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The straight-tusked elephant from Contrada Calorie (Basilicata, Southern Italy). Preliminary notes

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ABSTRACT - This research aims to provide preliminary information about the taxonomic identity, stature, and body weight of an elephant skeleton found in 1982 in the Contrada Calorie locality, near the village of Rotonda within the Mercure basin (Basilicata, Southern Italy). Although the elephant is well-known to the public and the remains have been exposed in the Geological, Paleontological, and Archeological Museum of Rotonda since their discovery and have been cited in some scientific articles, no one specifically deals with such remains. According to the analysis we were able to perform, the elephant is a straight-tusked elephant, *Palaeoloxodon antiquus*, representative. The skeleton belongs to an individual about 35 years old, about 3.9-4 meters tall at the shoulder, and weighing about 9.6-9.7 tons. Most of the diagnostic dimorphic characters provided by the skeletal bones, including those of the pelvis, are undetectable due to the bone preservation status. However, the attribution to a male individual is conceivable, considering the not-advanced ontogenetic age coupled with the large size and tusk dimensions.

Keywords: *Palaeoloxodon antiquus,* Middle Pleistocene; age; sex; stature; body mass.

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1. INTRODUCTION

In the Mercure basin (Basilicata, southern Italy), at the Contrada Calorie (Potenza) locality (hereinafter CC), near the village of Rotonda, a local farmer, Mario Caldarelli, discovered on November 5, 1982, nearby his house, an almost complete skeleton of a straight-tusked elephant, *Palaeoloxodon antiquus* (Fig. 1). The Curator of the Geological and Paleontological Museum of Florence University, V. Borselli, was charged with the excavation of this finding by the "Soprintentenza Archeologica delle Belle Arti e del Paesaggio" of Basilicata, with the scientific collaboration of eminent paleontologists from different Italian Institutions (W. Landini, Pisa University; E. Cravero, U. Moncharmont and M. Moncharmont Zei, Naples University; A. Varola and A. Meleleo, Lecce University; F. Landucci, Florence University; D. Ormezzano, Regional Museum of Natural Sciences, Turin; and S. Bianco, officer of the "Soprintentenza Archeologica delle Belle Arti e del Paesaggio" of Basilicata). The restoration work was entrusted to the COEDIL SUD Company in the early 1990s under the scientific supervision of W. Landini and V. Borselli. The elephant from Contrada Calorie is nowadays exhibited at the Museo Geo-Paleontologico e Archeologico of Rotonda (hereinafter Mugepa).

Palaeoloxodon antiquus, the continental European representative of the African *Palaeoloxodon recki* stock, is a rather common component of the Italian fauna, particularly during the late Middle and early Late Pleistocene. It has been present in Basilicata since MIS 16 (Notarchirico, Cassoli et al., 1999; Pereira et al., 2015; Moncel et al., 2023).

The two European (*P. antiquus*) and Asian (*Palaeoloxodon naumanni*) elephant lineages, indeed, originated from a *P. recki* representative that dispersed out of Africa towards Eurasia around the transition from the Early to Middle Pleistocene. A *P. recki* partial skull from the Israeli Gesher Benot Ya'aqov site (0.8 Ma, MIS 21) testifies such dispersal (cfr., Larramendi et al., 2020 and references therein). However, the dispersal might have occurred earlier if more compelling specimens will confirm the hypothetical occurrence of *P. antiquus* in Turkey (Dursunlu) at about 0.9 Ma (Albayrak and Lister, 2012). In Europe, the species was first recorded in the Slivia

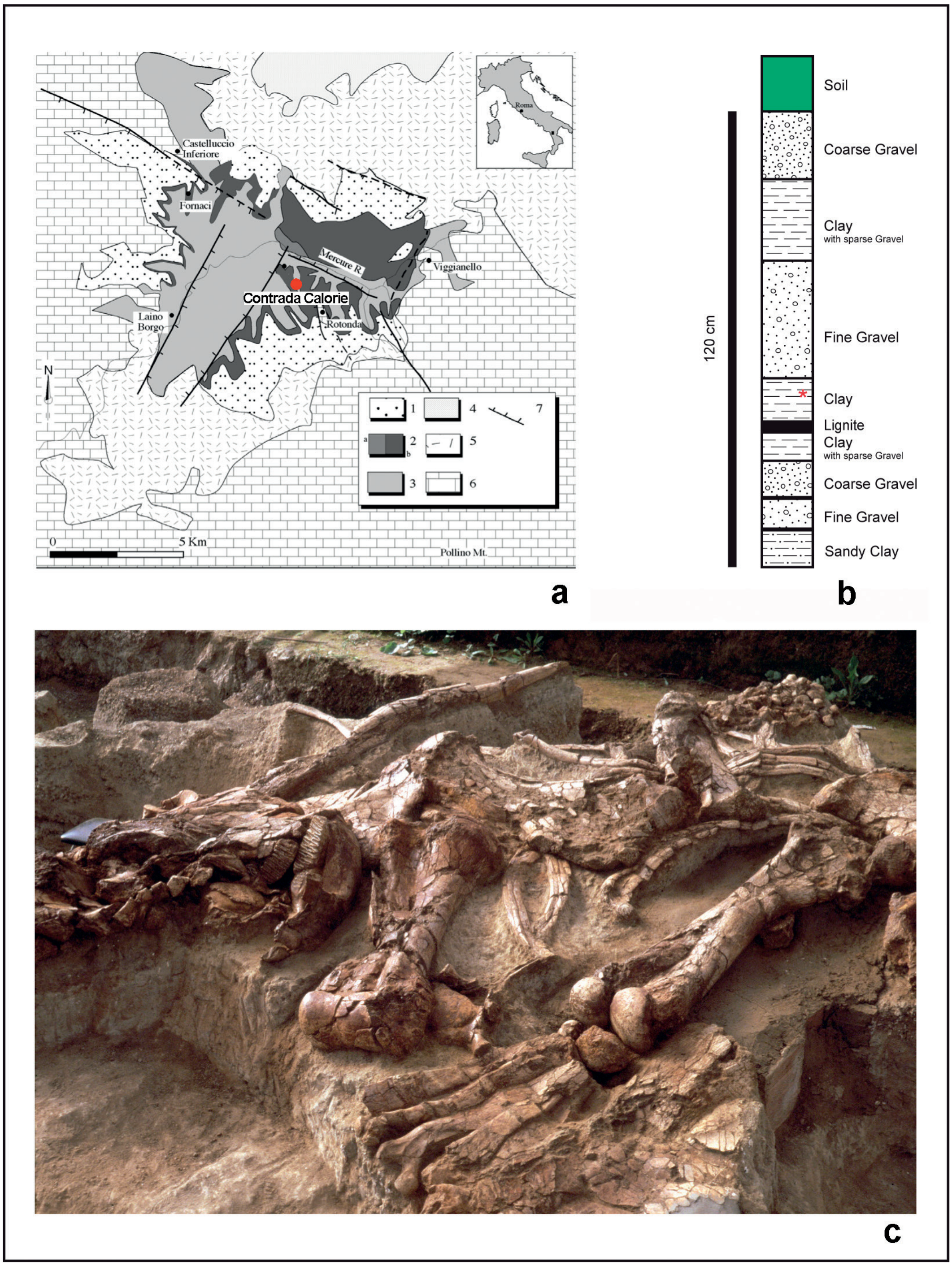

Fig. 1 - The Contrada Calorie site: a) Localization of the site and geological map of the Mercure Basin (modified from Cavinato et al., 2001) (top left); b) Simplified stratigraphic scheme of the Contrada Calorie site (modified from Ciminelli, 2005) (top right); c) Panoramic view of the elephant remains during the excavations of the Contrada Calorie fossiliferous deposit (1985) (photo credit Vittorio Borselli). Legend of the geological map: 1 - Alluvial fan (Upper Pleistocene); 2) Palustrine (a) and lacustrine deposits (b) (Middle Pleistocene) (with mollusks and ostracods); 3) Alluvial fan and fluvial deposits with mammal fauna (? Lower Pleistocene-Middle Pleistocene); 4) S. Arcangelo flysch (Upper Pliocene); 5) Frido Unit (Cretaceous); 6) Maddalena and Pollino Unit (Triassic-Miocene); 7) Normal and transtensional faults.

Italian local faunal assemblage (LFA), shortly before the beginning of the Middle Pleistocene (c. 0.8 Ma). The age was inferred on the basis of the small mammal association found at the site. Later, the species is recorded in Southern Italy in the Notarchirico (0.65 Ma, Pereira et al., 2015; 670-695 ka, lowest layers, Moncel et al., 2023) and Isernia (583-561 ka, MIS 15, Peretto et al., 2015) LFAs. The straight-tusked elephant remains are particularly abundant in Southern Europe, whereas in central and Eastern Europe they are mainly recorded during interglacial phases, especially, if not exclusively, during the pronounced climatic warming of the last interglacial (MIS 5e) (e.g., Palombo et al., 2010, and references therein; Palombo, 2014, and references therein). The last glacial-marked climate changes (MIS 4-MIS 2) significantly affected the numerical consistency and distribution of the straight-tusked elephant populations in Europe. Since the MIS 5a climatic cooling, most populations have gradually reduced their geographic range to core refugial areas, mainly located in southern Europe. In Italy, some remains have been found in the Balzi Rossi, Grimaldi cave, in deposits ranging from MIS 5 to MIS 3 (cf., Moussous et al., 2014), while there is no compelling evidence of a straight-tusked elephant presence in the Italian peninsula later than MIS 5a to MIS 4 (Braun and Palombo, 2012, and references therein). Conversely, dwarf island species persisted till the Last Glacial Maximum (20,350-19,840 cal. BP) on the Favignana island (Aegadian archipelago, Sicily) (Palombo et al., 2021a). *P. antiquus* was still present in the Iberian Peninsula during the late MIS 3, e.g., at the Portuguese site of Foz do Enxarrique in layers dated at about 33-34 ka (Brugal and Raposo, 1999), while in continental Greece, the species has not been reported during the last glacial phase (e.g., Tsoukala et al., 2011).

This research aims to provide, for the first time, some preliminary information about the elephant skeleton exposed at the Mugepa (Rotonda) (focusing on those more significant features for a taxonomic-specific identification), to give estimates about its ontogenetic age, body mass (BM), and stature (SH), and to discuss its possible sex. We will provide elsewhere more exhaustive information when the bone preservation status permits more complete and compelling analyses.

2. THE SITE: MAMMALIAN FAUNA AND GEOLOGICAL NOTES

The CC site is located in the Mercure basin, an intramontane depression of the southern Apennines, situated along the Calabria-Lucania boundary. This basin is placed along a regional tectonic discontinuity (Mt. Pollino area) that was filled during Quaternary times with fluvial and lacustrine deposits (Monaco et al., 1995) (Fig. 1). The origin of this basin is related to the extensional and transtensional tectonic events that occurred in this portion of the Apennine chain, starting from the Early and/or Middle Pleistocene (Schiattarella et al., 1994).

The chronology of the lacustrine stage of the Mercure basin succession was constrained by $^{40}Ar/^{39}Ar$ age of two tephra layers cropping out in the south-eastern sector of the basin, not far from the top of the lacustrine deposits. Tephrocronological data indicate an age of 516±3 ka and 493±3 ka, which allowed to assign to the MIS13 the final stage of lacustrine deposition of the study area. Geochronological data (Giaccio et al., 2014), pollen analysis (Petrosino et al., 2014) and morpho-stratigraphic consideration provide a framework for the timing of genesis, evolution, and extinction of the endorheic phase of the basin that was chronologically constrained between 0.7 and 0.5 My (Robustelli et al., 2014).

