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PALEOART AS A TEACHING TOOL: LIFE RESTORATIONS OF QUATERNARY MAMMALS OF SICILY (ITALY)

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ABSTRACT. Paleoart is an important teaching tool in palaeontology. Accurate reconstructions of extinct organisms are particularly impressive in the transmission of research results to a wide public. Life restorations of endemic elephants and hippopotamuses that lived in Sicily during Quaternary are here presented. The restorations are based on anatomical and biometric studies and are realized using graphite pencil on cardboard. The drawing have been digitalized to be reproduced and only few adjustments have been provided with photoshop.

1. Introduction

Paleoart is an increasing teaching tool in paleontology. Artistic restorations of landscapes and animals are particularly evocative just because they picture scenes from deep time.

Quaternary mammals of Sicily are intriguing subjects for paleoartists thanks to the presence of endemic species. Dwarf elephants and large dormice are impressive when drawn together, however they were rarely represented. The famous engraving by Jemima Wedderburn in Leith Adams (1870) proposed a life restoration of the Maltese fauna also suitable for Sicily, including a dwarf hippopotamus, a giant dormouse, a giant swan, a giant tortoise and three elephants of different sizes. Endemic species were figured resembling living ones but in different scales and mixing species of different ages. Similar restorations, based on a scaling starting from affine living species persisted in later illustrations, often simplified for scientific or didactic purposes, as in Azzaroli (1990). Some reliable illustrations, based on morphological data, appeared in popular books (*i. e.*, Attenborough (1987) and Lambert (2001) and scientific papers (Romano *et al.* 2019).

Paleoart needs the support of a deep anatomic study on bones. It is not coincidence that George Cuvier, considered the founding father of vertebrate' paleontology, has argued the importance of life restorations. He draw remarkable reconstructions of the life appearance of several mammals considering the musculature, but he was concerned that drawing could have been considered speculative (Rudwick 1995). Finally, his reconstructions remained unpublished and he commissioned his assistant to make stylized drawings for the second edition of "Recherches sur les ossemens fossiles" in 1822 (Rudwick 1995; Antón 2007).

Since then, paleoart supported the process of discoveries and studies, especially the popularization.

The artists who support paleontologists in the course of their research play an important role in disseminating this knowledge to the general public (Antón 2007). The techniques are disparate, and today the digital ones are widely spreading, although all have a common starting point: comparative anatomy.

2. Methods

Life restorations here presented are mainly addressed to reliable reconstructions based on morphometric studies. In absence of complete skeletons, the reconstruction starts from bones of comparable ontogenetic age, then an estimation of the volume of muscles and their attachment points is provided (Antón 2007).

Data on the morphomogy and biometry of *Hippopotamus pentlandi, Palaeoloxodon mnaidriensis* and *Palaeoloxodon falconeri* has been collected from the available papers (Accordi 1955; Ambrosetti 1968; Marra 2005). These data have been supported by a rich photographic report of the mounted skeletons of *Hippopotamus pentlandi* and *Palaeoloxodon mnaidriensis* exibited at the "Museo di Geologia e Paleontologia dell'Università di Padova" (MGPUP) and of *Palaeoloxodon falconeri* exibited at the "Museo di Paleontologia dell'Università La Sapienza di Roma" (MPUR). The observation of modern relatives (*Hippopotamus amphibius and Elephas maximus*) supported the reconstruction of the life appearence of the fossil species.

The preferred technique was graphite pencil on cardboard, both for reconstructing skeletons and life appearance. It is a basic technique, more widely used in the past, but which allowed the realization of several sketches preparatory to the final work, as well as their re-elaborations and corrections. The reconstructions are all in scale 1:10 on A3 (ISO216) paper. The paper size is suitable to contain the reconstructions and to digitalize by scanner. After the digitalization, the texture has been modified with Photoshop CC.

3. Pleistocene mammals of Sicily

Life restorations are here focused on Middle Pleistocene of Sicily, when the island experienced two different geographic settings and two different faunal complexes of terrestrial vertebrates (see Marra 2013, 2019, and references contained therein).

