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Reevaluating the “elephant butchery area” at the Middle Pleistocene site of Notarchirico (MIS 16) (Venosa Basin, Basilicata, Italy)

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ABSTRACT

The archaeological site of Notarchirico, chronologically placed at the end of MIS 17 and MIS 16 (675–610 ka), is a key site for studying Acheulean technology in southern Europe and gaining a better understanding of human occupation in that region during the Middle Pleistocene. It was excavated between 1979 and 1995 by Marcello Piperno and re-opened since 2016. Between 1990 and 1991, around forty remains of *Palaeoxodon antiquus*, mostly comprising the head of the animal, such as cranium, mandible and tusks fragments belonging to a sub-adult male were discovered as a result of the excavation of a lateral discontinuity of the level A, situated in an area known as the “elephant butchery area”. Remains of deer, mainly assigned to *Dama* sp., and 42 stone tools, including choppers, hand-axes, cores and some flakes were also identified in the surroundings. This accumulation was originally interpreted as a butchering site, reflecting a single event of processing of an elephant carcass, and the entire paleosurface was exposed to visitors *in situ*. This work re-evaluates the original archaeological materials, especially those still preserved on the paleosurface, in terms of stratigraphic distribution, taphonomy and technology, to critically evaluate the putative role of hominins in the exploitation of the megaherbivore. After a meticulous examination of each element's surface and its deposition, we conclude that there is no support for the previous interpretation of the so-called “elephant butchery area” of Notarchirico as the result a butchery event, as there is no evidence of human exploitation of the remains and the accumulation derives from at least two diverse and unrelated depositional events, one resulting in the deposition of the elephant remains, and the other of the majority of the fallow deer remains and the stone tools.

1. Introduction

Different types of association between stone tools and faunal remains in the archaeological record can be used to explain the different hominin behavior during Paleolithic. Since the 1970s, several works have been dedicated to identifying and classifying anthropic accumulations and recognizing them in the archaeological record (Leakey, 1971; Isaac, 1978; Isaac and Crader, 1981). Different types of occupations can be distinguished based on variations in the presence or absence of particular artifacts and/or bone remains, as well as the spatial relationships

between different types of objects (Leakey, 1971; Isaac, 1978; Isaac and Crader, 1981; Carr, 1984, 1987; Kroll and Price, 1991; Whitelaw, 1991; Domínguez-Rodrigo and Cobo-Sánchez, 2017). In 1971, Lynn Isaac suggested that variations in the densities of bones and stone tools found at archaeological sites could reflect the distinct areas in which hominins acted as accumulation agents (Isaac, 1971). For example, high concentrations of lithic and faunal remains would be expected in contexts of relatively long occupation, referred to as “home bases”, while the presence of tools associated with the carcass of a single animal, generally megaherbivores (>1000 kg weight) such as proboscideans,

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hippopotamuses or rhinoceroses, would be interpreted as “*butchering sites*”, reflecting a single event of anthropic accessing to high quantities of meat (Isaac, 1971). The latter sites are very particular in their nature, and represent specific events that could be identified in the archaeological record.

Proboscideans were the largest terrestrial mammals throughout the Pleistocene and were therefore a major source of meat for hominins (Agam and Barkai, 2018). Not just meat, but other elements like the soft tissues found in the cranium (such as tongue or brain) or the marrow of limb bones are also sources of protein, fat (like the fibrous connective tissue or the adipose tissue), and other nutrients (Boschian and Saccà, 2015; Agam and Barkai, 2016, 2018; Boschian et al., 2019; Haynes and Krasinski, 2021; Starkovich et al., 2021; Haynes, 2022). The exploitation of these animals is well-documented since 1.7 million years ago (Domínguez-Rodrigo et al., 2014). However, determining the type of access (primary or secondary) to these animals is challenging, particularly in early periods. However, a number of studies indicate that proboscideans may have been frequently hunted during Late Pleistocene (Germonpré et al., 2014; Panera et al., 2015; Bosch et al., 2012; Brugère, 2014; Agam and Barkai, 2018; Wojtal et al., 2019; Gaudzinski-Windheuser et al., 2023a, 2023b). Additionally, Agam and Barkai (2018) have suggested that early humans possessed the necessary skills to actively hunt proboscideans on a regular basis. However, it is also noteworthy that other researchers have argued against frequent hunting of proboscideans during the Pleistocene (Byers and Ugan, 2005; Lupo and Schmitt, 2016).