The Pleistocene successions include, from the bottom to the top, alternating conglomerates and sands, which pass to carbonate silty deposits that end with gravel deposits; the elephant remains were found in the fluvial deposits of the first filling phase in the southern area of the Mercure basin; taphonomical features on the excavation area showed evidence of short transportation by the fluvial stream and a quick burial of the carcass of this specimen (Cavinato et al., 2001) (Fig. 2).

Some other large mammal remains were discovered in the 1990s at CC., represented by a rhino mandible, *Stephanorhinus hundsheimensis,* and some teeth of *Hippopotamus antiquus* (Cavinato et al., 2001). These remains have not been described in detail and are nowadays housed, as the elephant ones, at the Mugepa. This large mammal association was referred to the early Middle Pleistocene (Middle Galerian ELMA *sensu* Gliozzi et al., 1997).

3. MATERIAL AND METHODS

3.1. MATERIAL

The analyzed material of the *P. antiquus* skeleton from CC consists of the following anatomical elements: a flattened and deformed skull, still not completely restored and partially embedded in expanse polyurethane; a right and left tusks, still not restored and more or less fragmented; the partially incomplete mandible with the molars; the atlas; the proximal portions of the right and left scapula; right and left humeri and ulna; the left radius and the distal part of the right one; the incomplete pelvic girdle; the right and left femuri; and a distal portion of a tibia. In addition, five complete and three incomplete vertebrae, nine complete and four largely incomplete ribs, the right and left patellae, some carpal, tarsal, and metapodial bones, and phalanges were recovered from the site, whose analysis is irrelevant for the purpose of this note and will be the object of a future study (Fig. 3).

Since most of the recovered bones were not in good preservation status, sometimes deformed and frequently cracked or fractured at several points, it was necessary to reconstruct the missing parts of the bones. All bones were restored using special putty formed by scagliola chalk, Greek pitch, paraffin, beeswax, and zinc oxide (V. Borselli, pers. communication to LB.), and most of the long bones were placed and fixed on a fiberglass base. Therefore, we were unable to take some measurements, whereas others were approximated. Moreover, tusks were removed from the skull to be easily recovered and transported, but they have not been completely restored.

3.2. METHODS

3.2.1. Molariform teeth: nomenclature and dental identification

The six molariform teeth of the polyphyodont elephants, which are morphologically similar, are

Fig. 2 - Panoramic view of the Contrada Calorie fossiliferous deposit during the excavation campaign carried out in 1984-1985 (photo credit Vittorio Borselli).

continuously replaced in rotation cycles throughout their lives, progressively increasing in size and number of enamel plates (lamellae). The terminology adopted to identify these teeth may vary. Many authors name the first three molariform teeth, developmentally homologous to deciduous premolars, DP2/dp2, DP3/dp3, and DP4/dp4 (dm, in Maglio, 1973), and generally the last three upper and lower teeth, M and m, respectively, numbering them from 1 to 3. We chose to follow this nomenclature, though in derived Elephantinae, such as extant elephants and *Palaeoloxodon* species, the DP3/dp3, and DP4/dp4 premolars are suppressed rather than lost during the molars horizontal progression and displacement, whereas possibly atavistic premolars are only recorded twice in *Mammuthus* (Sanders, 2018). The tiny plates present at the mesial and distal ends of the tooth are called "talon" or "platelet" if they do not extend or extend to the base of the crown, respectively (Lister and van Essen, 2003).

Measurements of molariform teeth were taken according to Aguirre (1968-1969), Maglio (1973), and Lister (1996), with minor modifications. For instance, to avoid possible mistakes due to the convergence of enamel plates towards the top of the crown in lower molariform

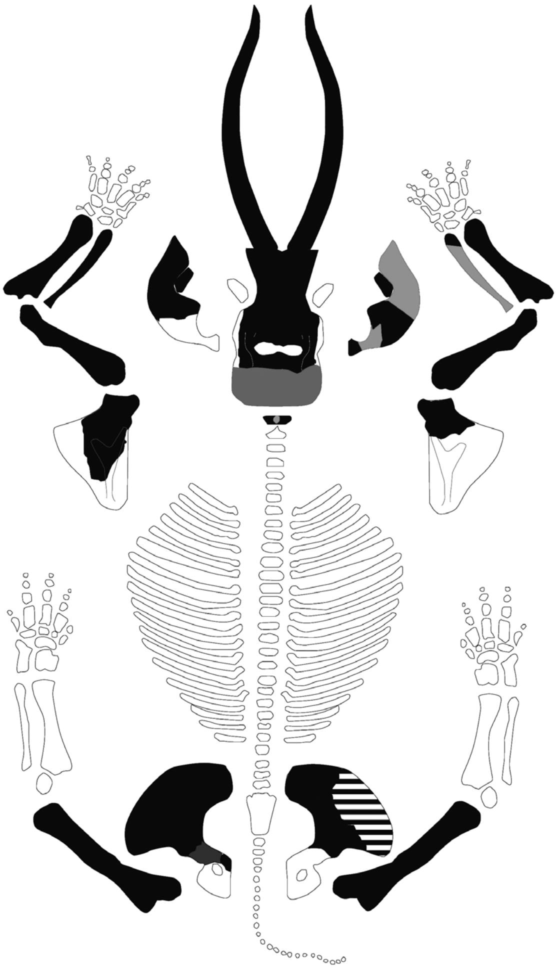

Fig. 3 - Outline of a *Palaeoloxodon* skeleton from Contrada Calorie (Museo Geo-Paleontologico e Archeologico of Rotonda) indicating the bones analyzed in the present note (modified from Santucci et al., 2016). Black = well-preserved bone portion; light grey = reconstructed bone portions; dark grey = preserved but highly damaged bone portion; stripped = highly fragmented and reconstructed bone portion.

teeth, lamellar frequency (F= number of enamel plates in 100 mm in teeth with a total length >/=100 mm, F*= number of plates in 50 mm in teeth with a length <10 mm) was estimated by averaging the F measured on the occlusal (Foccl), lateral (LFl), and medial (LFm) surfaces.

We measured the skeletal bones with digital calipers and metric taps. All measures are in mm.

3.2.2. Ontogenetic dental age

We estimate the ontogenetic dental age at the death of the CC elephant following the method proposed by Laws (1966), one of the most frequently applied because it is simple and easy to use but considering corrections and the alternative aging schemes proposed by Jachmann (1988) and Lee et al. (2012), as well as the method proposed by Stansfield (2015). All these methods estimated the African [elephant] equivalent years (AEY) based on the wear stages of African elephants' premolars and molars.

Particularly useful to estimating the ontogenetic age of continental *Palaeoloxodon* representatives is the method developed by Roth and Shoshani (1988), since the number of plates in each *E. maximus* tooth is rather similar to that of *Palaeoloxodon*, whereas the number is lower in the *Loxodonta* teeth. The method was developed for inferring the age of *Elephas maximum* individuals (Asian [elephant] equivalent years, AsEY) based on the wear stage of their lower premolars and molars.

3.2.3. Stature and Body mass estimates

We estimated the skeletal shoulder height (SH) according to regression equations proposed by Lister and Stuart (2010) (SH= a x long bone length + b). The in-flesh stature can be obtained by adding 6% to the calculated SH. We also applied both the methods proposed by Larramendi (2015, 2016). In one method, the author also proposed a proportion for calculating the stature from the length of a single bone (Larramendi, 2016, table 3, p. 541). According to the other method, the skeletal stature roughly corresponds to the sum of the scapula, humerus, and ulna maximum or physiological lengths, plus the manus height, multiplied by 0.95 or 0.98, respectively. Since we could not measure the manus height, which is rather difficult to measure even in a mounted skeleton since sometimes it could be incorrectly assembled or lack some elements, we derived its height from the third metatarsus length (manus height=25% of the third metatarsus length) (Larramendi, 2016). As the shoulder heights in the flesh are greater than the skeletal ones, Larramendi (2014) proposed that the skeletal stature has to be augmented by 5.5% to estimate the stature in the flesh in elephants. Later, the author reappraised the question, stating that a factor of 1.055 could be applied to the skeletal height in order to estimate the shoulder height in the flesh (Larramendi, 2016).

Among the various methodological approaches proposed to estimate the body mass of proboscideans (e.g., Roth, 1990; Christiansen, 2004; Palombo and Giovinazzo, 2005; Lister and Stuart, 2010; Larramendi, 2015, 2016; Larramendi and Palombo, 2015; Romano et al., 2022, and references therein), we have chosen the widely employed Christiansen's (2004) regression equations because the most convincing 3D in vivo restoration method (Romano et al., 2023, and references therein) can be applied only to mounted skeletons. Christiansen's (2004) method was specifically proposed for proboscideans. It is based on long bone dimensions and shows good predictive consistency in estimating the body mass of large mammals because long bones support the body weight in static and dynamic conditions.

We also applied the formulas proposed by Campione and Evans (2012), based on the circumferences and lengths of the femur and humerus, as well as the femur plus humerus last circumference combination. These regression equations were intended for estimating, among others, the weight of large tetrapods, such as dinosaurs, but the database includes large mammals and pachyderms, such as elephants and hippopotamuses, as well as non-avian reptiles. We also applied the equation regressions proposed by Roth (1990), just for comparative purposes. Indeed, the method was specifically developed for dwarf proboscideans and generally returns some unrealistic BM estimates if applied to continental proboscideans. Finally, we estimated the CC BM from the inferred stature, following Larramendi (2016).

3.2.4. Sex determination

The evident sexual dimorphism of body size in extant elephants is the basic criterion for identifying males and females in free-roaming Asian and African populations, but some osteological cranial and postcranial bone traits can also aid in determining the sex of fossil specimens. The most convincing morphological and biometric dimorphic characters are unquestionably related to pelvic girdle morphology and proportion. The ratios between both the width and diagonal height of the pelvic aperture and the minimum width of the *corpus ossis ilii* (ilium shaft), which are higher in females than in males (Lister and Agenbroad, 1994; Lister, 1996), are the most frequently used dimorphic parameters. The dimensions and proportions (e.g., length, curvature index, and lip and alveolar circumferences) may also be considered, especially if male and female individuals of similar ontogenetic age are compared (e.g., Hanks, 1972; Pilgram and Western, 1986; Sukumar et al., 1988; Moss, 1996; Smith and Fisher, 2013; Whyte and Hall-Martin, 2018).

Some authors proposed other sexually dimorphic characters of different bones for determining the sex of fossil elephants (e.g., molar plates, atlas, epistropheus, and carpal bones, among others). Various studies dealt with the genus *Mammuthus* representatives (e.g., Averianov, 1994, 1996; Lister, 1996). The characters considered valid for mammoths have also been adopted for determining the sex of other proboscideans, including *P. antiquus* (e.g., Göhlich, 2000; Palombo and Villa, 2003; Marano and Palombo, 2013; Larramendi et al., 2017; Konidaris et al., 2018; Ekker and Lister, 2021). A few analyses aimed to detect additional dimorphic features of straight-tusked elephants (e.g., Ambrosetti, 1968; Dubrovo and Jakuboswski, 1988). Each method has some limitations; thus, an estimation of the sex of the CC *Palaeoloxodon* would be based on the relationship between pelvic aperture width and ilium width (following Lister, 1996), but the CC pelvis is incomplete, as is the atlas. Therefore, we attempted to infer the sex based on the size of tusks and long bones since the variability in the carpal potential dimorphic characters in *P. antiquus* (cf. Palombo and Villa, 2003).

3.2.5. Quantitative data analysis

We analyzed the variation ranges of the BM estimates using box plots and univariate statistical analysis (summary statistics and normality tests).

