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DID ELEPHANTS MEET HUMANS ALONG THE DEVIL'S PATH ? A PRELIMINARY REPORT

Maria Rita Palombo [1], Adolfo Panarello [2], Paolo Mietto [3]

1 IGAG-CNR, c/o Dipartimento di Scienze della Terra, Università di Roma "Sapienza", Roma, Italy
2 Dipartimento di Scienze Umane, Sociali e della Salute, Università Studi Cassino e Lazio Meridionale, Cassino (FR), Italy
3 Dipartimento di Geoscienze, Università degli Studi di Padova, Padova, Italy
Corresponding author: M.R. Palombo <mariarita.palombo@uniroma1.it>

ABSTRACT: This research aims to give notice of and provide preliminary information on some elephant footprints recently identified at Foresta ichnological site (Tora-Piccilli, Caserta, central Italy). The elephant-footprint area was previously poorly investigated because partially affected by anthropic modifications during historical times. The footprints, ascribed to the *Proboscipeda panfamilia* ichospecies, were left by a young strait-tusked elephant, passing the top of the slope formed during the deposition of the Roccamonfina Brown Leucitic Tuff (BLT), close to the renowned prehistorical Devil's path. The Foresta elephant footprints are the unique conceivably belonging to *Palaeoloxodon* recorded in Italy and the first elephant tracks reported from the continental Italian territory.

KEYWORDS: *Palaeoloxodon,* footprints, Foresta ichnosite, early MIS 10, central Italy

1. INTRODUCTION

Since the time of the first announcement to the scientific community of the identification of the so-called "Ciampate del Diavolo" as prehistoric hominin tracks and track-ways (Mietto et al., 2003), the notoriety of the ichno-site, located on the northeastern slope of the Roccamonfina volcano (N41°19.954' - E14°01.488'), has been constantly increasing not only due to its proved antiquity (349-350±3 ka, Panarello et al., 2017a), but also because of the unique and rich information the human footprints may provide with regard to the physical characteristic and behaviour of Italian hominins (likely *Homo heidelbergensis*) at the beginning of a Middle Pleistocene glacial phase (early MIS 10) (Avanzini et al., 2008; Panarello et al., 2017 a, b). Although few mammal tracks were noted on the surface of the Roccamonfina Brown Leucitic Tuff (BLT) recording the hominin tracks, initially the research activity at the site mainly focused on hominin footprints and their depositional context. In the last couple of years, archaeological and palaeontological investigations, mainly finalised to investigate the environmental context, started and are still in progress. In particular, an attentive analysis of the palaeosurface led to the detection of a few middle-sized artiodactyl and horse tracks (Panarello et al., 2017b).

This research aims to give notice of and provide preliminary information on some elephant footprints detected near and roughly along the prehistoric path during a new survey on an area previously poorly investigated because affected, during the last century, by anthropic modifications.

2. MATERIALS AND METHOD

The studied material consists of some isolated impressions (manus and pes), preserved as concave epireliefs, organised in a quite narrow, short track-way developed nearly along the Devil's path. Herein we briefly describ only the best preserved footprints where some anatomical details (i.e. toe/nail impressions) are still more or less discernible. Different length and width measurements were taken considering, if possible, the outline and the edge of the manus/pes impression, and the extent of sediment deformations (Fig. 1).

The height at the shoulder of the trace-maker has been estimated following Lee & Moss (1995), the possible age range has been inferred on the basis of the growth curve (height for age) of extant bush African elephants corrected according to data available for straight-tusked elephants (Marano & Palombo, 2013; Larramendi et al, 2017). Estimate of body mass was derived by the manus circumference and height at the shoulder, following the method proposed by Palombo & Giovinazzo (2005, pag. 258, table1).

The area recording the elephant fossil footprints was georeferenced with a Garmin Etrex 10 detector (accuracy ±3 m) and photographed through Sony *Nex6* camera with Sony 16-50 lens. A detailed 3D model was then created by processing the pictures with Agisoft Photoscan Pro and Kitware Paraview software following the procedures proposed by Mallison & Wings (2014) and Belvedere et al. (2013).