Looking at the archaeological record, identifying “*butchering sites*” is not common during the Early and Middle Pleistocene chronologies, becoming more usual during Late Pleistocene times (Isaac, 1971; Cassoli et al., 1993; Shipman and Rose, 1983b; Goren-Inbar et al., 1994; Piperno and Tagliacozzo, 2001; Yravedra et al., 2010, 2019; Rabinovich et al., 2012a, 2012b; Espigares et al., 2013; Germonpré et al., 2014; Panera et al., 2015; Vallverdú et al., 2014; Boschian and Saccà, 2015; Mosquera et al., 2015; Chen and Moigne, 2018; Pineda and Saladié, 2019; Wojtal et al., 2019; Daschek, 2021; Konidaris et al., 2023; Gaudzinski-Windheuser et al., 2023a, 2023b). The conventional interpretation of these accumulations, formed by a lone megamammal individual surrounded by stone tools, construes them as isolated instances of carcass acquisition and butchery by Palaeolithic hominin groups due solely to their spatial proximity. However, contemporary research and methodological proposals reveal that bones and stone tools can appear spatially related due to other factors, demanding more evidence to validate these behavioral inferences (e.g. Binford, 1981; Domínguez-Rodrigo, 2008; Palombo and Cerilli, 2023). Several butchering sites described in historical literature lack concrete evidence (Domínguez-Rodrigo, 2008) or have been dismissed, such as the iconic Spanish archaeological sites of Torralba and Ambrona (Villa, 1990; Villa et al., 2005; Pineda and Saladié, 2019, 2022).

Modern methodological approaches underline the necessity to consider several factors to validate the interpretation of an accumulation as a butchery event (Domínguez-Rodrigo, 2008; Palombo and Cerilli, 2023). The clearest evidence of animal consumption by hominins is the identification of cut marks, which are unintentionally made when the tool’s cutting edge comes into contact with the bone during the butchery process (e.g. Binford, 1981; Potts and Shipman, 1981; Shipman, 1981; Shipman and Rose, 1983a). However, as an unintentional side-effect of carcass-processing, cut marks are not always present or preserved on animal remains. This has been considered especially relevant when carcasses of megaherbivores were processed, because the high volume of meat they contain may facilitate the extraction without rushing the meat that adheres more closely to the bones (Crader, 1983; Haynes, 1991, 2022; Villa et al., 2005; Domínguez-Rodrigo, 2008; Haynes and Klimowicz, 2015; Haynes et al., 2020). On the other hand, it has been demonstrated in previous studies that the processing of megaherbivores can generate cut marks (Haynes and Krasinski, 2021), although their frequency is highly variable (Starkovich et al., 2021) and depends on factors such as the butcher’s experience and knowledge of the anatomy

of these animals and the type of tools used (Haynes, 1991). Cut marks on megaherbivores were also often documented in Early and Middle Pleistocene archaeological assemblages (e.g., Yravedra et al., 2010; Boschian and Saccà, 2015; Mosquera et al., 2015), but especially during the Late Pleistocene (Palombo and Cerilli, 2023). This is the case for the processing of a rhinoceros carcass at the site of Taubach (Bratlund, 1999). In proboscideans, cut marks were identified in an assemblage of up to 70 individuals of straight-tusked elephants from the site of Neumark-Nord 1 (Gaudzinski-Windheuser et al., 2023a) and in several skeleton from Gröbern and Taubach (Gaudzinski-Windheuser et al., 2023b), which confirm that the processing of proboscideans can leave cut marks and raises doubts about those assemblages where cut marks are absent. In certain instances, indirect evidence, namely use-wear analysis of flakes associated with the carcass, may serve as an indication of butchery activities (Palombo and Cerilli, 2023).