The explanatory data analysis diagrams, known as box plots or whisker plots, are used to visually represent the distribution of variation in the analyzed sets of numerical data by displaying data quartiles (or percentiles) and medians. If required, the values that are the largest and smallest data points less or greater than 1.5 times the box height from the box's upper and lower inner fences can be displayed, as well as the values outside the inner fences and further than 3 times the box height from the box, indicated with circles and stars, respectively.

The normality tests (the Shapiro-Wilk and Anderson-Darling, which are the most precise, and the Lilliefors and Jarque-Bera tests) are useful to verify whether the data are normally distributed (null hypothesis) in the analyzed sample or not. The null hypothesis has to be rejected if the given p (normal) is <0.05.

We used the PAST (Paleontological Statistics) 4.0 software package for paleontological data analysis (Hammer et al., 2001) for scrutinizing our data.

4. THE ELEPHANT FROM CONTRADA CALORIE

4.1. SYNTHETIC DESCRIPTION

4.1.1. Skull

The apomorphic distinctive characters of the platycephalic skull of the representatives of the genus *Palaeoloxodon* are the development of the parieto-occipital crest (POC) and premaxillary bones. POC is formed by the forward bending and subsequent overhang of the occipital surface, which is more accentuated in Eurasian species than in African ones. The premaxillary bones are broadly divergent from the midline, directed forward and downward, and joined to each other across the midline by a broad, horizontal, triangular flap portion of the bone. In addition, the squamous part of the occipital is anteriorly bent, and the nuchal line (occipito-temporal line) is detectable in anterior view. Moreover, the Eurasian species show an *isthmus frontalis* wider than that of *P. recki* (Larramendi et al., 2020).

The CC skull is badly preserved, crushed, and deformed after the burial during the diagenetic processes (Fig. 4). It was only partially restored and is still protected by an expanded polyurethane casing that leaves only its dorsal side free and visible (Fig. 5). As a result, the upper molars, if present, are not visible. The cranial vault is highly damaged and extremely defective; the *isthmus frontalis* seems rather wide; and PCO is not preserved, as the *processus nasalis* and the zygomatic arches are. The external *choanae nasalis* and the premaxillary bone are partially crashed, but the later (clearly divergent from the midline and distally broadly expanded) are almost completely preserved, which enables us to detect the essential morphological features typical of straight-tusked elephants. According to a few measurements taken during the excavation, the distal width of the premaxillary bones could be about 97-100 cm.

4.1.2. Mandible

The main morphological features of the *Palaeoloxodon* mandible are the following: the mandibular body is short, deep, and thick, with a rounded lateral side; the ascending branch is usually high, and its anterior margin, anteriorly direct at its base, forms a well-defined anterior *angulus*, then it develops vertically; the position of the coronoid process is lower than that of the condyle; the condyles are parallel to each other and anteriorly oriented. The shape of the symphysis is not taxonomically distinctive since it varies according to the sex and the ontogenetic age. Moreover, the *Palaeoloxodon* mandible frequently lacks the medial mental foramen. The latter, located on the medial side of the incisive part of the mandible, is a derived character

Fig. 4 - *Palaeoloxodon antiquus* skull from Contrada Calorie (Basilicata): Panoramic views of skull, tusks and some bones exposed in place after excavation (photo credit Vittorio Borselli).

Fig. 5 - *Palaeoloxodon antiquus* skull from Contrada Calorie (Basilicata): skull in frontal (a) and anterolateral-oblique (b) view.

of the Elephantini mandible and a synapomorphy of *Mammuthus* representatives (Ferretti and Debruyne, 2011), frequently present in all the Eurasian species except for *M. rumanus*. It is unquestionably less common in *P. antiquus*, but has been reported in some dwarf insular species (see Ferretti and Debruyne, 2011 and references therein). As a result, the presence or absence of such foramen cannot be considered a compelling taxonomic feature, and it has just an indicative value.

The CC mandible is broken into two hemimandibles, the left keeping the symphysis. The ascending left branch was nearly totally reconstructed as the lateral horizontal ramus. The right hemimandible lacks its anterior part; the coronoid process is preserved and tentatively placed in the modeled part of the ascending branch, but its actual position with respect to the condyle cannot be verified. The morphology of the preserved part conforms to that of *P. antiquus*. On the lingual side of the left hemimandible, the best preserved, although restored, the medial mental foramen seems to be absent (Fig. 6).

4.1.3. Teeth

Tusks - In the continental *P. antiquus*, tusks lack the marked, more or less twisted curvature typical of mammoths. They are long, proximally moderately divergent, and then gently curved towards the sagittal plane, with the distal part very weakly pointed upwards. The morphological features of the CC tusks, detectable on the more or less fragmented specimens stored in the Mugepa deposit (Fig. 7) and from the picture taken during the excavation (Fig. 4), conform to the characters typically observed in *P. antiquus* tusks. The left tusk, although deformed, is gently curved towards the sagittal plane (Fig. 4), as it is the largest portion of the best-preserved right tusk (Fig. 7a). The high value of the ratio of the length of the chord against the length measured on the external curvature of the latter (curvature index) confirms this character (Tab. 1). Both tusks are rather longer and more massive than most of the adult *P. antiquus* females.

Premolars and Molars - The *P. antiquus* premolars and molars are high-crowned and rather longer and narrower in comparison with the rather massive and oval-shaped molars of *Mammuthus*, which have generally less concave lower molars. Moreover, the straight-tusked elephants differ from advanced *Mammuthus* species in having an inferior number of less densely packed plates (lamellae), a lower lamellar frequency, a ticker, and less folded enamel,

Fig. 6 - *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata): mandible in dorsal view.

Fig. 7 - *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata): right (a) and left tusks (b) stored in the deposit of the Rotonda's Geo-Paleontological and Archeological Museum.

Tab. 1 - Dimensions of the tusks and lower molars of the straight-tusked elephant individual, *Palaeoloxodon antiquus,* from Contrada Calorie (Basilicata, southern Italy). Abbreviation and symbols: x, talon; p, platelet; ∞, incomplete tooth due to wear or molar break; +, incomplete plate; >, minimum measure of incomplete tooth; -, unable to measure.

TEETH - Measuraments in mm

Tusks

Side	*Maximun Length (externlal curvature)*	*Chord length*	*Naximum circunference*	*Curvature index (max.length/ chord length)*
Right	*>2000*	*>1940*	*>550*	*<0.97 (c. 0.94-0.95)*
Left	*c. 2400*	*-*	*c. 590*	*-*

Lower molars

Tooth	*Plates*			*Length*		*Windth*		*Lamellar Frequency (Occlusal, Fo)*	*Enamel tickness*		
	*Formula (Pl) **	*Total*	*in use (PlF)**	*Total (L)*	*Occlusal (LF) **	*Crown (W)*	*Occlusal (WF)*		*Minimum (2m)*	*Average (e)*	*Maximum (emax)*
Left m2	*∞8.5 x*	*8.5*	*8.5*	*>186.97*	*186.97*	*-*	*93.65*	*5*	*1.9*	*2.2*	*2.5*
Right m2	*∞10 x*	*10*	*10*	*>212.92*	*212.92*	*-*	*67.06*	*5*	*2.0*	*2.1*	*2.6*
Left m3	*c. 18∞*	*>18*	*4*	*>221.80*	*110.8*	*-*	*110.80*	*-*	*c. 2.6*	*c. 2.5*	*c. 3.3*
Right m3	*c. 16∞*	*>16*	*5*	*>168*	*95.47*	*-*	*97.53*	*-*	*c. 2.5*	*c. 2.4*	*c. 3.2*

with an irregular folding pattern, with folds rather loosely packed. On the occlusal surface of chewing teeth, particularly of molars, the loops of the plates in an early wear stage show in *P. antiquus* the characteristic dot-dash-dot pattern, whereas the averagely worn plates are frequently cigar-shaped; sometimes their loops show a "loxodont" form.

In the CC mandible, the m2 and m3, not completely erupted but with a few worn plates, are present. The most striking morphological trait is the dental anomaly that affected both mandible sides. The last molar, during its horizontal progressive replacement of m2, partially slid under this molar, and its anterior side deformed and shifted towards the buccal side of the hemimandible horizontal ramus. As a result, the last plates of m2 and the first ones of m3 deformed and were displaced (see below) (Fig. 8).

The left m2 is anteriorly broken, and the posterior enamel wall of a plate is present on the anterior tooth's surface. The molar is in a moderately advanced wear stage. The eight complete plates have oval occlusal figures, cigar-shaped and weakly enlarged in the first two, while in the other, the presence on the middle part of a large V-shaped fold, much more evident on the posterior side, and some other rather large folds give the plate the loxodont form, which is frequently observable in *P. antiquus* molars. Some "estrangements" could be occasionally present on the lingual and buccal plate sides. The enamel is not particularly thick. On the posterior lingual side, where the tooth is not in contact with m3, a thin double enamel band is present. It likely belongs to the posterior talon, deformed by the pressure exerted medially and buccally by m3.

As expected, also the right m2 is anteriorly broken and in a moderately advanced wear stage. It consists of a higher number of worn plates (10), with the enamel bands moderately and coarsely folded. The enamel is thin or slightly thick, and the occlusal plate loops are cigar-shaped or characterized by a loxodont middle expansion. The anomalous pressure of m3, which reduces the occlusal width of the most posterior plates, deformed the m2 posterior side. The occlusal figure of the penultimate plates consists of an asymmetrical large oval loop and a buccal small enamel band, possibly corresponding to the anterior side of one or two enamel rings, whereas on the most posterior side, only three small enamel rings are detectable.

Fig. 8 - *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata, southern Italy): Penultimate (m2) and ultimate (m3) right (a) and left (b) lower molars in occlusal view.

Both m3 are at an initial wear stage, with the most posterior side of the tooth still inside the alveolus, and the occlusal figures of the few worn plates are subdivided into subequal loops. The cement is thick and hampers a compelling count of the unworn but erupted plates.

The left m3 is at an initial wear stage, with a few not-erupted plates. The actual total number of the erupted plats, tentatively estimated at about 16, is difficult to know since the cement covering the crown is thick, limiting the reliability of the data resulting from the plate count. On the molar occlusal surface, some small enamel rings are visible on the anterior edge, but it is hard to establish if they belong to an anomalously shaped plate or, more probably, to the anterior platelet. The first, clearly visible plate is highly deformed. It consists of two lingual rings obliquely directed towards the posterior side, forming an angle with the central ring and the curved oval loops. The latter are buccally flanked by an enamel ring in a more anterior position. As a result, the plate shows a rather sigmoid shape. An isolated enamel ring is present on the lingual side between the first and second plates. The latter consists of a small loop formed by two fusing rings and buccal rings. The third plate, consisting of four rings, is slightly curved, while the fourth and last worn plate is slant from the lingual to the buccal side. The enamel is slightly thick; the folds are small, sometimes undetectable, but a few rather larger folds could be present.

The anterior side of the right m3 is highly deformed due to the pressure obliquely exerted by the tooth against m2. On the anterior edge of the occlusal surface, some small enamel rings are detectable, which probably belong to the first plate, deformed and partially obliterated by the m2 pressure, rather than to the anterior platelet. The dental anomaly also affected the four detectable worn plates. The occlusal figure of the first consists of four loops, decreasing in size from the lateral to the buccal and from the posterior to the anterior sides. In the three following plates, the loops are sometimes fused with each other. The third and fourth plates are slightly curved, with the fourth obliquely oriented towards the buccal side. The enamel is rather thick and weakly folded, but the folds are small and sometimes hardly or not detectable.

All things considered, the morphological characters of tusks and molars match those of *P. antiquus*. Moreover, their dimensions (Tab. 1) fall within the variation range of this species (e.g., Aguirre, 1968-1969; Maglio, 1973; Palombo and Ferretti, 2005).