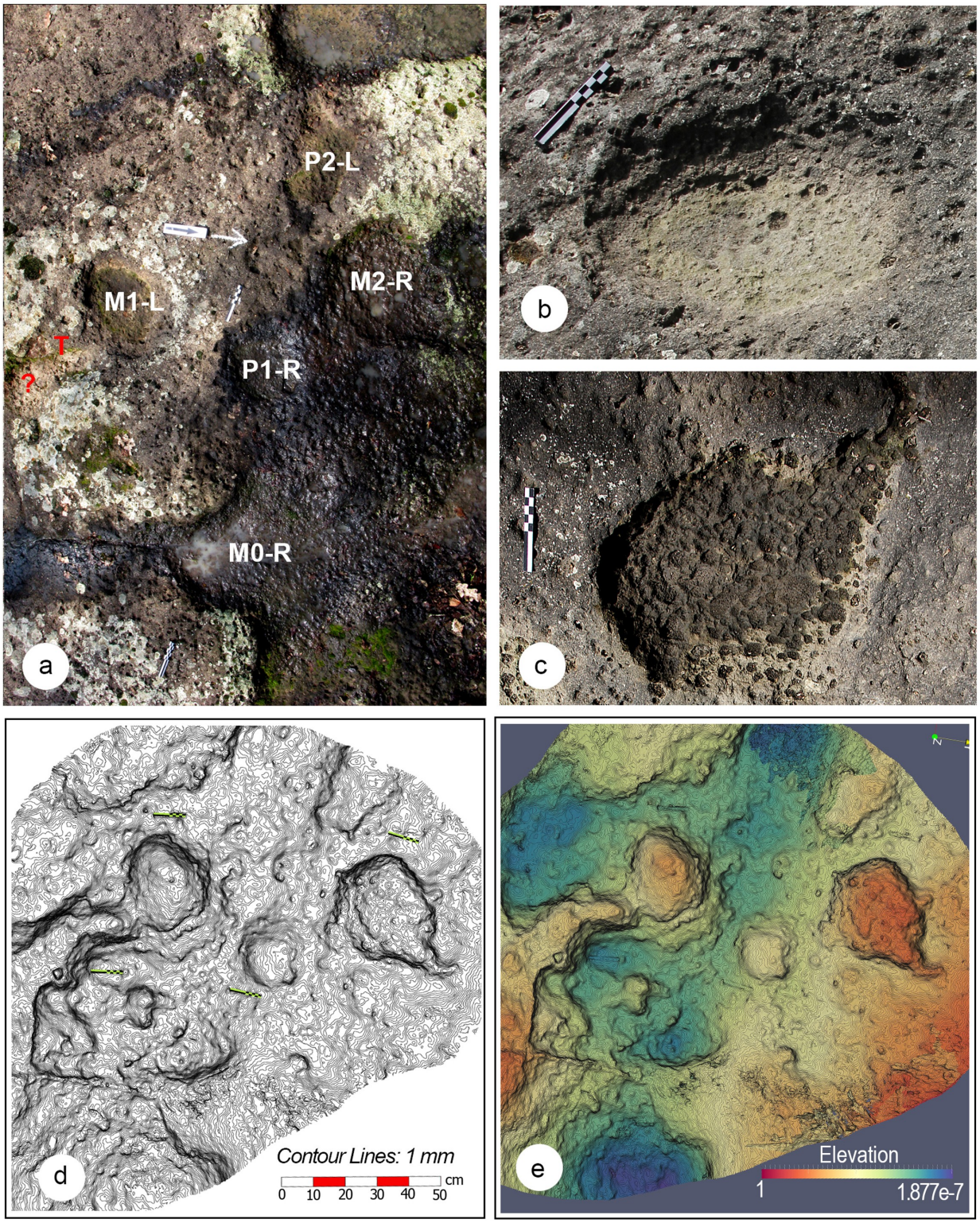

Fig. 1 - Foresta (Roccamonfina volcano): fossil Proboscidean track area: a) general photo view with notations; b) detail photo of the footprint M1-L; c) detail photo of the footprint M2-R; d) contour map (interval: 1 mm); e) contoured depth map.

