with a maximum value of 54.9%, followed by the width CB28 and weight with values exceeding 20%. Next is the height of the horizontal part of the maxillary bone CH31 with a value of 14.10%.

Measurements CL1, CB18 and CB26 have a Sexual Dimorphism Index (D.S) greater than 8%, indicating a significant level of sexual dimorphism.

CB28 and CH31 constitute the width and height of the rostral part of the cranium, which shows significant sexual dimorphism (this facial part is not only longer in males but also wider, giving the face a rather robust and hard shape). Weight is consistently a highly sexually dimorphic parameter with a D.S of 28.74%.

So, the sexual dimorphism of dromedaries is more pronounced in terms of lengths and less pronounced in terms of bone shape (negative value of the RC ratio -4.26%) than what is observed in cattle by Guintard (2001), even though similar general principles seem to govern these two ruminant species.

Our study confirms that cranial measurements in male dromedaries are larger than in females, which aligns with the findings of previous research in different regions of

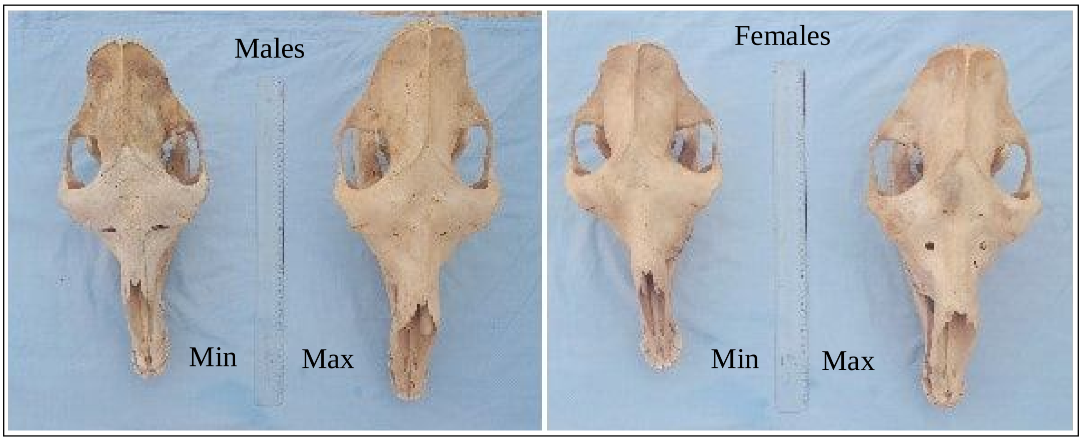


**Fig 3:** Photo of the maximum variability of skulls based on their great length (CL1).

**Table 3:** List of variables strongly correlated with each other ($r \geq 0.8$).

| Variables | $r \geq 0.8$ |
|---|---|
| CL1 | CL2, CL5, CL6, CL7, CL10, CB18, CB25, CB28, CH31, weight. |
| CL2 | CL1, CL5, CL6, CL7, CL10, CB18. |
| CL5 | CL1, CL2, CL7, CB18, CB25, CB26, CB28. |
| CL6 | CL1, CL2, CL7, CL10. |
| CL7 | CL1, CL2, CL5, CL6, CB18, CB25, CB26, CB28, CH31. |
| CL10 | CL1, CL2, CL6. |
| CB18 | CL1, CL2, CL5, CL7, CB25, CB28. |
| CB25 | CL1, CL5, CL7, CB18, CB26. |
| CB26 | CL5, CL7, CB18, CB25. |
| CB28 | CL1, CL5, CL7, CB18. |
| CH31 | CL1, CL7. |
| RC | Negatively correlated with all variables. |
| Weight | CL1. |

Northern Nigeria and a study in the Malha population in Saudi Arabia by AlSagair (2002) and Yahaya et al. (2012). This size difference is further supported by the absence of a correlation between neurocranial width (CB23) and length measurements in our study.