The Quaternary vertebrate fauna of Sicily is at present arranged into five Faunal Complexes (see Marra 2013, and references contained therein). Changes in faunal composition are related to dispersal events followed by isolation phases, which induced processes of endemism in the pioneer species (Fig. 1). Dispersals depend on palaeogeographical conditions, on sea level changes and on dispersal abilities of the precursor species (Marra 2009, 2013). The main dispersal direction acted from Peninsular Italy, through the Strait of Messina, however some earliest arrivals (Late Miocene?) from North Africa are still poorly documented (Marra 2013; Marra *et al.* 2017; Marra 2019).

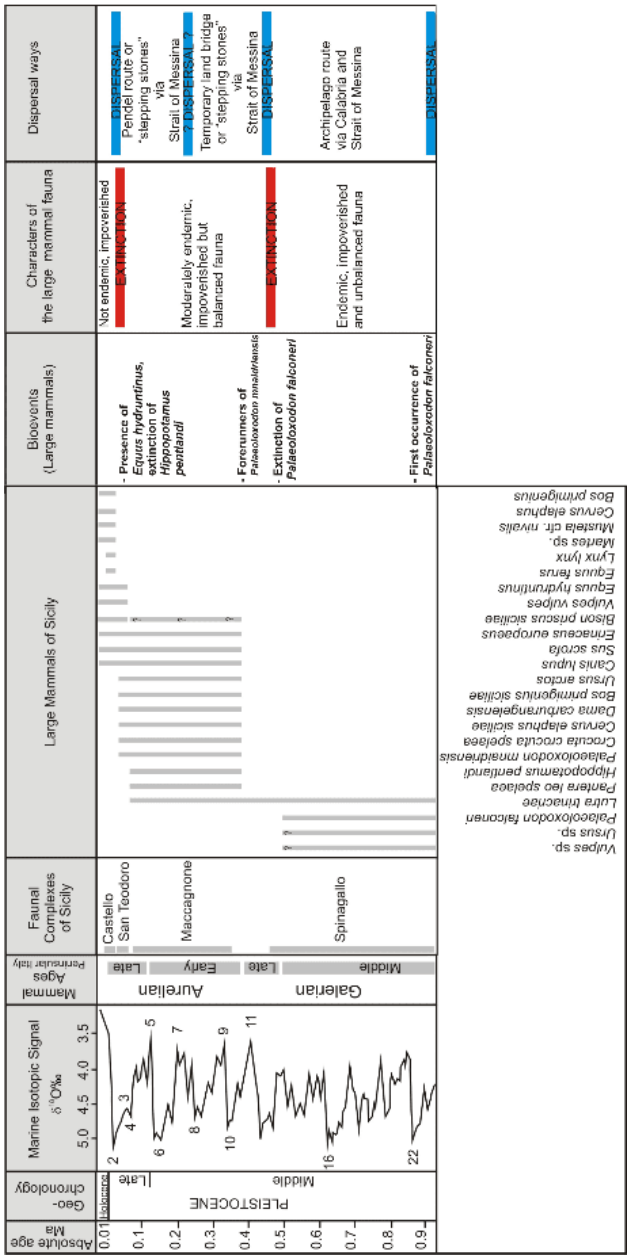


FIGURE 1. Mammals of the Middle and Late Pleistocene of Sicily: faunal complexes bioevents, characters of fauna and dispersal ways correlated to the standard mainland mammal biochronology, geochronology and Marine Isotopic Signal, redrawn after Marra (2013)

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The species here reconstructed comes from different faunal complexes, related to different paleogeographical and paleoecological assessments (Fig. 2).

Palaeoloxodon falconeri lived during Early Middle Pleistocene (*Spinagallo Faunal Complex*), when Sicily was divided in two small islands and mammal fauna was strongly impoverished in number of species and unbalanced in ecological composition (Figs. 1, 2; Marra 2013); Its ancestor was *Palaeoloxodon antiquus*, an elephant 4,5 meters high, spread from peninsular Italy, who undewnt darwism giving rise to the insular species about 0.9-1.10 m high. The strong reduction in size of this species was probably driven by the small area, the reduced environmental resources and the absence of predators and intra-guild competitors (Palombo 2004). The small size has probably been obtained by anticipation of the sexual maturity and shortage of the pregnancy period. *Palaeoloxodon falconeri* occupied the available ecological niches typical of medium- and large-sized herbivores (Palombo 2004). The reduced size allowed the persistence of *P. falconeri* populations with a number of individuals adequate to avoid extinction. Moreover, a smaller body mass reduced the deep modification of vegetation typically produced by elephants.

