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The size and body mass estimations of the proboscidean Paleoloxodon antiquus (Falconer & Cautley, 1847) from the Quaternary of São Antão do Tojal, Portugal

Estimativa de tamanho e massa corporal do proboscídeo Paleoloxodon antiquus (Falconer & Cautley, 1847) do Quaternário de São Antão do Tojal, Loures (Portugal)

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Abstract: The most complete proboscidean discovered in the Quaternary of Portugal comprises a nearly intact femur, a partial tibia, part of a spinal apophysis and a phalanx. It was found in São Antão do Tojal, Loures and was attributed to *Palaeoloxodon antiquus* (Falconer & Cautley, 1847) by the geologist Georges Zbyszewski in 1943. In this work, newly-obtained measurements of the femur and tibia will be used to calculate, for the first time on a Portuguese proboscidean, shoulder height and body mass according to the most up-to-date allometric equations. These methods yielded a shoulder height in life of about 3,8 meters and a body mass of nearly 11 metric tons, which is near the average of the species for males.

K**ey-words:** *Paleoloxodon antiquus*, Pleistocene, shoulder height, allometric equations

Resumo: O mais completo proboscídeo descoberto no Quaternário de Portugal apresenta um fémur quase intacto, uma tíbia parcial, parte de uma apófise espinhosa e uma falange. Foi encontrado em São Antão do Tojal e atribuído a *Palaeoloxodon antiquus* (Falconer & Cautley, 1847) pelo geólogo Georges Zbyszewski em 1943. Neste trabalho novas medidas do fêmur e a tíbia serão usadas para calcular, pela primeira vez num proboscídeo de Portugal, a altura ao ombro e a massa corporal de acordo com as mais modernas equações alométricas. Estes métodos dão como resultado uma altura ao ombro de cerca de 3,8 metros e uma massa corporal de cerca de 11 toneladas, próximo da média para os machos.

Palavras-chave: *Paleoloxodon antiquus*, Plistocénico, altura ao ombro, equações alométricas.

INTRODUCTION AND MATERIALS

The São Antão do Tojal proboscidean was originally found in February 1941 while a channel was being dug in Loures, approximately at the coordinates 38° 50' 27" N, 9° 8' 38" W (Zbyszewski, 1943). It comprised a right femur which distal part was broken (Catalog number MG 5788), a heavily damaged tibia (MG 5793) and a vertebral apophysis (MG 8081) (Zbyszewski, 1943). This work provided measurements of the femur that were compared to six specimens ascribed to *Mammuthus primigenius* Blumenbach, 1799, one to *Palaeoloxodon antiquus* and two to *Mammuthus meridionalis* (Nesti, 1825). The tibia was measured and compared with five specimens ascribed to *Mammuthus primigenius*, one to *Palaeoloxodon*

antiquus and one to *Mammuthus meridionalis*. In base of those comparisons the material was ascribed to *Elephas* [now *Palaeoloxodon*] *antiquus* by Zbyszewski (1943).

Subsequent authors (Antunes & Cardoso, 1992) agreed with the identification as *Palaeoloxodon antiquus*.

In Zbyszewski (1977) a phalanx (MG 8080) discovered in the same locality as the other remains was presented and in Raposo (1995) the femur was dated by the method of the Uranium-Thorium isotopic series 81.900, +4000, -3800 years before present, which is a younger age than expected by Zbyszewski (1943). Those remains are in exhibition at the Geological Museum, Lisbon (Figure 1).