The greater measurements in males may be due to physiological factors like hormonal secretions and sex-specific activities, as suggested by Callewaert (2010) and Antari (2018). These higher values could also be linked to body size and the observed sexual dimorphism in cranial

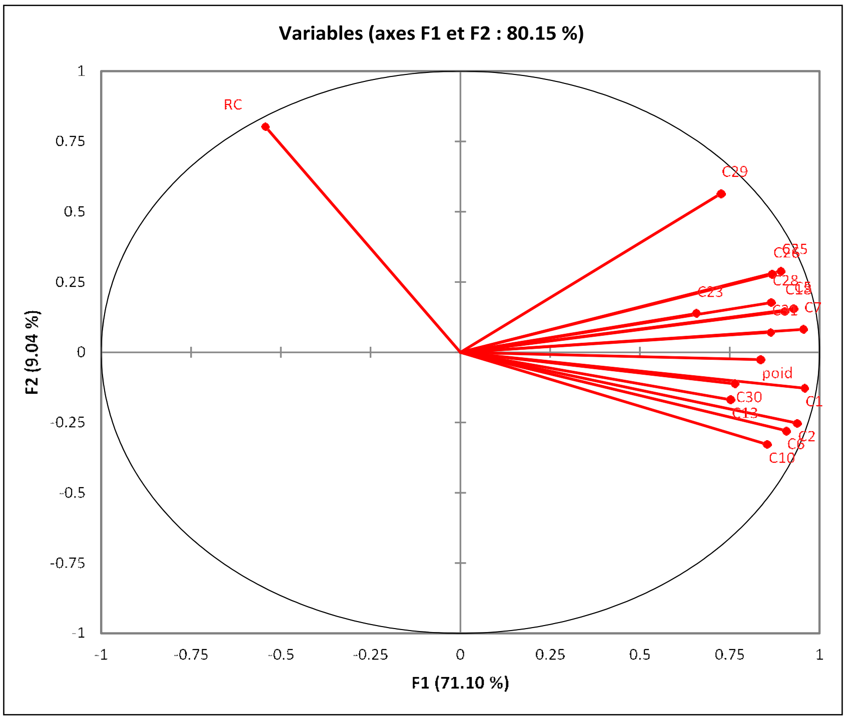


**Fig 4:** Principal component analysis (PCA) (60 individuals, 17 variables).

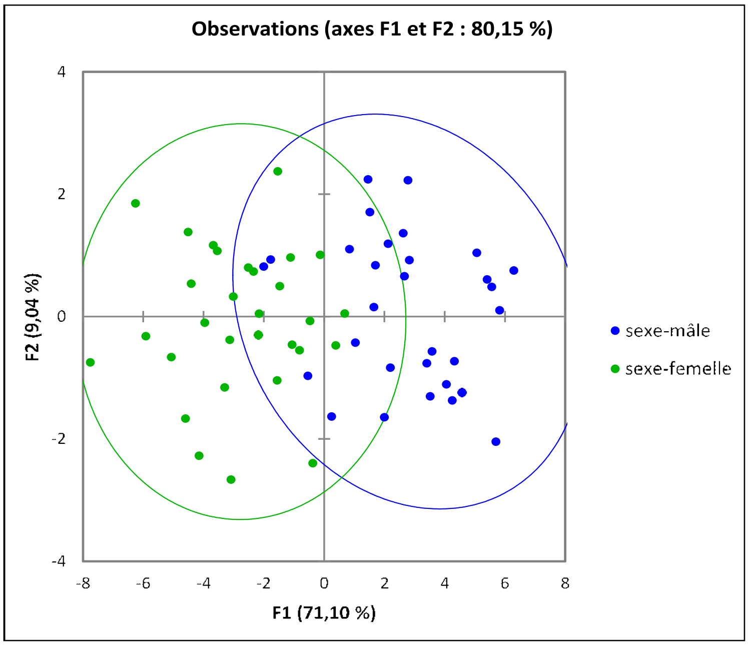


**Fig 5:** Scatterplot of PCA individuals (60 individuals, 17 variables). Each point represents an animal in the principal factorial plane (I-II).