During late Middle Pleistocene mammal fauna of Sicily was almost completely renewed and represented by an association impoverished but balanced and diversified, with a moderate endemism (Maccagnone Faunal Complex; Figs. 1, 2; Marra 2013). The environment was a typical of Mediterranean "macchia" with prairies and open woods, (Guglielmo and Marra 2011). The dwarf elephant *Palaeoloxodon falconeri* became extinct, and a new spreading of *P. antiquus* gave rise to the dwarf species *Palaeloxodon manidriensis*, high about 1,80m. In the fauna, *Hippopotamus pentlandi* was present, a dwarf species evolved from *H. amphibius*, smaller than the ancestor about -20% (calculated on bone measurements, Marra (2005)).

Palaeocological relationships were complex, with top predators feeding on populations of herbivores, mainly cervids. In conditions of isolation and reduced area, the slight reduction in size observed in herbivores might have been a strategy to maintain the number of individuals adequate to avoid extinction, also in presence of three species of social predators, which did not evolved endemic features because size of endemics fell into the variability range of usual preys (Guglielmo and Marra 2011). *Hippopotamus pentlandi* and *Palaeoxodon mnaidriensis*, thanks to their reduction in size, occupied ecological niches vacant on island, that are respectively those of large horses (grazers) and rhinoceroses (mixed-feeders) (Palombo 2004).

P. mnaidriensis persisted also later, in the San Teodoro Faunal Complex (late Pleistocene), when connections to mainland were probably easier than before.

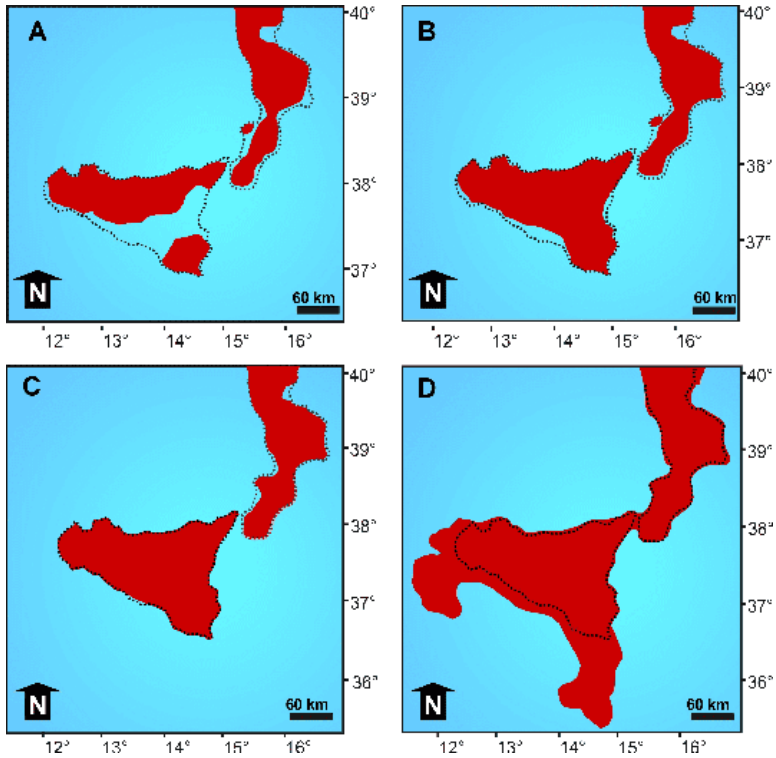


FIGURE 2. Paleogeography of Calabria and Sicily during early Middle Pleistocene (A), late Middle Pleistocene (B), Late Pleistocene (C), last glacial maximum (D); dotted lines represent the modern coastline; redrawn after Marra (2009).

4. Bringing fossil mammals to life

The first step in achieving realistic reconstructions was the observation of diagnostic characters of bones.

The life restoration of *Paleoloxodon falconeri* (Fig. 3) is based on two skeletons exposed at MPUR and on the morphometric data by Ambrosetti (1968). Skeletons exhibited at Rome are compiled with bones coming from Spinagallo cave (Syracuse) and are referred to a male and a female. The reconstruction considered the possible bias due to the use of skeleton compiled using bones belonging to different individuals. Morphometric studies show a marked sexual dimorphism in *Paleoloxodon falconeri*, consisting in small body size and absence of tusks in female specimens (Ambrosetti 1968). The study of body proportions reveals that the body of *Paleoloxodon falconeri* was proportionally longer than that of *P. mnaidriensis* and even longer than that of *P. antiquus* (Figs. 3, 4, 5). The back was slightly curved, with the head nearly aligned to shoulders. Length of cervical vertebrae suggests a neck proportionally longer than both *P. mnaidriensis* and *P. antiquus*, and more similar to the living *Loxodonta africana*. The neck was more mobile than other species and this

feature could be related to a different adaptation to environmental conditions and food availability.