3. SYSTEMATIC ICHNOLOGY

Ichnogenus *Proboscipeda* Panin & Avram, 1962

(Type Ichnospecies *Proboscipeda enigmatica* Panin & Avram, 1962)

Proboscipeda panfamilia Mc Neil, Hills, Tolman & Kooyman, 2007

(Fig. 1)

The elephant tracks here described consist at least of four well identifiable footprints (M1-L, M2-R, P1 and P2, Fig. 1a), nearly rounded to oval in shape, preserved as convex hyporeliefs, bordered by more or less inflated and prominent pressure pads (push up). The footprints are arranged in a short track-way along which some other impressions are present, potentially left by the same trace-maker. The footprints are present in an area modified by anthropic activity in historical time. This which further complicates the detection and identification of the tracks on the palaeosurface, which is challenging, "due to the characteristics of the pyroclastic flow they are impressed on, and the alteration undergone by the top of the volcanoclastic deposit during its prolonged exposure to weathering agents" (Panarello et al., 2017b, pag. 145). Accordingly, the actual nature of some impressions can only be hypothesised due to their poor preservation status.

The best preserved footprints (M1-L, M2-R) (Fig. 2e, f) show an oval outline, with the width being the greatest dimension, and evident four toe imprints at the anterior end of the manus impression as a result of the peculiar dynamic of cushion deformation, and the support offered to the limb rotational movement during the limb and foot rotational movements (Hutchinson et al., 2006; 2011). Interesting to note the sharp edges of the toe impressions that indicate the presence of nails, suggesting that the tracks were left by a young individual because nails are usually worn down in adult elephants and not always shown on their footprints. In both footprints the deepest zone corresponds to the front part, which is opposite of dip, following the typical rotation during the event foot on - foot off. The lateral border of the M2-R footprint shows a quite typical "dragging" imprint, likely left during the foot off event.

Only the medial margin is preserved of the right manus footprint M0-R (Fig.1) (measured length =314,76 mm). The impression, indeed, was destroyed in historical time to create a small quadrangular area for placing baskets at the southern verge of the prehistoric path, which was used as a shortcut up to recent time (Panarello et al., 2017a).

An intriguing, abnormally long track (T and ?, red in Fig. 1a) may suggest a hint foot (pes) dragging, although it actually may result from the combination of two different imprints: an imprint left by the trunk digging the surface at the anterior end (T) and an impression of a dragging foot (?). Further analysis is needed to support or reject this hypothesis.

The estimated dimensions of M1-L and M2-R footprints (length x width = 248.05x277.17 mm and 329.43x334.82 mm respectively) support the hypothesis of a young elephant trace-maker. The inferred age, about 4-9 years if female and 5-8 years if male, suggested it may have had a height at the shoulder in flesh not exceeding 1.9 m. Estimates of body mass of about 2600 kg, obtained using as variable the height at the shoulder, and 2350 kg, by using the circumference pad inferred from the dimensions of M1-L, are roughly consistent with the body mass range of adult forest African elephants (*Loxodonta cyclotis*), whose height only exceptionally reaches 2.2 m (e.g. Haynes, 1991; Morgan & Lee, 2003; Larramendi, 2016). The estimate of body mass based on the inferred pad circumference of M2-T, affected by the toe dragging, results overestimated (about 4250 kg). The value obtained largely exceeds the average value of *Loxodonta africana* males of a comparable stature, and even that of bush elephant adult females.

4. DISCUSSION AND CONCLUSION

Fossil Proboscidean tracks and track-ways (ichnogenus *Proboscipeda)*, which have been reported from all over the world (except for Oceania) although not so frequently, (e.g. Lucas et al., 2007 and references therein; Matsukawa & Shibata, 2015; Hunt & Lucas, 2016; Neto-de-Carvalho et al., 2016; Pillola & Zoboli, 2017; Retallack et al., 2018), may provide interesting information about the consistency of the proboscidean fossil record, animal behaviour, locomotor characteristics and social structure (e.g. Bibi et al., 2012) also in areas where fossil bones have never been reported. Proboscidean footprints, which are known from sites ranging in age from the Late Eocene (*Proboscipeda enigmatica* and cf. *Proboscipeda* isp., from Iran; Abbassi et al., 2018) to the latest Pleistocene, are rarely associated with human footprints (Kim et al., 2010).