**Table 4:** Sexual dimorphism for cranial parameters.

| Variables | The means for males | The means for females | D.S% |
|---|---|---|---|
| CL1 | 496.85 | 459.71 | 8.07 |
| CL2 | 473.56 | 443.29 | 6.82 |
| CL5 | 342.45 | 221.01 | 54.94 |
| CL6 | 258.59 | 239.83 | 7.82 |
| CL7 | 213.31 | 198.43 | 7.50 |
| CL10 | 286.34 | 269.66 | 6.18 |
| CL13 | 201.19 | 190.46 | 5.63 |
| CB18 | 139.01 | 127.93 | 8.66 |
| CB23 | 98.86 | 96.24 | 2.72 |
| CB25 | 227.46 | 214.03 | 6.27 |
| CB26 | 178.86 | 164.64 | 8.63 |
| CB28 | 58.61 | 46.43 | 26.24 |
| CB29 | 129.96 | 125.28 | 3.73 |
| CH30 | 119.25 | 111.28 | 7.16 |
| CH31 | 104.81 | 91.86 | 14.10 |
| RC | 26.10 | 27.26 | -4.26 |
| Weight | 2001.59 | 1554.73 | 28.74 |

measurements might be proportionate to size differences, consistent with observations made by Cardini and Eltonw (2008).

The best measurements to define sexual dimorphism in Targui dromedary skulls are total length CL1 and the greatest frontal width CB25. Additionally, all cranial lengths have shown significant differences between the sexes (Table 2).

Osteometric studies in the Sahraoui and Targui populations have shown that females have a more slender bone structure compared to males (Babelhadj *et al*., 2016a, b; Babelhadj, 2017; Guintard and Babelhadj, 2018).

No matter which approach is used, sexual dimorphism in dromedaries, at least for the Targui population, is primarily a size dimorphism.

Our findings on sexual dimorphism match those of Yahaya *et al*. (2012) in adult dromedaries from northeastern Nigeria's Maiduguri region, although Yahaya found no sexual dimorphism in dromedaries from Sokoto and Kano.

In the rostral aspect, males consistently have a greater width (CB28) than females, suggesting that males exhibit greater robustness, a pattern observed in various mammalian species.

Total cranial lengths (CL1) in adult male Targui dromedaries average 500.8 mm, while young adults measure 495.6 mm (Table 2). These measurements are slightly smaller than Malha dromedaries at 505.3 mm but larger than those from Northern Nigeria, ranging between 478.6 mm (Maiduguri) and 468.6 mm (Sokoto). The Northern Nigerian dromedaries are non-traditional to the region (Mohammed and Hoffmann, 2006).

Differences in neurocranial dimensions may suggest a larger cranial capacity in males. The greater development of the frontal sinus in males may contribute to variations in interorbital width CB26 and frontal width CB25. The frontal sinus is notable for its complex and variable drainage system (Daniels *et al*., 2003).

Great neurocranial width CB23 values in this study fall between those of the Malha population in Saudi Arabia at 159.6 mm (Alsagair and ElMougy, 2002) and dromedaries in Northern Nigeria at 96.06 mm (Yahaya *et al*., 2012). These variations might be related to differences in brain volume (Manjunath, 2002).

Activity significantly influences bone remodeling, where mechanical usage modifies bone architecture, following Wolff's Law (1986). This remodeling progresses with age (Ruff et al., 2006; Wescott, 2006).

Finally, considering recent work based on geometric morphometrics by Hanot *et al*. (2021) and Brassard *et al*. (2023), it would be relevant to explore the distinctions between sexes and age groups more deeply and to characterize this completely original camel population in greater detail, which could serve as a valuable reference for studies in archaeozoology.

## CONCLUSION

The study aimed to gather extensive cranial data from Algerian dromedaries, specifically the Targui variety, to identify key characteristics and sexual dimorphism. Dromedaries exhibit more pronounced cranial length dimorphism than cattle or sheep. Adding this population enhances camel species diversity for archaeozoologists. The data, including cranial parameter correlations, benefits dromedary healthcare, anatomy, breeding and phenotypic characterization. A more comprehensive study with diverse Algerian populations is required to validate these findings and identify population-specific variations.

## REFERENCES

Adamou, A., Tekkouk-Zemmouchi, F., Thorin, C., Brerhi, E.H., Borvon, A., Babelhadj, B., Guintard, C. (2013). Etude ostéobiométrique de la « race » cameline algérienne Sahraoui (*Camelus dromedarius* L., 1758). Revue de Médecine Vétérinaire. 164(5): 230-244.