The analysis of skeletal patterns and the identification of cut marks or other evidences of anthropic processing are necessary. The clear and concise description of the spatial relationship of remains or artifacts, such as the analysis of use-wear on flakes or other tools, is also required. In this regard, several purported butchering locations of the Pleistocene record are in need of a re-evaluation. The Italian Middle Pleistocene site of Notarchirico (Venosa, Basilicata, Italy) is undoubtedly one of these sites that needs to be revised. This open-air archaeological site formed within a volcanic sedimentary complex is a key site for the study of the development of Acheulean technology in southern Europe, as well as for the behavior of the Middle Pleistocene hominin population that inhabited the region. Multidisciplinary studies suggested the presence of a fluvio-deltaic environment with ponds and water channels (Moncel et al., 2020, 2023). This type of environment could be rich in several resources of interest to early hominins, such as fresh water, vegetables, raw materials for tool making, or prey for obtaining animal resources such as meat (Egeland, 2014). However, there has been a lack of subsistence studies of Notarchirico.

Most of the conclusions regarding subsistence were developed from the study of the so-called “*elephant butchery area*”. This 24 m² area was excavated during 1990 and 1991 and 42 lithic and 85 faunal remains were found, including 38 bone remains attributed to *Elephas antiquus* and 14 anatomically unidentifiable fragments of elephant bones (Cassoli et al., 1993; Lefèvre et al., 1994; Piperno, 1999; Piperno and Tagliacozzo, 2001). The initial interpretation proposed a relationship between at least part of the lithic artifacts and the elephant carcass, suggesting a potential human consumption of the soft tissues of the elephant’s cranial skeleton, such as the brain, tongue, and proboscis. However, these interpretations did not encountered consensus among the scientific community at all (Domínguez-Rodrigo, 2008; Moncel et al., 2019; Haynes, 2022). The current study presents a taphonomic, paleontological, and technological re-evaluation of the stone tools and faunal remains found in the so-called “*elephant butchery area*” of Notarchirico. As a portion of the site excavated in the 1980s and the 1990s was prepared for exhibit *in situ*, some remains, including those of the “*elephant butchery area*” rest in their original position. This allows us to directly reassess the stratigraphic relationships between the elephant remains, the other faunal remains (such as cervids), and the stone tools.

2. The site of Notarchirico and the Venosa Basin (Basilicata)

The region of Basilicata in Italy is known for its well-preserved archaeological and paleontological sequences in sedimentary complexes that formed during the Vulture stratovolcano’s eruptive activity (Raynal et al., 1999; Lefèvre et al., 2010; Moncel et al., 2020). The Venosa Basin (Fig. 1A) is one of the richest areas for archaeological and paleontological localities in the region, known since the discovery of the Middle Pleistocene archaeological sites of Loreto and Terrenera in the first half of the 20th century (Piperno, 1999). A few hundred meters from Loreto, the Middle Pleistocene archaeological site of Notarchirico was firstly investigated by Virginia Chiappella, during a stratigraphical



Fig. 1. The archaeological perspective of Notarchirico is as follows: A) Venusa's location on the Italian peninsula; B) an external view of the building erected to protect the paleosurfaces; C) a sequence of Notarchirico's site, showing the levels representing the so-called "elephant butchery area" highlighted in red; D) a glimpse of the paleosurfaces (B to G) in the principal excavation area; E) a view of the elephant butchery area paleosurface.

survey in 1956 (Piperno, 1999). The site was indeed discovered in 1979, following a survey by the Italian Institute of Human Palaeontology (ISIPU) (Piperno and Segre, 1982; Piperno, 1999). The first three excavation campaigns at Notarchirico took place in 1980, 1981, and 1984, covering 156 m² in the area known as "scavo esterno" (external

excavation zone, referencing to the outside of the building that was built to accommodate the palaeosurfaces excavated from 1985 onwards) (Fig. 1B). The fieldwork campaigns, coordinated by Marcello Piperno, were carried out in two areas named "scavo interno" 1 and 2, within the building mentioned earlier, between 1985 and 1995 (Fig. 1D). These

campaigns were conducted without interruption.