All the fossil and extant proboscidean tracks are included in the ichnogenus *Proboscipeda.* The ichnogenus was proposed for proboscidean tracks from the Miocene of Romania (Panin & Avram, 1962) and, according to the diagnosis, it includes footprints described as large (11.0 - 62.0 cm in diameter), ovoidal to circular depressions, sometimes showing digit impressions, and, quite frequently, repeated overstepping of manus and pes footprints in trackways. The ichnogenus includes two inchnospecies, *Proboscipeda enigmatica* and *Proboscipeda panfamilia. P. enigmatica,* erected by Panin & Avram (1962) for Miocene proboscidean tracks (likely deinotheres) found in Romania, mainly refer to primitive proboscideans, while tfootprints of elephants belonging to the Loxodontini and Elephantini tribe (sensu Shoshani & Tassy, 2005) are generally referred to the *P. panfamilia* ichnospecies, erected by McNeil et al. (2007) for Pleistocene mammouth tracks found at St. Mary Reservoir (Alberta, Canada). These tracks have been described as averagely larger and more circular than *P. enigmatica,* usually showing a bilateral symmetry, with toe impressions often visible, though the number of impression could not match the actual number of toes in the foot. In particular, "a short toe impressions at the anterior end is unique to *Mammuthus* and extant proboscideans" (McNeil et al., 2007, pag. 210). Toe impressions, however, were reported in a number of footprints left by the endemic Japanese species *Palaeoloxodon naumanni* (Nojiri-ko Fossil Footprint Research Group,

1992), and in *Palaeoloxodon antiquus* tracks (Neto-de-Carvalho et al., 2016).

The large footprints recently detected at Foresta ichnosite, and herein preliminarily described, can be confidently assigned to the *P. panfamilia* ichnospecies, as indicated by their overall morphology and size. It is however difficult to identify the species to which the trace-maker belongs, similarly to most animal tracks. The assignment of proboscidean footprints to a *Proboscipeda* ichnospecies and/or to a specific trace-maker is mostly based on the age of the deposits (as regards to the distinction between *P. enigmatica* and *P. panfamilia*), and on the known occurrences of fossil bones in the depositional context or in coeval sediments of the region, rather than on the size and morphology of footprints. Based on some literature data (i.e. McNeil et al., 2007), however, it would seem reasonable to suppose that the proportion between length and width and the presence vs absence of toe impressions, as well as the possible number of nails if visible, may have some taxonomic relevance and facilitate the identification of the trace-maker. It is worth noting, however, that "the morphology of an elephant footprint can change depending on the type of substrate the maker was walking on", and "the impression of toes ranged from absent to present depending on the type of substrate, even when made by the same elephant" (Pasenko, 2017, pag. 224). Accordingly, "the presence or absence of digit impressions should not be used solely to assign a proboscidean footprint to an ichnotaxonomic label … this is most likely a result of differences in substrate rather than specific distinction" (Pasenko, 2017, pag. 224). In addition, the foot shapes of Elephantinae representatives (*Elephas, Loxodonta, Palaeoloxodon, Mammuthus*) shows a basically similar structure. The differences in foot proportions and general shape among species are not relevant, particularly when the intraspecific variability (e.g. individual variation, ontogenetic growth, gender) are considered. Random factors (such as the nature of the substrate, topography, and locomotion dynamics), may, however, affect size, depth and shape of any footprint, making the identification of the trace-maker problematic, especially when the tracks are few and they do not belong to a track-way. There is little doubt, however, that, proboscidean footprints could provide useful information especially when fossil remains are absent. In the case of Foresta footprints, for example, they provide evidence for the presence of a proboscideans herd.

Some support to the hypothetical identification of the trace-maker of Foresta footprints could be provided by the fact that during the Middle Pleistocene straight-tusked elephant populations are widely recorded in a number of sites from Northern to Southern Italy. *P. antiquus* was the dominant species in various Local Faunal Assemblages (LFAs), while *Mammuthus* is recorded from a very few localities (Palombo & Ferretti, 2005). In southern Latium, straight-tusked elephant remains are reported from most of the LAFs where the presence of Lower Palaeolithic hominins (*Homo heidelbergensis*) is attested by artifacts and fossil remains. The hypothesis that the elephant trace-maker at Foresta was a young *P. antiquus,* is, therefore, the most plausible, but not demonstrable.

P. panfamilia tracks attributable to *Palaeoloxodon* have been reported to date only from the Iberian Peninsula (Portugal, Neto-de-Carvalho, 2009, 2011; Neto-de-Carvalho et al., 2016; Spain, Manzanares Valley, Panera et al., 2014) and in the eastern Mediterranean islands (Rhodes and Cyprus, Milàn et al. 2007, 2015). The tracks mostly belong to adult individuals, even if those from Rhodes and Cyprus, left by endemic small-sized elephants, show dimensions roughly comparable with those of Foresta. *Mammuthus* footprints are nearly unknown in the European Middle Pleistocene. In Italy, some tracks likely attributable to the endemic species *Mammuthus lamarmorai,* have been recently described from Late Pleistocene aeolian deposits in Sardinia (Pillola & Zoboli, 2017).