Height at the shoulders was about 100 cm for males and 80 cm for females. This reconstructive interpretation, dating back to 2014, have been more recently confirmed in detailed works on the morphology of the species (Larramendi and Palombo 2015; Romano *et al.* 2019).

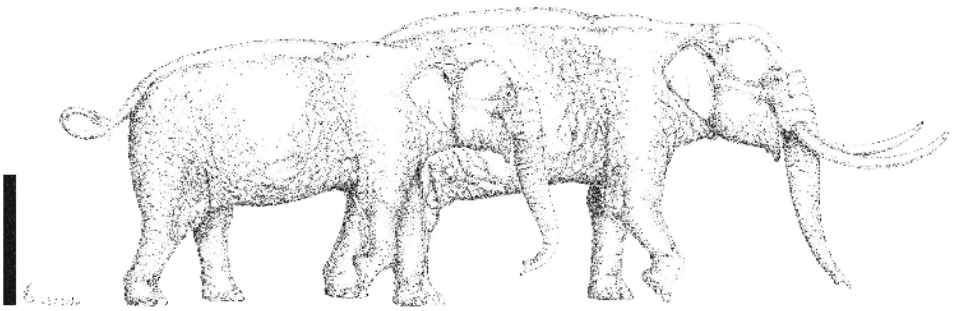


FIGURE 3. Life restoration of a female and a male (with tuskus) of *Paleoloxodon falconeri* (scale bar: 1 meter).

The restoration of the skeleton of *Palaeoloxodon mnaidriensis* is based on the skeleton exposed at MGPUP, and represents the starting point to realize the life appearance of the species (Fig. 4).

The skeleton is composed by bones of different individuals recovered at Puntali cave, near Carini (Palermo). A detailed morphology of the exposed skeleton is not available in scientific literature, so the recontruction required a deep anatomical study. Moreover, the intensive restorations present on vertebral processes, ribs and scapulae have been considered and amended. The correct position of vertebrae was probably similar to the ancestor *Palaeoloxodon antiquus* and also scapulae have been modelled on the mainland species (Maccagno 1962). The fusion of radius and ulna is a feature different from *P. antiquus* but present in *P. falconeri*, and is probably a locomotory adaptation. The limb bones proportionally more robust than*P. antiquus*and the proportion height/length give a stocky body. Similarly to *P. antiquus*, the head was aligned to the shoulders.

The trunk was very pronounced judging by the robustness of the supraorbital torus. Tusks were massive, onward curved and directed, nearly parallel. Details, such as ears dimensions and skin texture are reconstruncted on the living *Elephas maximus*. Heigth at the sholders was about 180 cm.

The reconstruction presented here is the first tentative to reach a reliable life appearance of *Palaeoloxodon mnaidrenis*. Recently, Larramendi *et al.* (2020) have described the peculiar morphology assumed by the parieto-occipital crest during ontogenesis in *Paleoloxodon genus*, so it will be interesting in the future to develop a new reconstruction of *Palaeoloxodon mnaidrenis* based on this new data (De Francesco and Marra 2014).