The excavation led to the discovery of 11 archaeological levels in a 7-m deep sequence from the upper level, referred to as alpha (α), to the lower level, referred to as G (Fig. 1C). The extension of the excavated areas varies between 133 m² down to 19 m², depending on the different archaeological levels. The archaeosurfaces consist of more or less dense beds of pebbles of limestone, secondary quartz and quartzite, corresponding to lakeshore remains (Moncel et al., 2020). The stratigraphic succession mainly consists of volcanoclastic sediments that were deposited and reworked in an alluvial setting. New geochronological data, encompassing ⁴⁰Ar/³⁹Ar ages and ESR, reveals that the sedimentary sequence (levels F to α) are dated between approximately between 675 and 610 ka, thus placing the site within the end of MIS 17 and MIS 16 (see Pereira et al., 2015: 641 p., for a detailed description of the whole sequence). The sediments were recently investigated and reassessed by Pereira et al. (2015). A new project started in 2016, focusing on the site of Notarchirico, including renewed excavations and the re-study of the previous excavated materials.

The archaeological record includes a human femoral fragment, and a rich faunal and lithic sample (e.g. Mallegni et al., 1991; Cassoli et al., 1999; Piperno, 1999; Santagata, 2016; Pereira et al., 2015; Moncel et al., 2019, 2020, 2023; Santagata et al., 2020; Mecozzi et al., 2021; Carpentieri et al., 2023). Notarchirico represents one of the ancient sites of southern Europe with bifacial tools manufacturing, being a key site for gaining greater insight into the behaviors and evolution of biface-producing hominins during the Middle Pleistocene. Palaeontological and taphonomic studies of faunal remains have been focused first on the highest levels of the sequence (levels A and α), while the rest of the levels are under study.

2.1. The “elephant butchery area”

The “elephant butchery area” was documented in a lateral discontinuity in the top of the sequence of Notarchirico, at the contact between levels B and A. Level B is identified in the top of geological level 2–10 and represents the top of the Intermediate volcano-sedimentary sequence complex of the site. It is described as an undulating bed of pebbles joined together to form a pavement with few archaeological materials. Level A is identified inside the geological level 1-1, at the base of the upper complex of Notarchirico. Some differences have been described between the two sectors of level A. The northern sector is a 0.3 m deep sector composed of greyish green gravel and sand with a vertical grading, more clayey at the top. The southern sector contains pebbles scattered throughout the mass, more numerous at the base (Lefèvre et al., 1994). Level A is probably the richest level of the entire sequence in faunal and lithic remains. Large mammals recovered in the level A of Notarchirico were referred to *Elephas* (= *Palaeoloxodon antiquus*, Bovinae indet., Bovinae cf. *Bos primigenius*, *Bos primigenius*, *Bison* sp., *Sus scrofa*, Cervidae, *Cervus elaphus* ssp., *Cervus* cf. *elaphus*, *Dama clactoniana*, *Dama* cf. *Clactoniana*, *Dama*-like deer, *Megaceroides* (= *Praemegaceros*) sp. and *Lepus* cf. *europaeus* (Cassoli et al., 1999). Some evidences of anthropic processing were described in level A, although frequencies were not given (Piperno, 1999).

The 24 m² excavated in 1990 and 1991 in so-called “elephant butchery area” preserved a special context in which a new sublevel, referred to as A1, was identified (Cassoli et al., 1993; Lefèvre et al., 1994; Piperno et al., 1999; Piperno and Tagliacozzo, 2001). 127 specimens were retrieved in this particular part of the deposit, where 85 faunal remains and 41 stone tools were found. According to the original description, the majority of fossils was retrieved from level A1, which is filled with sediment consisting of gravel and sand, including medium-sized pebbles. This level is followed by a deposit of sand (correlated with the level A) which covers the bed of pebbles (paleosurface B) (Cassoli et al., 1993).