4.1.4. Postcranial bones

The main morphological features and the dimensions and proportions of the limb bones of the CC skeleton fall within the variation ranges and fully fit with those of *Palaeoloxodon antiquus* specimens (e.g., Andrews and Cooper, 1928; Trevisan, 1948; Maccagno, 1962a; Kroll, 1991; Tsoukala and Lister, 1998; Marano and Palombo, 2011; Kevrekidis and Moll, 2016; Reppa, 2017; Konidaris et al., 2018; Ekkek and Lister, 2021).

4.2. AGE, BODY MASS, STATURE, AND SUPPOSED SEX

4.2.1. Ontogenetic age determination

In the CC mandible, the penultimate and ultimate molars are present. Both penultimate molars (m2) are nearly complete, though the actual total number cannot be estimated. All the preserved plates are in use (8.5 in the left and 10 in the right molar) and moderately worn, but it is not possible to estimate the original number of plates because the molars are anteriorly broken and the first root is not detectable. The last molars (m3) are nearly completely erupted from the alveolus, but the tooth horizontal progression was a little more advanced in the right than in the left m3. Indeed, in the right m3, about 18 plates are visible, of which 5 are at an incipient stage of wear, while in the left m3, the visible plates are about 16 and the worn ones are 4 (Tab. 1).

This degree of wear is similar to that of Laws' stage XXI (age range: 32-38 years).

The age (AEY) assignment for stage XXI provided by Jachmann (1988) and that revised by Lee et al. (2012) roughly corresponds to the average AEY (35 years) indicated by Laws (1966) (Tab. 2).

Combining the results obtained by different methods, the dental equivalent age at death inferred for the CC elephant is about 35 years, which roughly corresponds to the age of the two *P. antiquus* males from the Middle Pleistocene sites of Fonte Campanile and Grotte Santo Stefano (Viterbo, central Italy) (cf. Tab. 2).

Since in each molar of continental *Palaeoloxodon* the

Tab. 2 - Comparison among the ontogenetic age at death (AEY) estimated in some European *Palaeoloxodon antiquus* individuals. Data source: 1 = Kroll (1991); 2 = Larramendi (2016); 3 = Ekkerk and Lister (2021); 4 = (Maccagno (1962a); 5 = Trevisan (1948); 6 = Palombo and Villa (2003); 7 = Konidaris et al. (2018).

Locality	*Sex*	*Wear Stage (Laws, 1966)*	*AEY (Laws, 1966)*	*AEY (Jachmann, 1988)*	*AEY (Lee et al., 2012)*	*Average AEY*	*Source of data*
Rotonda	*?*	*XXI*	*32-36*	*35*	*35 (30-37)*	*35*	
Crumstadt	*F*	*XIII*	*18-22*	*18*	*16*	*17.5*	*1*
Neumark Nord (154-10B)	*F*				*24*	*24*	*2*
Neumark Nord (161-22A)	*F*				*24*	*24*	*2*
Selsey	*F*	*XVIII*	*28-32*	*29*	*31.5 (29-33)*	*30.5*	*3*
Neumark Nord (151-E8)	*F*				*37*	*37*	*3*
Deeping St James	*F*	*XXII*	*37-41*	*39*	*37 (35-44)*	*38*	*3*
Neumark Nord (171-E34A)	*F*				*39*	*39*	*2*
Neumark Nord (176-E24B)	*F*				*43*	*43*	*2*
Schöningen	*F*	*XXVI+*	*48-52*	*50*	*50*	*50*	*3*
Ciechanow	*F*	*XXIX*	*55-59*	*57*	*62 (56-68)*	*59.5*	*1*
Il Crocefisso (Riano)	*M*	*XV-XVI*	*23-27*	*22-26*	*20-24*	*23.5*	*4*
Aveley	*M*	*XVIII*	*28-32*	*29*	*31.5 (29-33)*	*30.5*	*3*
Viterbo I - Fonte Campanile	*M*	*XX*	*32-36*	*34*	*31 (30-32)*	*32.5*	*3; 5*
Grotte S. Stefano	*M*	*XXI*	*32-36*	*35*	*35 (30-37)*	*35.25*	*6*
Warsaw	*M*	*XXIII-XXIV*	*43-45*	*42-46*	*41-46*	*43.6*	*3*
Neumark Nord (175-E23A)	*M*				*44*	*44*	*2*
Amyntaio	*M*	*XXVI*	*47-51*	*49*	*47 (44-53)*	*47*	*3*
Neumark Nord (152-E9)	*M*				*47*	*47*	*2*
Neumark Nord (154-E10A)	*M*				*47*	*47*	*2*
Neumark Nord (167-E43A)	*M*				*47*	*47*	*2*
Jozwin (Konin)	*M*	*XXVI+*	*48-52*	*50*	*50*	*50*	*2*
Neumark Nord (176-E24A)	*M*				*50*	*50*	*2*
Neumark Nord (175-E23B)	*M*				*~50*	*50*	*2*
Upnor	*M*	*XXVII*	*51-55*	*53*	*58.5 (58-59)*	*58.5*	*3*
Marathousa 1	*M*	*XXVII*	*51-55*	*53*	*58.5 (58-59)*	*58.5*	*7*

number of plates is higher than in the corresponding tooth of a bush African elephant, the CC individual was possibly a little older. However, we have retained this age estimate for an easier comparison with other European *P. antiquus* specimens.

4.2.2. Shoulder Height Estimate

We calculated the height at the shoulder of the *P. antiquus* skeleton from CC applying the methods based on limb bone length, which have been proposed by Lister and Stuart (2010) for estimating the eight at the shoulders (SH) in mammoth and by Larremendi (2016) for proboscidean species (Tab. 3). We have also applied Larremendi's (2016, table 3, p. 541) method, based on the sum of the maximum (SH1) and the functional length (SH2) of the forelimb bones of *Mammuthus* and *P. antiquus.*

The skeletal shoulder height (SH hereinafter), calculated based on Lister and Stuart's (2010) equations using as variables the maximum length of the humerus, radius, and femur (the bones that have complete lengths in the CC skeleton), and the sum of the humerus and radius maximum length, ranges from 4344 mm (femur length) to 3644 mm (sum of the humerus and radius maximum length), with an average value of 3945 mm (about 4 m), while the estimates of the shoulder height in the flesh (SHf hereinafter), obtained by adding the 6% to the skeletal height, range from 4604 mm to 3714 mm, and the average SHf is 4059 mm (about 4 m) (Tab. 3). The values of the SH and SHf estimates calculated with Larramendi's (2016) regression equations are a little lower than those estimated for the same bones using Lister and Stuart's (2010) equations, although the femur length returned

Tab. 3 - Skeletal and flesh stature estimates obtained for the straight-tusked elephant, *Palaeoloxodon antiquus*, from Contrada Calorie (Basilicata, southern Italy) by means of the regression equation proposed by Lister and Stuart (2010) and Larramendi (2016). SH = skeletal height derived from the limb bone dimensions; SH1 = skeletal height at the shoulder, corresponding to 95% of the sum of the bone maximal length; SH2 = physiological height at the shoulder, corresponding to 98% of the sum of the bone articular length.

Stature estimate

Stature = b+ (a x bone length) (Lister and Stuart, 2010)					*Bone Length*		*Estimate Skeleton's height (cm)*			
Variable	*r square*	*r*	*a*	*b*	*Left*	*Right*	*Left*	*Right*	*Average*	*in Flesh*
Humerus length	*0.861*	*0.927*	*2.970*	*85.498*	*1280*	*1240*	*3887.23*	*3768.42*	*3827.82*	*4057.69*
Radius length	*0.883*	*0.939*	*3.724*	*152.284*	*-*	*900*	*-*	*3503.70*	*3503.70*	*3713.95*
Humerus + Radius length	*0.886*	*0.941*	*1.646*	*121.608*	*-*	*2140*	*-*	*3643.62*	*3643.62*	*3862.24*
Femur length	*0.886*	*0.941*	*2.958*	*438.919*	*1320*	*1360*	*4343.48*		*4343.48*	*4604.09*
Average									*3829.66*	*4059.49*

Stature Estimate (Larramendi, 2016)

Variable	*Ratio*	*Measurement*		*Stature estimate*			
		Left	*Right*	*Left*	*Right*	*Average*	*in Flesh*
Humerus maximum length	*2.83*	*1280*	*1240*	*3622.4*	*3509.2*	*3565.80*	*3761.92*
Humerus articular length	*2.95*	*1118*	*-*	*3298.1*	*-*	*3298.10*	*3479.50*
Ulna maximum length	*3.31*	*1010*	*1020*	*3343.1*	*3376.2*	*3359.65*	*3544.43*
Radius maximum length	*2.56*	*-*	*900*	*-*	*2304.0*	*2304.00*	*2430.72*
Femur maximum length	*4.15*	*1320*	*1360*	*5478.0*	*5644.0*	*5561.00*	*5866.86*
Average						*3617.71*	*3816.68*

higher average shoulder heights. Indeed, the average SH and SHf obtained using Larramendi's (2016) formulas are respectively 3618 mm (about 3.6 m) and 3817 mm (about 3.8 m), but the variation range of the shoulder heights is wider. SH and SHfs range from 5561 mm to 2304 mm and from 5867 mm to 2431 mm, respectively, where the highest and lowest values derive from the femur and radius length, respectively.

Following Larramendi's (2016) proportional method, the presumable skeletal shoulder height of the CC skeleton, calculated by adding the maximum length of forelimb long bones and manus height (SH 1), was 3548 mm, while that returned by the sum of the physiological length of long bones and manus height (SH 2) was 10 cm less (SH 2=3445 mm), with an average Sh of 3442 mm (about 3.4 m) (Tab. 4). The average SHf is estimated at 3631 mm. The estimated SH 1 of the CC straight-tusked elephant is about 11.2% less than that obtained applying Lister and Stuart's (2010) regression equations (SH=3830 mm), but comparable with the average shoulder height obtained with this method for the Italian 32.5 and 35.5-year-old males from Fonte Campanile (Tab. 5).

Critically combining the shoulder heights calculated with the different methods we have applied, the more realistic SH and SHf estimated for the straight-tusked elephant from CC could be about 3.6-3.7 m and 3.9-4.0 m, respectively, falling in the range of *P. antiquus* males (Tab. 4).

4.2.3. Body mass estimates

The BM values obtained for the CC adult straight-tusked elephant using the few measurements available for the left and right long bones among those suggested by Christiansen (2004) show a rather large variation, ranging from 8,023 kg to 12,829 kg, with an average BM estimate of about 10,455.70 kg (Tab. 6).

The ulna's maximum length returned the lowest BM estimate (8,023 kg), although this variable has a high r^2 (0.9950) and rather lower percentage prediction error (%PE=5.30) and percentage standard error (%SE=8.41). The diaphyseal diameter of the humerus taken in the lateromedial plane gave the highest estimate (12,829 kg), despite the rather good prediction indices (r^2=0.9890, %PE=12.21, and %SE=8.56). A similar estimate was provided by the medial condyle width of the humerus (12,384 kg), which conversely has a rather low r^2 (0.9440) and high %PE (18.51) and %SE (29.09).

When we considered only the four variables (i.e., humerus' and ulna's diaphyseal least circumference, maximum length of ulna, and radius) that have the best prediction indices, ranging the r^2, %SE, and %PE values from 0.9920 to 0.9970, from 10.11 to 5.78, and from 6.64 to 4.42, respectively, the average BM estimate slightly decreased (9,152 kg) with respect to the average value calculated for all the parameters (Tab. 6). The two variables with the best indices (diaphyseal least circumference of ulna and humerus) returned similar BM estimates (9,909 kg and 10,055 kg, respectively), which are slightly lower than the average BM value obtained using the measurements of all the available variables (10,455.70 kg).