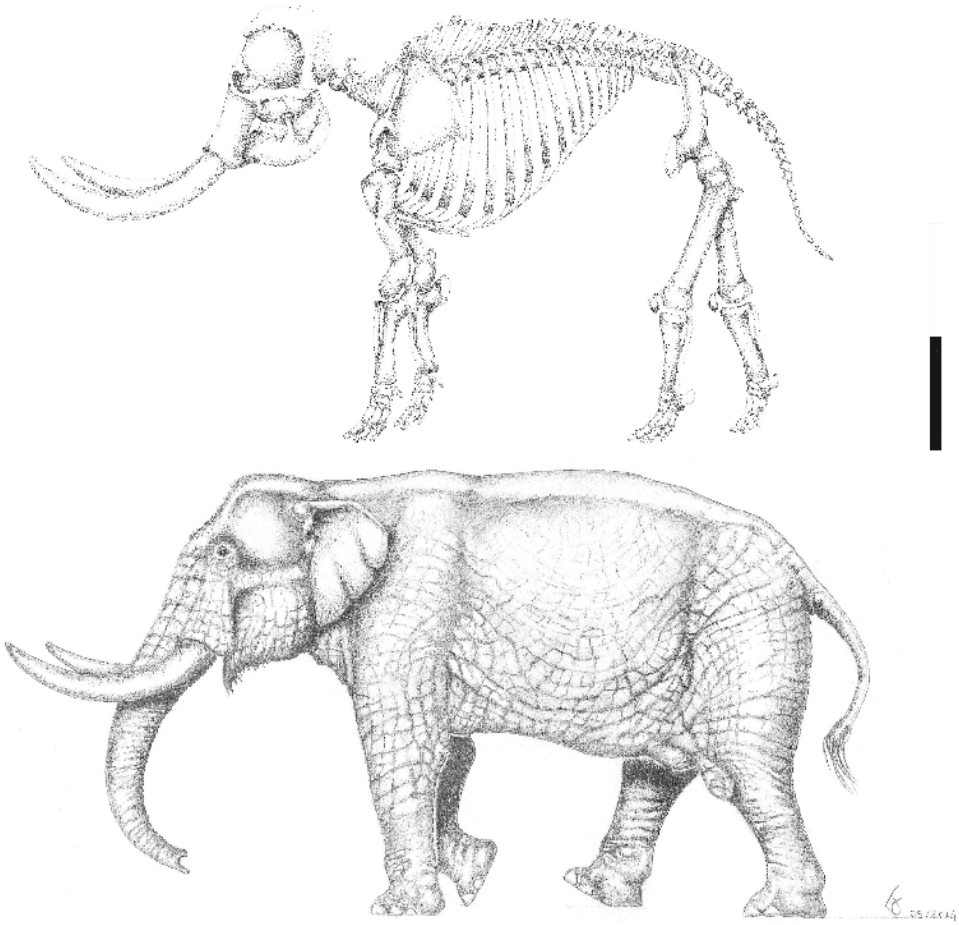


FIGURE 4. Recontruction of the skeleton and life restoration of *Paleoloxodon mnaidriensis* (scale bar: 1 meter).

The deep observation of the diagnostic features and an evaluation of the bone damages and deformations has been particularly important for the skull of *Hippopotamus pentlandi* which is based on that of the specimen conserved at MGPUP, labelled "Specimen A" (Accordi 1955) and mounted on skeleton, and on two other crania stored in the same Museum ("Specimen B" and "Specimen C"; Accordi (1955)).

The skulls are quite deformed, especially dorso-ventrally, and this has made the exact modelling rather complex. Descriptions and measurement after Marra (2005), have been used to correct the bias by defomations. The comparative anatomical study on skulls of *H. pentlandi* and its probable ancestors (*H. antiquus* and *H. amphibius*) led to the drawing in Fig.5.