Al-Sagair, O. and ElMougy, S.A. (2002). Post-natal development in the linear and tric morphometrics of the camelidae skull. Anatomia, Histologia, Embryologia. 31: 232-236.

Antari, R. (2018). Skeletal growth in response to the nutritional and hormonal manipulation. Thesis. Faculty of Science. University of Queensland Australia.

Antonot, P. (2000). Etude ostéométrique de têtes osseuses de bovins de l'île Amsterdam. Thèse de Doctorat Vétérinaire. Nantes, France.

Babelhadj, B., Adamou, A., Tekkouk-Zemmouchi, F., Benaissa, A. and Guintard, C. (2016a). Étude biométrique de dromadaires de 2 populations algériennes: la Saharaoui et la Targui (*Camelus dromedarius*, L.). Livestock Research for Rural Development. 28(2): http://www.lrrd.org/lrrd28/2/baai28030.html.

Babelhadj, B., Adamou, A., Thorin, C., Tekkouk-Zemmouchi, F., Benaissa, A. and Guintard, C. (2016b). Etude ostéo-biométrique comparée des races camelines algériennes Sahraoui et Targui (*Camelus dromedarius* L., 1758). Revue de Médecine Vétérinaire. 167(3-4): 77-92.

Babelhadj, B. (2017). Ostéo-biométrie et structure osseuse des métapodes de dromadaire (*Camelus dromedarius* L, 1758) : étude comparée de deux populations, Sahraoui et Targui. Thèse Doctorat en sciences agronomique. Université Kasdi Merbah Ouargla, Algérie, 202.

Bornholdt, R., Oliveira, L.R. and Fabián, M.E. (2008). Sexual size dimorphism in Myotis nigricans (Schinz, 1821) (Chiroptera: Vespertilionidae) from south Brazil. Brazilian Journal of Biology. 68: 897-904.

Brassard, C., Evin, A., Ameen, C., Curth, S., Michaud, M., Tamagnini, D., Dobney, K., Guintard, C., Porcier, S. and Jerbi, H. (2023). Wild or domestic? A 3D approach applied to crania to revisit the identification of mummified canids from ancient Egypt. Archaeological and Anthropological Sciences. 15: 59. https://doi.org/10.1007/s12520-023-01760-1.

Brugal, J.P. (1985). Le Bos primigenius Boj. 1827 du Pléistocène moyen des grottes de Lunel-Viel (Hérault), Bulletin du Musée d'Anthropologie Préhistorique. Monaco. 28: 7-62.

Callewaert, F., Sinnesael, M., Gielen, E., Boonen, S. and Vanderschueren, D. (2010). Skeletal sexual dimorphism: Relative contribution of sex steroids, GH-IGF1 and mechanical loading. Journal of Endocrinology. 207(2): 127-34.

Cardini, A. and Elton, S. (2008). Variation in guenon skulls (I): species divergence, ecological and genetic differences. Journal of Human Evolution. 54: 638-647.

Daniels, D.L., Mafee, M.F., Smith, M.M., Smith, T.L., Naidich, T.P., Douglas Brown, W., Bolger, W.E., Mark, L.P., Ulmer, J.L., Hacein-Bey, L. and Strottmann, J.M. (2003). The frontal sinus drainage pathway and related structures. American Journal of Neuroradiology. 24: 1618-1627.

Driesch, A von den. (1976). A guide to the measurement of animal bones from archaeological sites. Peabody Museum Bulletin, Peabody Museum of Archaeology and Ethnology. Harvard University. 1: 137.

Fouché, S. (2006). Etude ostéométrique de têtes osseuses de moutons (*Ovis aries*, L.). Thèse de Doctorat Vétérinaire. Ecole ONIRIS, Nantes, France.

Grigson, C. (1974). The craniology and relationship of four species of Bos.1, Basic Craniology: *Bos taurus* L. and its Absolute Size. Journal of Archaeological Science. 1: 353 379.

Guintard, C. and Babelhadj, B. (2018). Morphotypes et force animale développée. Comparaison de deux populations de dromadaires algériens : la Sahraoui et la Targui (*Camelus dromedarius*, L.). In : Animal source d'énergie, Enquêtes dans l'Europe pré-industrielle, Guizard, F., Beck, C. (Dir.), Presses Universitaires de Valenciennes, France. 133-147.