Applying the Roth (1990) formula to the three available variables (humerus and femur length and humerus diaphyseal least circumference) (Tab. 6), only the humerus diaphyseal circumference returned a BM estimate comparable with those obtained using the Cristiansen (2004) regression equations (11,663 kg). Those based on humerus and femur length gave too low BM estimates (5,442 kg and 3,536 kg, respectively). The last two results are non-surprising since Roth's equations were intended for dwarf elephants.

The same variables returned BM estimates close to those obtained using Christinasen's (2004) regression formulas when BM was estimated utilizing the formulas proposed by Campione and Evans (2012) (Tab. 6). In particular, the average BM (9,981 kg) is slightly lower than the average BM value (10,455 kg), while slightly superior to that obtained using the for variable with the best prediction indices (9,192 kg). The universal formula proposed by Campione and Evans (2012) as the best proxy for calculating body mass in extinct tetrapods cannot be used since it is based on the combination of the humerus and femur circumferences.

We also estimated the BM of the CC elephant using the formula proposed by Larramendi (2016), based on the two shoulder heights we calculated following the method indicated by the same author (SH1=354.8 cm, corresponding to 95% of the sum of the bone maximal length and physiological length; SH2=333.6 cm, corresponding to 98% of the sum of the bone articular length). The BM values obtained (SH1 BM=7,920 kg; sSH2 BM=6,760 kg, average value=7,340 kg) (Tab. 4) are lower than the average BM value obtained

Tab. 4 - Skeletal and flesh stature, and body mass estimates obtained for the straight-tusked elephant, *Palaeoloxodon antiquus*, from Contrada Calorie (Basilicata, southern Italy) using the method proposed by Larramendi (2016), based on the sum of the maximum and functional length of the forelimb bones.

Stature and Body Mass Estimates

SHOULDER HEIGHT (cm)				*BODY MASS (kg)*
maximum lenght		*physiological length*		*Larramendi (2016)*
Scapula	*890.0*	*Scapula*	*860.0*	
Humerus	*1280.0*	*Humerus*	*1118.0*	
Radius	*900.0**	*Ulna*	*880.0*	
Manus Height	*478.0*	*Manus Height*	*478.0*	
SH1 (cm)	*354.8*			*7920*
SH2 (cm)			*333.6*	*6760*
Average BM				*7340*

Tab. 5 - Comparison among the ontogenetic age at the death (AEY), the average shoulder height (SH) and body mass, estimated in some European *Palaeoloxodon antiquus* individuals.
* Average SH estimates obtained averaging the maximum length of the humerus and femur (Data form Erkerk and Lister, 2021-Appendix SI 4- and personal MRP personal observations). ** Average SH estimates obtained averaging the measurement of selected long bones (see Tab. 3). *** Body Mass estimates obtained averaging the BM values returned using as variables the maximum length of the humerus and femur. (Data form Ekkerkand Lister, 2021, Appendix SI 4 and MRP personal observations). ^ Stature estimated from the maximum length of fore limb bones. Data source (1-7) as in table 2.

Average Estimates of Body mass and Stature

Locality	*Sex*	*Average AEY/ AsEY*	*Average Stature (SH) (mm)*		*Average Stature in the Flesch (mm)*		*Body Mass Estimates*		*Source of raw data*
			*(Lister and Stuart, 2010)**	*(Larramendi, 2016; Larramendi et al., 2017)*	*(Lister and Stuart, 2010)**	*(Larramendi, 2016; Larramendi et al., 2017)***	*Christiansen (2004) ****	*(Larramendi, 2016; Larramendi et al., 2017)^*	
Rotonda	*? M*	*35*	*3944.58*	*3445*	*4059.49*	*3634.47*	*9511.5*	*7920*	
Crumstadt	*F*	*17.5*	*2721.5*		*2885*		*4619*		*1*
Neumark Nord (154-10B)	*F*	*24*				*3000*		*5550*	*2*
Neumark Nord (161-22A)	*F*	*24*	*2625*	*2760*	*3041*	*2910*	*4848*	*5074*	*2*
Selsey	*F*	*30.5*	*2928*		*3104*		*5168*		*3*
Neumark Nord (151-E8)	*F*	*37*	*2625*	*2500*	*2782*	*2640*		*3900*	*2*
Deeping St James	*F*	*38*	*2818*		*2987*		*4625*		*3*
Neumark Nord (171-E34A)	*F*	*39*	*2713*	*2800*	*2876*	*2950*		*4500-5400*	*2*
Neumark Nord (176-E24B)	*F*	*43*				*~3000*		*5500-5600*	*2*
Schöningen	*F*	*50*		*~3008*	*3200*				*3*
Ciechanow	*F*	*59.5*	*3222*		*3415*		*6643*		*3*
Il Crocefisso (Riano)	*M*	*23.5*	*3431*	*3130*	*3637*	*3300*	*8316*	*8000*	*4*
Aveley	*M*	*30.5*	*3106*		*3292*		*6221*		*3*
Fonte Campanile I (Viterbo I)	*M*	*32.5*	*3845*		*3766*				*3;5*
Fonte Campanile II (Viterbo II)	*M*	*35.25*	*3553*		*4076*				*3*
Warsaw	*M*	*43.6*	*3537*	*3350*	*3749*	*3530*		*9500-9800*	*6*
Neumark Nord (175-E23A)	*M*	*44*				*3630*	*8703*		*2*
Amyntaio	*M*	*47*	*3561*		*3774*		*9718*	*9650*	*3*
Neumark Nord (152-E9)	*M*	*47*	*3579.5*	*3440*	*3794*	*3630*		*12350*	*2*
Neumark Nord (154-E10A)	*M*	*47*				*3950*		*11500*	*2*
Neumark Nord (167-E43A)	*M*	*47*	*3679*	*3650*	*3900*	*3850*	*11188*	*11500*	*2*
Jozwin (Konin)	*M*	*50*	*3839.5*	*3700*	*4070*	*3900*	*10802*	*10900*	*3*
Neumark Nord (176-E24A)	*M*	*50*	*3858*	*3590*	*4089*	*3790*		*12850*	*2*
Neumark Nord (175-E23B)	*M*	*50*				*~4000*	*11257*	*13000*	*2*
Upnor	*M*	*58.5*	*4014.5*	*3830*	*4256*	*4040*			*3*
Marathousa 1	*M*	*58.5*	*3479*		*3688*		*8547*	*8.500*	*7*

Tab. 6 - Body mass estimates obtained for the straight-tusked elephant, *Palaeoloxodon antiquus*, from Contrada Calorie (Basilicata, southern Italy) by means of the regression equations proposed by Christiansen (2004), Campione and Evans (2012), and Roth (1990).

Body Mass Estimates (Christiansen, 2004)

Variable	*a*	*b*	*r*	*%SEE*	*%PE*	*Measuremente (mm)*		*Body Mass (kg)*		
						Left	*Right*	*Left*	*Right*	*Average*
HUMERUS										
Humerus maximum length	*-4.145*	*2.635*	*0.990*	*11.520*	*6.740*	*1280*	*1240*	*11028*	*10143*	*9157*
Humerus least circumference of diaphysis	*-1.598*	*2.062*	*0.995*	*7.780*	*5.540*	*520*	-	*10055*	-	*10055*
Humerus diaphysial diameter in the lateromedial plane	*-0.660*	*2.124*	*0.989*	*12.210*	*8.560*	*182.19*	*169.05*	*13847*	*11811*	*12829*
Humerus width of distal articular surface	*-5.290*	*3.872*	*0.960*	*24.330*	*16.720*	*250*	*235*	*9882*	*7776*	*8829*
Humerus medial condyle width	*-3.202*	*3.409*	*0.944*	*29.090*	*18.510*	-	*138*	-	*12384*	*12384*
Humerus lateral condyle length	*-2.294*	*2.867*	*0.904*	*39.340*	*25.430*	-	*156*	-	*9856*	*9856*
Humerus lateral condyle width	*-3.784*	*3.775*	*0.752*	*66.580*	*39.610*	-	*111*	-	*8652*	*8652*
AVERAGE BM HUMERUS								*11202.97*	*10103.61*	*10456*
RADIUS										
Radius maximum length	*-3.838*	*2.634*	*0.992*	*10.110*	*6.640*	-	*900*	-	*8780*	*8780*
AVERAGE BM RADIUS									*8779.60*	*8780*
ULNA										
Ulna maximum length	*-4.135*	*2.674*	*0.995*	*8.410*	*5.340*	*1010*	*1020*	*7917*	*8128*	*8023*
Ulna least circumference of diaphysis	*-1.349*	*2.022*	*0.997*	*5.780*	*4.420*	-	*440*	-	*9909*	*9909*
AVERAGE BM ULNA								*7916.90*	*9018.62*	*8966*
FEMUR										
Femur maximum length	*-5.568*	*3.036*	*0.985*	*14.540*	*6.150*	*1320*	*1360*	*8055*	*8819*	*8437*
Femur diaphysial diameter in the lateromedial plane	*-0.342*	*1.904*	*0.966*	*22.230*	*14.420*	*160*	*180*	*7156*	*8954*	*8055*
AVERAGE BM FEMUR								*7605.26*	*8886.77*	*8246*
AVERAGE BM										*9112*

Bdy Mass Estimates (Campione and Evans, 2012)

Variable	*%PE*	*%PE CI*	*SEE*	*R2*	*AIC*	*Measurements (mm)*		*Body Mass (kg)*		
						Left	*Right*	*Left*	*Right*	*Average*
Humerus least circumference of diaphysis	*26.922*	*30.117 to 23.727*	*0.143*	*0.986*	*-251.996*	*520*	-	-	*12916*	*12916*
Humerus maximum length	*50.658*	*57.212 to 44.104*	*0.264*	*0.95*	*46.983*	*1280*	*1240*	*8949*	*9365*	*9157*
Femur Maximum length	*70.822*	*87.438 to 54.206*	*0.311*	*0.93*	*122.345*	*1320*	*1360*	*8010*	*7684*	*7847*
AVERAGE BM										*9981*

Bdy Mass Estimates (Roth, 1990)

Variable	*Formula*				*Measurements (mm)*		*Body Mass (kg)*			
					Left	*Right*	*Left*	*Right*	*Average*	
Humerus least circumference of diaphysis	*BM=9.448 x 10-4 x Humerus circumference 2.611*				*520*	-	*11663*	-	*11663*	
Humerus maximum length	*BM=2.767 x 10-5 x Humerus length 2.675*				*1280*	*1240*	*5673*	*5211*	*5442*	
Femur maximum length	*BM=1.774 x 10-5 x Femur length 2.654*				*1320*	*1360*	*3396*	*3676*	*3536*	
AVERAGE BM									*6880.38*	

applying Christiansen's (2004) regression equations and considering both the value returned from all the available variables (10,455 kg) and the length of the forelimb bones (9,129 kg) (Tab. 6).

4.2.3.1. Quantitative data analysis

The quantitative analysis of the BM estimates obtained using the regression equations proposed by Christiansen (2004), confirms the moderate variation ranges of their values and their normal distribution (Tab. 7).