The faunal remains were primarily identified as fragments of elephant bones and teeth, with an additional 19 remains attributed to

cervids and 14 undetermined remains (Cassoli et al., 1993; Piperno et al., 1999; Piperno and Tagliacozzo, 2001). The following taxa were recognized: *Elephas* (= *Palaeoloxodon antiquus*, Cervidae, *Dama clactoniana*, *Dama* sp. (Piperno et al., 1999; Piperno and Tagliacozzo, 2001). The elephant remains were the most significant and representative findings. Both tusks and the cranium were recovered in anatomical connection, although inverted. Two upper molars were also discovered close to their natural position. However, the jaw of the elephant was found almost 3 m away from the cranium, inverted and broken at the level of the ascending ramus, which was located 20 cm away from the mandible. Additionally, a complete thoracic vertebra, the sacrum, fragments of ribs, vertebrae, tusks, cranium and other bone fragments complete the elephant’s record (Cassoli et al., 1993). The lithic record includes a chopper, two limestone hand-axes, a schist denticulate, and a percussed pebble discovered in the vicinity of the mandible. The remaining stone tools were primarily revealed in the vicinity of the cranium and between the two tusks. The nearly complete lack of flakes is noteworthy (Cassoli et al., 1993).

Although there are no cut marks or other physical evidence of the hominin processing of the carcass, initial interpretations suggested that hominins may have consumed the soft parts of the elephant’s cranial skeleton, such as the brain, tongue, and proboscis (Cassoli et al., 1993; Piperno et al., 1999; Piperno and Tagliacozzo, 2001). The hypothesis proposed in the initial descriptions was based on: a) the consideration that the assemblage suffered minimal post-depositional disturbances; b) the presence of faunal refits; c) most of the elephant’s cranial remains were found in anatomical connection, with the exception of the mandible; d) possible spatial association between the elephant remains and the lithic tools (Cassoli et al., 1993).

3. Materials and methods

3.1. Stratigraphic distribution

The “elephant butchery area” of Notarchirico is exposed in the Archaeological Park of Notarchirico, where the palaeontological and archaeological material is still preserved *in situ*. The studied material is accompanied by a progressive number reported in a list and drawn by Cassoli et al. (1993); these numbers, however, are not reported directly on bones or tools. The stratigraphic position of each of the remains analyzed on the paleosurface has been revised, indicating whether they were deposited on the sands (A), the mixture of sands and gravel (A1) or above the pebbles bed (B).

3.2. Taphonomic analysis

Out of the 85 faunal remains initially detailed in the “elephant butchery area” (Cassoli et al., 1993; Piperno et al., 1999; Piperno and Tagliacozzo, 2001), 66 remains were found on the original paleosurface and were comprehensively examined. The remaining 19 remains were likely unearthened during the discovery of this area, but they are presumably lost, being not preserved in the two main repositories that housed the Notarchirico collections (the *Museo Archeologico Nazionale “Marco Torelli”* in Venosa or the *Museo delle Civiltà* in Rome). Based on the given descriptions, the 19 missing specimens include a molar, several tusk fragments and an undetermined elephant limb bone fragment, together with four fragmentary fallow deer remains (including the cranium, mandible, coxa and limb bone fragment), and some other undetermined remains (Cassoli et al., 1993: 112-124 pp.; Piperno, 1999: 90-92 pp.). These identifications have been considered for the quantification of the remains, although taphonomic data has only been acquired on the 66 remains founded in the paleosurface.