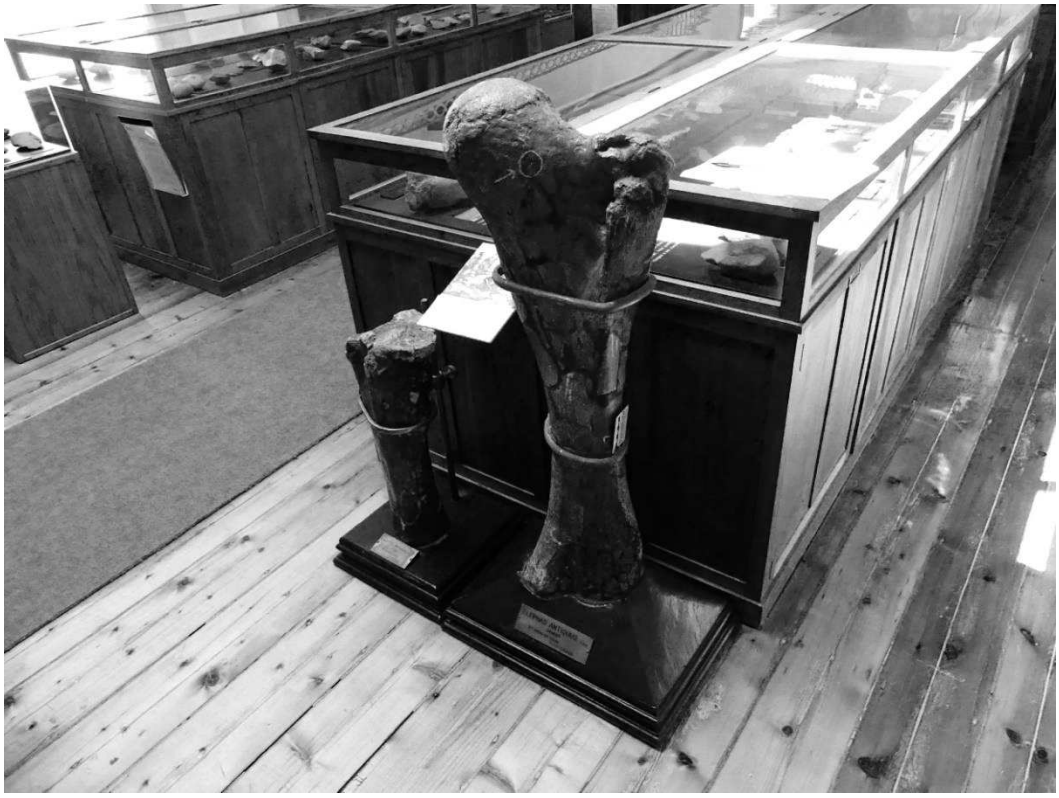

Figure 1: The femur (MG 5788) and the tibia (MG 5793) from the São Antão do Tojal proboscidean at exhibition in the Geological Museum of Lisbon.
Figura 1: O fémur (MG 5788) e a tíbia (MG 5793) do proboscídeo de São Antão do Tojal em exibição no Museu Geológico de Lisboa.

METHODS

Considering the incompleteness of the São Antão do Tojal proboscidean, the total length for both bones was inferred from the equation developed by Christiansen (2007). The shoulder height of the animal was calculated in base of the specific ratios for *Palaeoloxodon antiquus*, developed by Larramendi (2015). Finally in base of a specific allometric equation developed from volumetric reconstruction of better preserved specimens presented in that same work, a body mass is given.

BODY MASS ESTIMATION

Developed by Christiansen (2007):

$$\log Y = \alpha + \beta \log X$$

This equation is used to estimate the maximum length of the bones, where "**Y**" represents the maximum length of the bone in mm, "**X**" its least circumference in mm and " **α** " and "**β**" represent two constants, empirically parameterized either for Elephantidae Gray, 1821 (femur) and for proboscideans in general (tibia). Considering the measurements of the least circumference for both bones (470 mm for the femur and 400 for the tibia), the above equation provides an estimation for the lengths of the femur (**1388 mm**) and tibia (**865 mm**).

According to Larramendi (2015) the shoulder height of a given individual *Palaeoloxodon antiquus* is about **2,56** times the femur length and **4,15** the tibia length, which yields **3553 mm** and **3589 mm** of skeleton shoulder height respectively. The average of this estimation gives a result of **3,57 meters** for the shoulder height. According to Larramendi *et al.* (2017) for animals with similar proportions to the São Antão do Tojal specimen the shoulder height with flesh would have been about 20 cm larger than the correspondent ostheological parameters, therefore the shoulder height in life is estimated in **377 centimeters**. This estimated value is used in the equation presented in the same work for the body mass of average specimens of *Palaeoloxodon antiquus*:

$$\text{Body Mass} = 3{,}63 \times 10^{-4} \times (\text{Shoulder height in centimeters})^{2{,}903}$$

Thus, the weight of the specimen *Palaeoloxodon antiquus* was about **11 metric tons** at the time of the death**.**

DISCUSSION

The estimated size and weigh for the *Palaeloxodon antiquus* from São Antão do Tojal is within the average for the males of the species according to Larramendi (2015). It is remarkably similar in dimensions to one specimen from Neumark-Nord (Germany) that lived 40.000 years before in Central Europe or the Fontana de Campanile specimen from Viterbo, Italia (Larramendi *et al.*, 2017); despite the time difference (several dozens of thousands years later) and distance (it was discovered in the Southwestern fringe of the species distribution) this specimen was not so different in size and body mass to these other better known specimens.

CONCLUSIONS

The *Palaeloxodon antiquus* from São Antão do Tojal is estimated to had been almost 3,8 meters in shoulder height and nearly 11 metric tons in body mass, which is typical for a male of this species.

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