Guintard, C., Betti, E., C. Thorin and P. Antonot (2001). Etude crâniométrique des bovins de l'île Amsterdam: Modélisation du dimorphisme sexuel. Revue Archéométrie. 25: 157-177.

Guintard, C. and Fouché, S. (2008). Etude ostéométrique de têtes osseuses de moutons (*Ovis aries*, L.). Revue de Médecine Vétérinaire. 159(12) : 603-617.

Guintard, C. and Tekkouk-Zemmouchi, F. (2010). Aperçu ostéo biométrique de la race ovine (*Ovis aries*, L.) Ouled Djellal (Algérie). Revue de Médecine Vétérinaire. 161(11): 521-531.

Guintard, C., Ridouh, R., Thorin, C. and Tekkouk-Zemmouchi, F. (2018). Etude ostéométrique des métapodes de Chèvres (*Capra Hircus*, L., 1758) d'Algérie: Cas de la race autochtone Arabia. Revue de Médecine Vétérinaire. 169(10-12): 221-232.

Hanot, P., Bayarsaikhan, J., Guintard, C., Haruda, A., Mijiddorj, E., Schafberg, R. and Taylor, W. (2021). Cranial shape diversification in horses: Variation and covariation patterns under the impact of artificial selection. BMC Ecology Evolution. 21: 178 https://doi.org/10.1186/s12862-021-01907-5.

Manjunath, K.Y. (2002). Estimation of cranial volume in dissecting room cadavers. Journal of Anatomical Society of India. 51: 168-172.

Mazak, J.H. (2004). On the sexual dimorphism in the skull of the tiger (Panthera tigris). Mammalian Biology. 69: 392-400.

Méniel, P. (1984). Contribution à l'histoire de l'élevage en Picardie [...], du Néolithique à la fin de l'âge du fer. Société de Préhistoire du Nord et de Picardie, n° special, 56p.

Messaoudi, B. (1999). Point de situation sur l'élevage camelin en Algérie. In: Les premières journées sur la recherche cameline de Ouargla, 25-26 mai 1999. Université de Ouargla, Algérie. 13-14.

Mohammed, I. and Hoffmann, I. (2006). Management of draught camels (*Camelus dromedarius*) in crop-livestock production systems in northwest Nigeria. Livestock Research for Rural Development. 18(1): Article 16.

Monteiro, L.R., Duarte, L.C., dos Reis, S.F. (2003). Environmental correlates of geographical variation in skull and mandible shape of the punare rat, Thrichomys apereoides (Rodentia: Echimyidae). Journal of Zoology. 261: 47-57.

Olopade, J.O. (2006). Morphometric analysis of the skull of three breeds of goats in Nigeria. Ph.D. Thesis. Department of Veterinary Anatomy, University of Ibadan, Nigeria.

Ridouh, R. (2021). Crâniométrie et ostéométrie des métapodes de la chèvre autochtone. Thèse de Doctorat en Science Vétérinaire, Université des frères Mentouri, Constantine, Algérie.

Ruff, C., Holt, B., Trinkaus, E. (2006). Who's afraid of the big bad Wolff ? "Wolff 's law" and bone functional adaptation. American Journal of Physical Anthropology. 129: 484-498.

Tekkouk-Zemmouchi, F. and Guintard, C. (2007). Approche ostéométrique de la variabilité des métacarpes de bovins et recherche de modèles applicables pour l'archéozoologie: Cas de races rustiques françaises, algériennes et espagnole. Revue de Médecine Vétérinaire. 158: 388-396.

Virgl, J.A., Mahoney, S.P. and Mawhinney, K. (2003). Phenotypic variation in skull size and shape between Newfoundland and mainland populations of North American black bears, Ursus americanus. Canadian Field-Naturalist. 117: 236-244.

Wescott D.J. (2006). Effect of mobility on femur midshaft external shape and robusticity. American Journal of Physical Anthropology. 130: 201-213.

Yahaya, A., Olopade, J.O., Kwari, H.D. and Wiam, I.M. (2012). Investigation of the osteometry of the skull of the one-humped camels. Part II: sex dimorphism and geographical variations in adults. Italian Journal of Anatomy and Embryology. 117(1): 34-44.