Assuming as true that the Foresta footprints can be attributed to a young straight-tusked elephant, negotiating the top of the slope formed during the deposition of the Roccamonfina Brown Leucitic Tuff (BLT) close to the renowned prehistorical Devil's path, they would be the only tracks of *Palaeoloxodon* recorded in Italy and the first elephant tracks reported from the continental Italian territory.

The results present herein have to be regarded as preliminary. The detailed investigation of the imprinted volcanic surface currently in progress at Foresta may provide new data and answer a number of still open questions about the mammalian species walking along and in vicinity of the Devil's prehistoric path.

REFERENCES

Abbassi N., Alinasiri S., Lucas S.G. (2017) - New localities of Late Eocene vertebrate footprints from the Tarom Mountains, Northwestern Iran. Historical Biology, 29(7), 987-1006.

Avanzini M., Mietto P., Panarello A., De Angelis M., Rolandi G. (2008) - The Devil's Trails: Middle Pleistocene Human Footprints Preserved in a Volcanoclastic Deposit of Southern Italy. Ichnos, 15, 179-189.

Belvedere M., Jalil N.-E., Breda A., Gattolin G., Bourget H., Khaldoune F., Dyke G.J. (2013). Vertebrate footprints from the Kem Kem beds (Morocco): A novel ichnological approach to faunal reconstruction. Palaeogeography, Palaeoclimatology, Palaeoecology, 383/384, 52-58.

Bibi F., Kraatz B., Craig N., Beech M., Schuster M., Hill A. (2012) - Early evidence for complex social structure in Proboscidea from a late Miocene trackway site in the United Arab Emirates. Biology Letters 8, 670-673

Kim C.B., Kim J.Y., Kim K.S., Lim H.S. (2010) - New age constraints for hominid footprints found on Jeju Island, South Korea. Journal Archaeological Science, 37(12), 3338-3343.

Haynes G. (1991) - Mammoths, Mastodonts, and Elephants: Biology, Behavior and the Fossil Record. Cambridge University Press, Cambridge, UK, pp. 413.

Hunt A.P., Lucas S.G. (2016) - Vertebrate trace fossils

from New Mexico and their significance. New Mex Mus Nat Hist Sci Bull, 64, 9-40.

Larramendi A. (2015) - Shoulder height, body mass, and shape of proboscideans. Acta Palaeontologica Polonica, 61(3), 537-574.

Larramendi A., Palombo M.R., Marano F. (2017) - Reconstructing the life appearance of a Pleistocene giant: size, shape, sexual dimorphism and ontogeny of *Palaeoloxodon antiquus* (Proboscidea: Elephantidae) from Neumark-Nord 1 (Germany). Boll. Soc. Pal. It., 56(3), 299-317.

Lee P.C., Moss C.J. (1995) - Statural growth in known-age African elephants (*Loxodonta africana*). J. Zool., Lond. 236, 29-41.

Lucas S.G., Spielmann J.A., Lockley M.G. (2007) - Cenozoic Vertebrate Tracks and Traces. New Mexico Museum of Natural History and Science Bulletin, 42, 241-249.

Mallison H., Wings O. (2014). Photogrammetry in paleontology - a practical guide. J. Paleont. Tech., 12, 1-31.

Marano F., Palombo M.R. (2013) - Population structure in straight-tusked elephants: a case study from Neumark Nord 1 (late Middle Pleistocene?, Sachsen-Anhalt, Germany). Boll. Soc. Paleont. It., 52 (3), 207-18.

Matsukawa M., Shibata K. (2015) - Review of Japanese Cenozoic (Miocene-Modern) Vertebrate Tracks. Ichnos, 22(3-4), 261-290.

McNeil P., Hills L.V., Tolman S.M., Kooyman B. (2007) - Significance of latest Pleistocene tracks, trackways, and trample grounds from southern Alberta, Canada. In Lucas S.G., Spielmann J.A., Lockley M.G. (eds): Cenozoic Vertebrate Tracks and Traces. New Mexico Mus. Nat. Hist, Sc. Bull., 42, 209-223.