The BM values derived from all the available variables (Tab. 7) range from 8,033 kg (maximum length of ulna) to 12,829 kg (medial condyle width of the femur), with an average BM estimate of about 9,700 kg. The coefficient of variation (16,386) is lower than the maximum value (20.0) for considering the mean value reliable. In the normality test, all the p values of the Anderson-Darling, Lilliefors, and Jarque-Bera texts are higher than 0.05, confirming the null hypothesis of normally distributed data. The kurtosis and skewness indices, both reflecting a little deviation from normality, support the normal distribution of data. The values of the skewness and kurtosis indices are, respectively, slightly positive and negative and indicate a slight deviation from normality in the data distribution. When the analyzed sample is reduced to the five variables with the r^2 [(diaphyseal least circumference of ulna (U-diaph.circ.) and humerus (H-diaph.circ.), and maximum length of ulna (U-MaxL), radius (R-maxL), and humerus (H-maxL)], the range of variation slightly decreases, ranging from 8,033 kg (U-MaxL) to 10,586 kg (H-maxL), with an average BM estimate of about 9,471 kg. The coefficient of variation is rather lower than in the previous sample (11.0117), and the p-values of the normality texts still confirm the null hypothesis of normally distributed data. The values of the skewness and kurtosis indices have values rather similar to those resulting for the sample, with the BM estimates derived from all the variables and once again indicating a slight deviation from normality in the data distribution.

In the box plot, based on all the BM estimates obtained for the CC (Fig. 9), no values outside the inner fences or larger than 3 times the box height are present. The BM estimate derived from the diaphyseal mediolateral diameter of the humerus variable (H-diaphm-l.diam) (about 13 tons) corresponds to the upper inner fence (the largest data point less than 1.5 times the box height), while those derived from the diaphyseal mediolateral diameter of the femur (F-diaphm-l.diam) and ulna maximum length (U-maxL) correspond to the lower inner fence (the smallest data point more than 1.5 times the box height), and the BM value returned by the femur maximum length (F-maxL) falls close to the inferior limit of the box plot. The values of the other BM estimates fall within the box (values of the 25-75 percent quartiles) in two separate small groups, while values close to the median are not present. In the box plot obtained for the BM values derived from the available measurements of

Tab. 7 - Summary Statistics and Normality test obtained for the analyzed samples of body mass estimates obtained for *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata, southern Italy) applying the method proposed by Christiansen (2004).

Summary Statistics			*Normality Test*		
	All variables	*Best variables*		*All variables*	*Best variables*
N	12	5	*N*	12	5
Min	8023.000	8023.000	*Shapiro-Wilk*	0.876	0.930
Max	12829.000	10586.000	*p (normal)*	0.077	0.595
Sum	116395.000	47353.000	*Anderson-Darling*	0.586	0.274
Mean	9699.583	9470.600	*p (normal)*	0.100	0.502
Std. error	458.839	466.386	*p (Monte Carlo)*	0.102	0.579
Variance	2526400.000	1087577.000	*Jarque-Bera*	1.601	0.513
Stand. dev	1589.465	1042.870	*p (normal)*	0.449	0.774
Median	9342.500	9909.000	*p (Monte Carlo)*	0.128	0.517
25 prcntil	8490.750	8401.500			
75 prcntil	10453.250	10320.500			
Skewness	1.005	-0.621			
Kurtosis	0.132	-1.321			
Geom. mean	9588.506	9423.126			
Coeff. var	16.387	11.012			

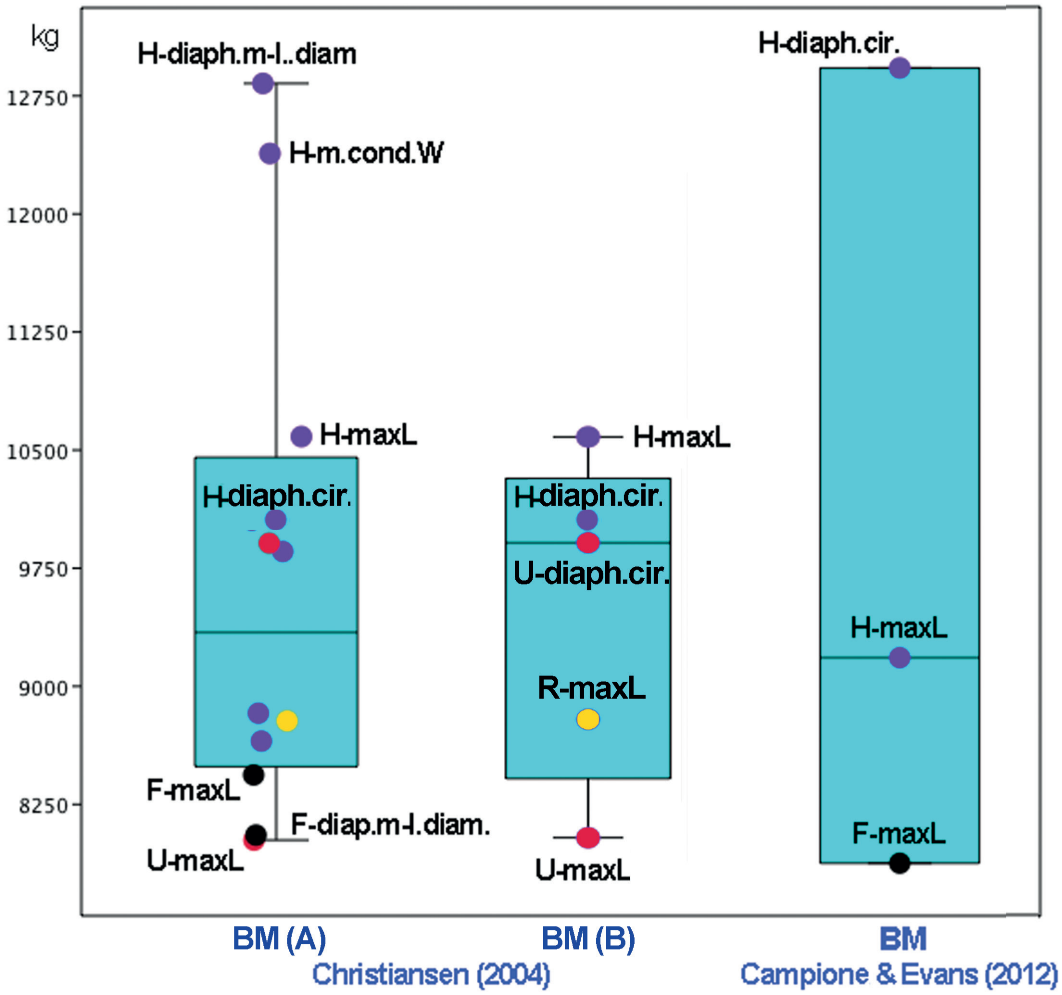

Fig. 9 - Box plot illustrating the variation range of body mass (BM) estimates obtained for *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata, southern Italy). BM was calculated by averaging the BM values obtained from the measurements of the left and right sides of the long bones using the regression equations proposed by Cristiansen (2004) and Campione and Evans (2012). BM A = BM estimated obtained from all the available variables (measurements); BM B = BM estimated obtained from all the six variables corresponding to the equation with the best r^2 and prediction indices.

the variable with an r^2 equal to or higher than 0.9900, the values derived from H-maxL (10,586 kg) and U-MaxL (8,023 kg) correspond to the upper and lower inner fences, respectively, while those derived from U-diaph. circ. (9,909 kg) corresponds to the median.

The box plot obtained from the three BM estimates returned by the regression equations proposed by Campione and Evans (2012) highlights their wide variation range, although the median value (9,157 kg, corresponding to that returned by the H-maxL variable) is similar to the value of the box plot obtained by applying Christiansen's (2004) equation regressions to all the available variables. However, in this case, the BM value returned by the H-maxL variables is higher (10,055 kg).

The BM estimate inferred by critically combining the results obtained by the various analyses and considering the information provided by the quantitative analysis of data was probably about 9,500-9,600 kg.

4.2.4. Male or female? Inferences about the sex determination

The sex of the *P. antiquus* specimen from CC can be inferred only based on the dimensions of the skeletal bones, especially those of long bones, because we could not determine the CC sex through pelvic anatomy using the ratio between pelvic aperture width, or diagonal height, and ilium width (Lister, 1966; Göhlich, 2000). Several authors considered this ratio the most compelling and sound method for determining the sex of fossil elephants, in particular *Mammuthus* (e.g., Lister, 1994, 1996; Lister and Stuart, 2010) and *Palaeoloxodon antiquus* (e.g., Göhlich, 2000; Palombo and Villa, 2003; Larramendi et al., 2017; Konidaris et al., 2018; Ekkerk and Lister, 2021). In the CC specimen, the left iliac wing is preserved but restored, while the right one was partially reconstructed, and the right outline of the pelvic aperture might be erroneously recreated (Fig. 10). Moreover, the lower part of the left pelvic halve is largely missing.

Fig. 10 - *Palaeoloxodon antiquus* from Calorie (Basilicata): posterior view of the two pelvic halves assembled in approximately life position.

As a result, the pelvic aperture diagonal height and the smallest ilium width cannot be measured.

Among the other morphological characters that might have some dimorphic significance and support a sex determination, those of the CC atlas are poorly or non-detectable. Indeed, the atlas is complete except for the medial portion of the dorsal arch (Fig. 11); therefore, we could not verify whether the *tuberculum dorsale* (the vertebral spine to which the muscles attach) was marked as in males or poorly developed as in females (Averianov, 1996). In the CC elephant, most carpal bones are present and rather well-preserved. Dubrovo and Jakubowski (1988) examined the carpal bones of three *P. antiquus* skeletons from Poland and claimed the presence of dimorphic character based on their analysis of the well-preserved bones of the skeletons from Jozwin and Ciechanow. However, Palombo and Villa (2003), after having compared several *P. antiquus* carpal bones, found wide individual variability in their structure and morphology. The morphology of *P. antiquus* carpal bones in the rich sample from Neumark Nord 1 (Germany), even belonging to the skeleton, whose sex had already been determined, supports such variability (Palombo, unpublished data). The comparison of the dimensions of the long bones of the CC skeleton, particularly their maximum length, with those of some *P. antiquus* male and female skeletons indicates that it belongs to an individual of quite relevant size.

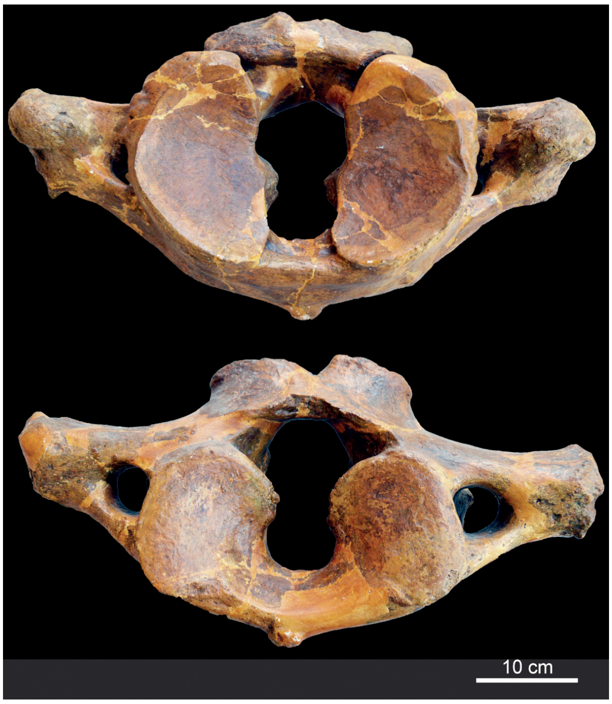

Fig. 11 - *Palaeoloxodon antiquus* from Contrada Calorie (Basilicata): atlas in cranial (a) and caudal (b) view.

The dimensions of the long bones of the CC skeleton, in particular the maximum length, indicate an individual of relevant size, comparable to those of males (Tab. 8). The relationships among the AEY of some *P. antiquus* skeletons of both sexes and their SH and BM support the hypothesis that the CC elephant could be a male. In both diagrams, females and males form two distinct groups, despite some data dispersion and the very low R2 of linear regressions, which is higher for males (R2=0.24632) than females (R2=0.01792) when the relationship between SH and AYE is considered, while both R2 have a rather similar value (R2=0.29231 in males and R2=0.25402 in females) in the case of the relationship between BM and AYE. In both diagrams, the score of the CC skeleton falls in the male group, in particular on the regression line in the case of the BM and AYE relationship (Fig. 12).