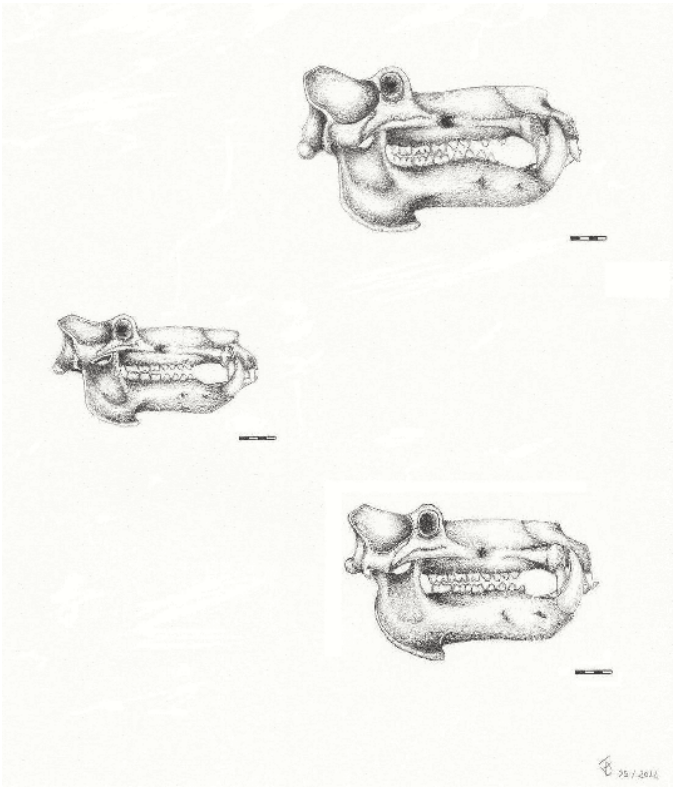


FIGURE 5. Reconstruction of the skulls of *Hippopotamus antiquus*, *Hippopotamus pentlandi*, *Hippopotamus amphibius* (from the top to the bottom; scale bar: 10 cm).

The skull of *H. antiquus* has been reconstructed on a specimen from Colle Curti (Macerata; "Specimen 12an" in Mazza (1995). As the specimen is much deformed, the reconstruction has taken into account the descriptions and the measurements by Mazza (1995). *H. amphibius* has been drawn on a complete and undeformed skull found at Tor di Quinto (Rome; inventory reference: MPUR/V 149; Caloi and Palombo (1980)).

The life appearance of *H. pentlandi* was not to differ much from that of *H. amphibius*, the reliable ancestor species (Marra 2005). The head was more slender than that of *H. amphibius*, with a comparable elevation of the orbits, but with frontal and occipital bones more flat. Going to consider the whole skeleton, the limb bones seems to be more adapted to walk on a dry ground.

The reconstruction of the whole animal (Fig. 6) has been based on the modern hippopotamus, following a treatese of mammals anatomy for artistis (Goldfinger 2004) and taking into account the differences highlighted by the anatomical an morphometrical studies.

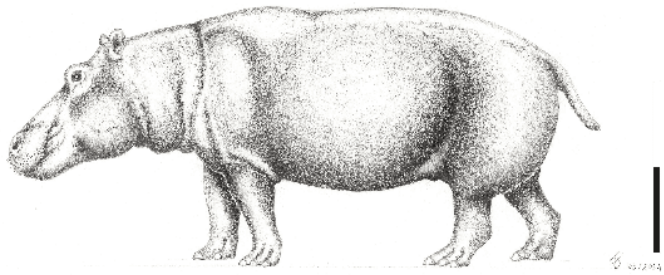


FIGURE 6. Life restoration of *Hippopotamus pentlandi* (scale bar: 1 m).

5. Conclusions

Life restorations realised by T. De Francesco in 2014 and here published are mainly addressed to reliable reconstruction based on morphometric studies, besides classical illustrations based on scaling of dimensions starting from living or continental relatives (Fig. 7). The artist used the classical technique of drawings, without the use of digital technologies. Life restorations here presented are the first ever obtained for mammals of Sicily using a biometrical method (De Francesco and Marra 2014).

Drawings permit to immediately appreciate life appearances, as well as body proportions and allometries. Reduction in size of elephant is relevant when compared with the forerunner. It is also interesting to compare *Hippopotamus pentlandi* and *Palaeoloxodon mnaidriensis*, whose difference in body size is lower than that existing between continental relatives.

Life restorations are extraordinary teaching tools, which allow to immediately visualise the results of palaeontological researches.

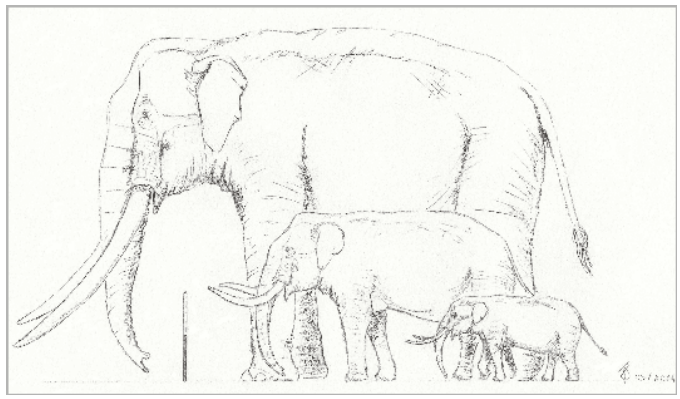


FIGURE 7. Interpretation of the classic figure of Azzaroli (1990): comparisons among *Palaeoloxon antiquus*, *P. mnaidriensis*, and *P. falconeri* (from left to right; scale bar: 1 m).

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