Mietto P., Avanzini M., Rolandi G. (2003) - Human footprints in Pleistocene volcanic ash. Nature, 422, 133.

Milàn J., Theodorou G., Loope D. B., Panayides I., Clemmesnsen L. B., Gkioni M. (2015) - Vertebrate tracks in late Pleistocene-early Holocene (?) carbonate aeolianites, Paphos, Cyprus. Ann. Soc. Geol. Poloniae, 85, 507-514.

Milàn J., Bromley R.G., Titschack J., Theodorou G. (2007) - A diverse vertebrate ichnofauna from the Quaternary eolian oolite, Rhodes, Greece. Sediment-Organism interactions: a multi- faceted Ichnology, SEPM Special Publ., 88, 333-343.

Morgan B.J., LeeP.C. (2003) - Forest elephant (*Loxodonta africana cyclotis*) stature in the Reserve de Faune du Petit Loango, Gabon. J. Zool., 259, 337-344.

Neto-de-Carvalho C. (2009) - Vertebrate tracksites from the Mid-Late Pleistocene eolianites of Portugal: the first record of elephant tracks in Europe. Geol. Quarterly, 53(4), 407-414.

Neto-de-Carvalho C.N., Figueiredo S., Belo, J. (2016) - Vertebrate tracks and trackways from the pleistocene eolianites of SW Portugal. Comunicaçõe Geológicas, 103, 101-116.

Nojiri-ko Fossil Footprint Research Group (1992) - Footprint fossils of Naumann's elephants discovered from the Upper Pleistocene Nojiri-ko Formation: Chikyou Kagaku (Tokyo), 46, 385-404 (in Japanese, English abstract).

Palombo M.R., Ferretti M.P. (2005) - Elephant fossil record from Italy: knowledge, problems, and perspectives. Quaternary International, 126, 107-136.

Palombo M.R., Giovinazzo C. (2005) - Elephas falconeri from Spinagallo Cave (South-Eastern Sicily, Hyblean Plateau, Siracusa): a preliminary report on brain to body weight comparison. Societat d'Història Natural de les Balears, 12, 255-264.

Panarello A., Santello L., Farinaro G., Bennett M. R., Mietto P. (2017a) - Walking along the oldest human fossil pathway (Roccamonfina volcano, Central Italy)? J. Archaeol. Sc. Reports, 13, 476-490.

Panarello A, Palombo M.R., Biddittu I., Mietto P. (2017b) - Fifthteen years along the "Devils2 trails": new data and perspectives. Alpine and Mediterranean Quaternary, 30 (2), 137-154.

Panera J, Rubio-Jara S, Yravedra J, Blain HA, Sesé C, Pérez-González A. (2014) - Manzanares valley (Madrid, Spain): a good country for Proboscideans and Neanderthals. Quaternary International, 326, 329-343.

Panin N., Avram E. (1962) - Noi urme de vertebrate in Miocenul Subcarpatilor Rominesti (Nouvelles empreintes de vertèbres dans le Miocène de la zone subcarpathique roumaine). Studii si Cercetari de Geologie, 7, 455-484.

Pasenko M.R. (2017) - Quantitative and qualitative data of footprints produced by Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants and with a discussion of significance towards fossilized proboscidean footprints. Quaternary International, 443, 221-227.

Pillola G.L., Zoboli D. (2017) - Dwarf mammoth footprints from the Pleistocene of Gonnesa (southwestern Sardinia, Italy). Boll. Soc. Paleont. It., 56(1), 57-64.

Remeika P. (2006) - Fossil footprints of Anza-Borrego. In: Jefferson G.T., Lindsay L. (Eds.), Fossil Treasures of the Anza-borrego Desert. Sunbelt Publication, San Diego, 311-327.

Retallack G.J., Martin J.E., Broz A.P., Breithaupt B.H., Matthews N.A., Walton D.P. (2018) - Late Pleistocene mammoth trackway from Fossil Lake, Oregon. Palaeogeography, Palaeoclimatology, Palaeoecology, 496, 192-204.

Shoshani J., Tassy P. (2005) - Advances in proboscidean taxonomy & classification, anatomy & physiology, and ecology & behavior. Quaternary International, 126, 5-20.

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