The tusks are not as massive as those of fully adult Italian males but more than those commonly observable in specimens from Central Europe. The factors that contribute to the difference in slenderness between Italian

Tab. 8 - Comparison among the ontogenetic age at the death (AEY) and the maximum length of limb bones of some *Palaeoloxodon antiquus* individuals. Data source (1-7) as in table 2; 8 = Tsoukala and Lister (1998).

Long bone maximum length (mm)

Locality	*Sex*	*Inferred AEY*	*Scapula*	*Humerus*	*Ulna*	*Radius*	*Femur*	*Tibia*	*Fibula*	*Source*
Rotonda	*? M*	*35*	*>670*	*1260*	*1015*	*900*	*1340*	*-*	*-*	
Crumstadt	*F*	*17.5*	*730*	*1056*	*630*	*650*	*1040*	*602*	*-*	*1*
Neumark Nord (154-10B)	*F*	*24*	*750*	*-*	*860*	*657*	*1040*	*576*	*570*	*2*
Neumark Nord (161-22A)	*F*	*24*	*858*	*937*	*735*	*685*	*-*	*638*	*-*	*2*
Selsey	*F*	*30.5*	*-*	*960*	*-*	*-*	*1140*	*-*	*635*	*3*
Neumark Nord (171-E34A)	*F*	*39*	*-*	*-*	*810*	*760*	*1070*	*624*	*-*	*2*
Grabshütz	*F*	*>50*	*811*	*-*	*865*	*765*	*1130*	*666*	*637*	*3*
Ciechanow	*F*	*59.5*	*-*	*-*	*857*	*722*	*1310*	*600*	*-*	*3*
Il Crocefisso (Riano)	*M*	*23.5*	*790*	*1150*	*935*	*820*	*1290*	*744*	*715*	*4*
Aveley	*M*	*30.5*	*3106*	*1030*	*807*	*735*	*1190*	*-*	*-*	*3*
Fonte Campanile I (Viterbo I)	*M*	*32.5*	*900*	*930*	*1110*	*990*	*1440*	*890*	*795*	*3;5*
Warsaw	*M*	*43.6*	*1050*	*1162*	*-*	*-*	*-*	*880*	*-*	*3*
Amyntaio	*M*	*47*	*700*	*1170*	*975*	*920*	*-*	*-*	*-*	*3*
Neumark Nord (152-E9)	*M*	*47*	*1058*	*1220*	*1030*	*882*	*1320*	*795*	*740*	*2*
Neumark Nord (154-E10A)	*M*	*47*	*-*	*-*	*1108*	*965*	*-*	*914*	*-*	*2*
Neumark Nord (167-E43A)	*M*	*47*	*1102*	*-*	*-*	*934*	*1389*	*842*	*-*	*2*
Jozwin (Konin)	*M*	*50*	*1025*	*1287*	*1083*	*1002*	*1429*	*880*	*871*	*3*
Neumark Nord (176-E24A)	*M*	*50*	*1112*	*1270*	*-*	*910*	*-*	*-*	*-*	*2*
Grevena	*M*	*>45*	*1010*	*990*	*-*	*-*	*-*	*-*	*840*	*8*
Gröbern I	*M*	*>45*	*1075*	*1340*	*1100*	*967*	*1402*	*915*	*860*	*3*
Kiesäcker 72	*M*	*>45*	*-*	*1135*	*1030*	*890*	*1320*	*845*	*830*	*3*
Marathousa 1	*M*	*58.5*	*-*	*-*	*1035*	*-*	*-*	*-*	*-*	*7*
Upnor	*M*	*58.5*	*1170*	*1290*	*1135*	*990*	*1545*	*1020*	*930*	*3*

and Central European specimens (i.e., those from the German site of Neumark Nord1) are unknown. New studies involving specimens from different geographic areas and the improvement of the database might contribute to disentangling the actual diagnostic importance of tusk in determining the elephant sex in fossil specimens.

All things considered, the available data supports the hypothesis that the CC *P. antiquus* skeleton could belong to a male individual.

5. REMARKS

5.1. ABOUT TAXONOMICAL IDENTIFICATION

During the Middle Pleistocene, the Italian large mammal fossil record includes two continental elephant species: *Mammuthus trogontherii* and *P. antiquus*. The latter is a rather common component of the Italian mammalian fauna, especially in the period corresponding to MIS 13-MIS 5, while the steppe mammoth is less frequent and was recovered from very few sites (e.g., Palombo, 2014). In the CC skull, the premaxillary bones, whose morphology corresponds to that typical of straight-tusked elephants and is different from that of *Mammuthus,* provided the only available diagnostic characters. As in *Palaeoloxodon*, the CC premaxillary bones, whose plane is nearly in continuity with that of the forehead and only weakly inclined downwards, are divergent with respect to the sagittal plane, and the tusk alveoli are separated by their flattened middle part. Conversely, in mammoths, the inclination of the forehead plane relative to that of the premaxillary bones is more accentuated; the tusk alveoli are close to each other, nearly parallel, with a concave lateral outline. The morphological and biometrical characteristics of the CC dental remains, such as the general shape of the tusks and lower molars, confirm the identification of the CC elephant as *P. antiquus*.

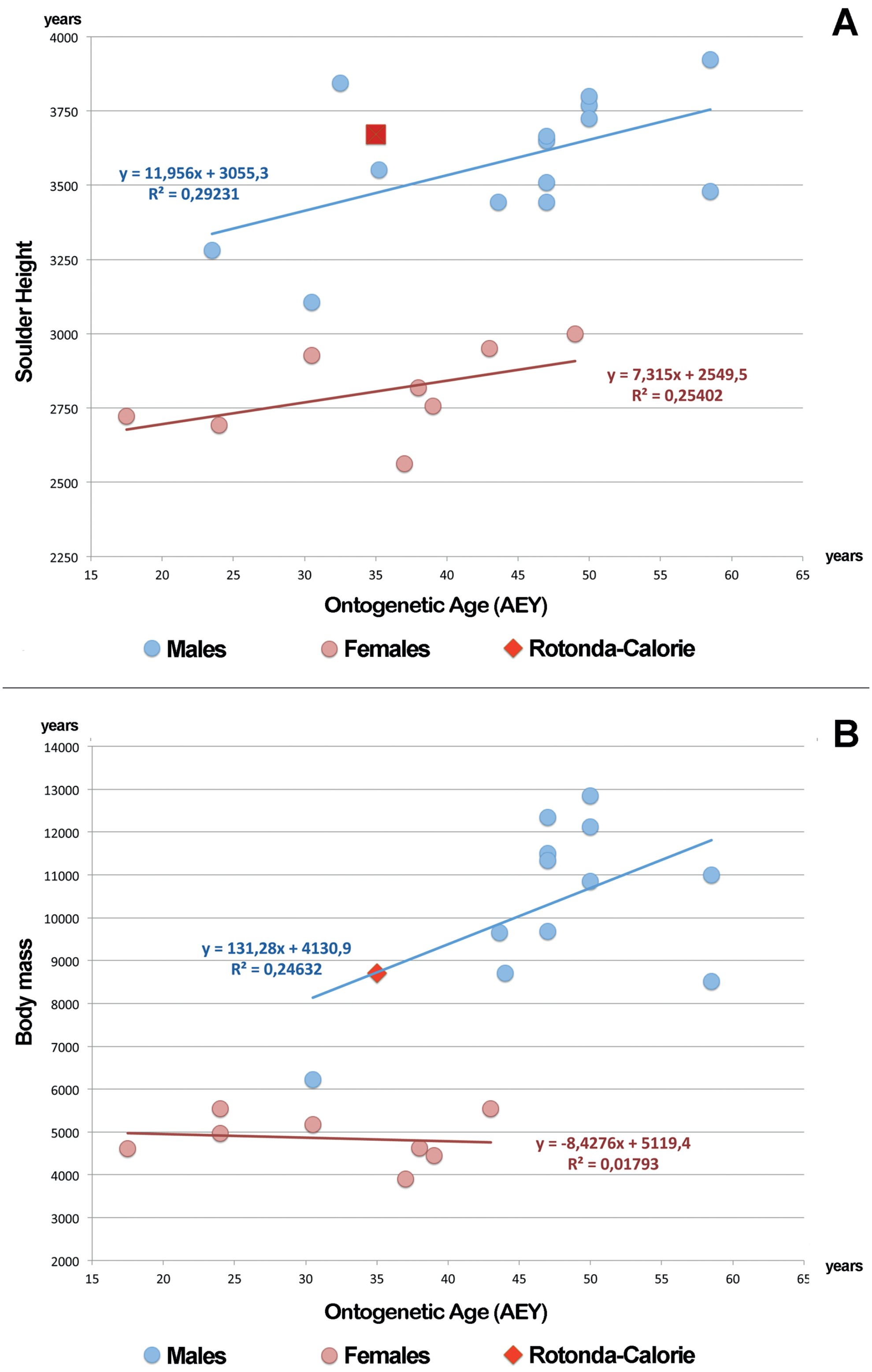

Fig. 12 - Scattered diagrams showing the relationships between the ontogenetic dental age (AEY) and either the average values of the skeletal shoulder height (SH) (a) and the average body mass estimate (BM) in straight-tusked elephant from Contrada Calorie (Basilicata, southern Italy) and selected European *Palaeoloxodon antiquus* male and female individuals.

Particularly, in m2, the loops of the averagely worn plates are cigar-shaped and frequently show the median loxodont expansion; the lamellar frequency is lower than the average frequency of *M. trogontherii;* and enamel in CC molars is thicker and less folded, with individual folds rather loosely packed. The dental anomalies characterizing the CC m3, which have been observed in both fossil and living elephants (e.g., Roth, 1989), hamper the possibility of verifying the possible occurrence of the dot-dash-dot pattern characterizing the *P. antiquus* plates in an early wear stage.

The identification of the CC skeleton as *P. antiquus* confirms the presence of its populations in Basilicata during the early Middle Pleistocene, such as some teeth and bones from Contrada Prato in the surrounding area of the Laino Borgo village (Mercure Basin) described by De Angelis d'Ossat (1895).

5.2. ABOUT ONTOGENETIC AGE, SHOULDER HEIGHT, BODY MASS, AND SEX

Several methods have been proposed for inferring the age at death, the size, and the sex of fossil proboscideans. The appraisal of such parameters first depends on the nature and preservation quality of the studied material, which is generally less problematic if it consists of single and rather complete individuals with a preservation status able to permit the application of different methodological approaches for analyzing dental remains and postcranial skeletal bones. The critical comparison of the results obtained using various methods could lead to the formulation of more realistic assumptions since each method has its advantages and limitations.

The methods employed to infer ontogenetic age at death in mammals are mainly related to tooth development and wear, the epiphyseal fusion in skeletal bones, and the extent of skeletal maturation as shown by the rhythmic growth increments in bone hard tissue.

Conversely to other mammals, Elephantini and Loxodontini elephants are characterized throughout life by tooth rotation, progression and wear, and an extended growth period of epiphyseal fusion, which generally fused at different ages in males and females, with succession in the fusion of each long bone epiphysis that differs from one species to another (see inter alios, Herridge, 2010; Palombo et al., 2021b, and references in those papers). Therefore, the methods applied to determine elephant ages mainly rely on dental progression and wear, and size (cranial and limb bone dimensions, shoulder height, and sometimes body mass).

The method most frequently applied to infer the ontogenetic age from tooth progression and wear is that proposed by Laws (1966), derived from the analysis of several culled wild elephants from Uganda. Since the results obtained from this method for other African wild elephant populations, as well as some captive elephants, highlighted some inconsistencies between the estimated and actual age, several corrections and alternative aging schemes have been proposed (e.g., Lang, 1980; Fatti et al., 1980; Roth, 1982; Lark, 1984; Jachmann, 1988; Lindeque, 1991; Lee et al., 2012; Stansfield, 2015; Haynes, 2017). Furthermore, if, on the one hand, the dental progression and degree of wear of elephant teeth may be suitably estimated when the position of the tooth and the dental progression are correctly identified, on the other hand, the teeth of bush African elephants, especially the molars, have several plates lower than that of *P. antiquus*. As a result, when two teeth that are differently worn are present, their reciprocal wear stage must be carefully examined. Since *Elephas maximus* teeth have several plates rather similar to those of continental straight-tusked elephants, the dental age scheme proposed by Roth and Shoshani (1988), based on Asian elephant lower teeth, maybe a useful tool for estimating the dental age of *P. antiquus*. Regrettably, the latter scheme fails to cover all the age ranges and cannot be used, for instance, for aging the CC elephants.

Finally, the AYE and the AsYE estimates of a fossil continental Elephantini species likely undervalue the actual ontogenetic age of the continental *Palaeoloxodon* and *Mammuthu* relatives, who are larger with respect to the average size of *E. maximus* and *L. africana* and were also longer-lived (e.g., Lister and Agenbroad, 1994; Lister et al., 2012; Larramendi, 2016; but also see Mayne et al., 2019). Hence, methods based on dental progression and wear in extant elephants could represent a further source of error in estimating the age of these fossil species, even if they remain an available method for comparing specimens and samples of different provenances, and could be improved taking these limitations into account. Accordingly, we have assigned the plausible AEY (African [elephant] equivalent years) (Saunders, 1977; Saunders et al., 2010) ontogenetic age to the CC elephant, combining the results obtained by applying the methods based on living *L. africana* data as well as considering the size of this individual in comparison with those of some *P. antiquus* of known AEY.

Female and male elephants of the same ontogenetic age have different sizes, with females being smaller than males because the two sexes have a different growth pattern due to the earlier sexual maturation in females, the fallow rapid slowdown of growth, and the precocious fusion of some epiphyses with respect to males. Accordingly, knowing the conceivable shoulder height and weight of an elephant of known age may facilitate the inference of its sex.

Since the first half of the last century, some authors have attempted to calculate the shoulder height of fossil elephant species based on the relationship between the lengths of selected forelimb bones verified on living specimens. For instance, Depéret et al. (1923) based their estimate of the SH of *Mammuthus planifrons* from Chagny (France) on the following equation: SH=2.8 x femur length. The formula applied to the CC skeleton returned a value of 3752 mm, which is consistent with the CC average SH (3695 mm) obtained by averaging the SH values estimated using Lister and Stuart 's (2010) regression equation and with Larramendi's (2015) formulas. Osborn (1942, page 1250) calculated the SH of *P. antiquus* from Pignataro Interamna (Latium, central Italy) according to the relationship between SH and scapula length he had verified on the skeleton of the bush African elephant named Yumbo, stored at the American Museum of Natural History (New York, USA). Although based on few empirical data, Osborn's (1942) method was later applied by some authors even on *P. antiquus* Italian specimens (e.g., Trevisan, 1948; Maccagno, 1962a, 1962b). In more recent times, more compelling methods have been proposed on the basis of large sets of data, such as, for instance, those applied in this note.

Some authors attempted to find the relationship between stature and weight in elephants. Osborn (1942, p. 1250) was the first researcher who used the empirical data derived from the analysis of living elephants to estimate that of fossil proboscideans, i.e., *P. antiquus*. The American scientist found that each inch (304.8 mm) of height would correspond to 65 pounds (31.30 kg) of weight. Such a relationship would provide a rather underestimated stature for the CC elephant, considering that it gives a SHf value of about 250 cm and that the difference in height between caput and shoulder is of little relevance in *P. antiquus* (Larramendi et al., 2017).

The relationships between shoulder height and BM are even debated for living elephants. Beverton and Holt (1957), for instance, developed the study of von Bertalanffy (1938 and references therein) and proposed an equation for BM that fits well with empirical data. However, Hanks (1972) showed that in African elephants above 30 years of age, height increases much less than weight (allometric growth), suggesting that the relationship between these two body measurements would be best expressed using a semilogarithmic plot of log body weight against in-flesh shoulder height. Based on these data, Sukumar et al. (1988), analyzing some captive Asian elephant populations, found that a linear regression of the cube root of body weight on shoulder height gave a better fit than the semilog plot. Moreover, the authors showed that the height-weight relationships derived for both male and female elephants were very similar.

The issue of the actual SH/SHf-BM relationship remains a debated matter. Therefore, we have chosen to infer the BM of the CC straight-tusked elephant by averaging the values obtained utilizing the methods we have considered the most suitable to be applied to Elefantini among the various proposed by authors (e.g., regression equations resulting from measurements of selected skeletal elements from living species, formulas based on shoulder height, the graphic double integration volumetric method, and 3D *in-vivo* restorations) (e.g., Roth, 1990; Shipman, 1992; Christiansen, 2004; Palombo and Giovinazzo, 2005; Lister and Stuart, 2010; Larramendi, 2014, 2016; Larramendi and Palombo, 2015; Romano et al., 2023 and references therein).

The research based on the 3D method relies on various tetrapod taxa. Several contributions have empirically highlighted that the BM estimate based on a volumetric calculation generally gives more plausible results than the BM values calculated with the classical regression formulas proposed in the literature (e.g., Bates et al., 2015; Brassey and Gardiner, 2015; Romano and Manucci, 2019; Romano and Rubidge, 2019). Some papers, which compared the weight estimates of proboscidean mounted skeletons with those obtained by applying the regression formulas to their limb-long bones, have evidenced some inconsistencies in the BM values resulting from the latter (e.g., Romano et al., 2021, 2022, 2023). It varies not only among the bones but also concerning the values returned using as variables different measurements of a single bone. For instance, the BM values obtained for the CC skeleton, using the limited number of available variables among those proposed by Christiansen (2004) (12 variables on 36 measured on 4 bones instead of 6), range from a minimum of 8,029 kg (width of the humerus distal articular surface) to 12,829 kg (diaphyseal diameter in the lateromedial plane of the humerus), with an average BM value provided by each bone ranging from 8,780 kg (radius) to 10,476 kg (humerus), which is greater by 19.09% than the previous one (Tab. 6).

Nonetheless, if, on the one hand, the results obtained using the regression formulas proposed by Christiansen (2004) indicate that the BM estimates based on a single, maybe fragmentary, bone could overestimate or underestimate the presumed BM of the proboscidean, on the other hand, they are the most suitable to apply when no complete mounted skeleton is available.

A high level of sexual size dimorphism is particularly evident in extant elephants (e.g., Hanks, 1972; Laws et al., 1975; Moss, 1988; Haynes, 1990; Lister, 1996; Sukumar, 2003). As a matter of fact, the growth patterns differ in mature extant elephants, whereas immature females and males of the same age have similar stature and weight, as the results obtained by Schiffmann et al. (2020), who analyzed the growth patterns of captive Asian and African bush, suggested. After the sexual maturation, which occurs earlier in females than males, the growth in females slows down, and the growth curve approaches the asymptote since the age of about 20-25 in some African populations such as those of the National Parks of Amboseli (Kenya) and Addo (South Africa), while the few Neumark Nord 1 (Germany) data would indicate for *P. antiquus* a very moderate SH increase until an age of about 40-45 years. Conversely, in the African bush males, the growth rate is a little decrease but stays almost constant from the age of about 25-30 years onwards, while *P. antiquus* males from Neumark Nord 1 show a rather high growth rate till the age of 50 years, as confirmed by the very late fusion of some epiphyses (cf. Palombo et al., 2010). However, the age of sexual maturity in African bush elephants varies across populations and in extant elephants, but the body size and shape of some skeletal bones commonly differ in mature males and females of the same age. All things considered, our attempt to infer the sex of the straight-tusked elephant from CC was based prevalently on the maximum lengths of limb bones critically compared with those of *P. antiquus* individuals, males, and females, with a similar AEY. This is because other osteological features are considered dimorphic by some authors (e.g., Dubrovo and Jakuboswski, 1988; Averianov, 1996; Kroll, 1991; Debruyne, 2003; Smith and Fisher, 2003; Todd, 2010; Sedláčková, 2015; Larramendi et al., 2017, 2020; Chang, 2019), such as those of the atlas and pelvic girdle, are unavailable in the CC bones, and the allege dimorphic characters of *P. antiquus* are rather variable (Palombo and Villa, 2003).

The length of the CC long bones is significant and exceeds that of compact female specimens even of advanced age, as in the straight-tasked female from Ciechacow (Poland), which is 59.5 years old (Tab. 8). The length of CC limb bones is comparable with that of the Italian skeleton from Fonte Campanile (Viterbo, northern Latium) at 32.5 years and with those of the two *P. antiquus* specimens from Neumark Nord 1, with an AEY of about 47 and 50 years, from Gröbern I (Germany) and Upnor (UK), while the long bone length of the 30.5-year-old Aveley (UK) male is slightly lower.

Although most of the CC long bone epiphyses seem to be fused or in an advanced stage of fusion, as frequently occurs in females of a similar age, their actual degree is sometimes doubtful due to the bone restoration. Moreover, a rather high intra-individual variation has been observed in the timing of relative epiphyseal fusion of some *P. antiquus* long bones (Palombo et al., 2021b). Tusks can also provide some clues as to the sex of a straight-tusked elephant, being proportionally longer and more massive in males than in females. However, this difference is less relevant in some specimens, such as those of the Neumark Nord 1 rich sample (Palombo, unpublished data). The CC tusks are rather massive but rather long, as expected in a relatively young adult. The right and left tusks of the 23.5-year-old male from "Il Crocefisso" (Riano, Latium) are shorter, being 15.30 m and 15.46 m long, respectively (Maccagno, 1962). Conversely, the tusks of the 32.5-year-old male from Fonte Campanile (Viterbo), 2.20 m long with a circumference of 57 cm at the distal edge of the alveolar sockets (Trevisan, 2948), have a size similar to that of the CC tusks, which possibly are slightly longer and massive, considering that we could not estimate their actual length and circumference at the distal edge of the alveolar sockets. Therefore, the dimensions of the 35-year-old CC elephant support its attribution to a male individual.

6. CONCLUSION

The elephant skeleton, found in 1982 in Middle Pleistocene deposits of the Mercure Basin (Basilicata, Southern Italy) cropping out near the village of Rotonda, is one of very few nearly complete skeletons of straight-tusked elephants recorded in Italy. Although the results of this preliminary study must be considered not definitive pending some restoration of skeletal remains, this would permit us to scrutinize in depth the morphological and biometric characters, enabling us to provide more compelling data.

Based on the analysis of currently available data (i.e., skull and mandible taxonomically diagnostic morphology, morphology and dimension of tusk and molars, ontogenetic age at the death, determined through dental wear, sex estimation through long bones maximum length, together with the tusk dimensions), support the identification of the elephant skeleton from Contrada Calorie as a *Palaeoloxodon antiquus* male of approximately 35 years old (AEY), with a putative live shoulder height (SHf) of about 3.9-4.0, a skeletal height (SH) of about 3.6-3.7 m, and a body mass (BM) of about 9,600-9,700 kg.

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Authors' contribution

mRP conceived and wrote the article with the assistance of LB; MRP analyzed data and executed quantitative analyses; LB and RS wrote the geological note; LB took the measurements of the elephant remains and handled the project for the site stratigraphy and for the elephant study and valorization.

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