Considering the poor state of preservation and the impossibility to remove the material from the paleosurface (nearly all the studied material is still embedded in sands and pebbles), part of taxonomic identifications is limited to the family or genus, while some remains cannot

be determined. When identification was not possible, remains were categorized based on bone morphology, including limb, flat and articular bones. Additionally, animal groups were classified based on weight, following the categories adapted by Saladié et al. (2011). In cases where remains were not identified, they were classified as either middle-sized (30–100 kg) or very large-sized (>1000 kg). Age profiles were estimated using the level of tooth eruption and the degree of bone ossification (Schmid, 1972; Barone, 1976; Stiner, 1994). The sample was quantified through determination of the Number of Identified Specimens (NISIP), Minimum Number of Elements (MNE), and Minimum Number of Individuals (MNI) (Binford, 1984; Grayson, 1984).

A handheld magnifier was used to analyse the remains, although the observation was limited by the partial burial and inaccessibility of the material, the surfaces' poor preservation, and the presence of a glue applied to consolidate the surfaces for the exhibition *in situ*. Weathering was described according to the stages described by Behrensmeier (1978) for fallow deer remains and by Haynes and Wojtal (2023) for elephant remains. The presence/absence of additional taphonomic modifications such as root-etching, trampling, fissuring, chemical dissolution, manganese (Mn) and iron (Fe) coating, concretion and deformation was also documented (e.g., Brain, 1981; Shipman, 1981; Lyman, 1994; Haynes et al., 2020).

3.3. Stone tools

The lithic material, left on the paleosurfaces and stored in the *Museo Archeologico Nazionale "Marco Torelli"* in Venosa, was described and studied according to the technological approach and the concept of "chaîne opératoire". Categories were distinguished according to their raw materials: bifaces, flakes, flake-tools, cores, entire pebbles with percussion marks, broken pebbles and pebble-tools (Boëda et al., 1990; Geneste, 1991; Inizan et al., 1999; Moncel et al., 2020a). The organization and number of removals and hierarchy of flaking surfaces were observed on cores. Types of flakes and possible retouches were taken in account. Mode of management of the bifaces (location of removals, type of support, mode of shaping) and morphological results (general form, symmetry, tip and base forms, shape of the cutting edges) were described on pebble tools and bifaces. As in the case of faunal remains, not all the material listed and described by Piperno (1999) were found.

4. Results

4.1. Stratigraphic distribution

The analyzed paleosurface has a north-eastern slope. The thickness reached up to 60 cm in the western part due to the high volume of *Palaeoloxodon antiquus* remains, especially the cranium. Three distinct horizons (Fig. 2) were observed for the distribution of the different archaeological and palaeontological materials, namely on the sands (level A), on the bed of pebbles (level B), or in the base of cobbles, representing the contact between A1 and B.

Upon the *in situ* re-examination of the position of the remains on the paleosurface, it has been confirmed that the majority of elephant remains is deposited above the sands of level A, as shown in Fig. 3 (A-C). As indicated in previous studies (Cassoli et al., 1993; Piperno et al., 1999; Piperno and Tagliacozzo, 2001), the cranial and axial elements of the elephant were recovered in an inverted position, with little distribution and respect for their anatomical position, with the sole exception of the mandible, which was found broken and 3 m away from the other cranial bones (Fig. 4). The mandible and the sacrum represent the furthest elephant remains and are the sole deposition above the pebble layer denoting level B (Fig. 3D).

Although fallow deer remains were found alongside those of elephants, the majority of these remains was discovered in the bed cobbles, which denote the contact between A1 and the top of level B (see Fig. 3E–F). Likewise, the lithic tools found *in situ* were located at the top of level B or at the bottom of A1, in direct contact with the bed of pebbles (see Fig. 5). No stone tools were discovered above the sands of level A, as was originally documented in the case of the elephant remains (Piperno and Tagliacozzo, 2001).

4.2. Paleontological description

The paleontological revision of the fossils still preserved on the palaeosurface confirms the presence of *Palaeoloxodon antiquus* and cervids (Cervidae and *Dama* sp.). Remains of elephant show several features useful for taxonomic attribution. In particular, the tusks are long and slightly curved. The upper teeth are hypsodont and display a high number of laminae and lamellar frequency, and reduced enamel thickness. These features are considered typical of *P. antiquus* (Palombo, 1986, 1995; Palombo et al., 2003).

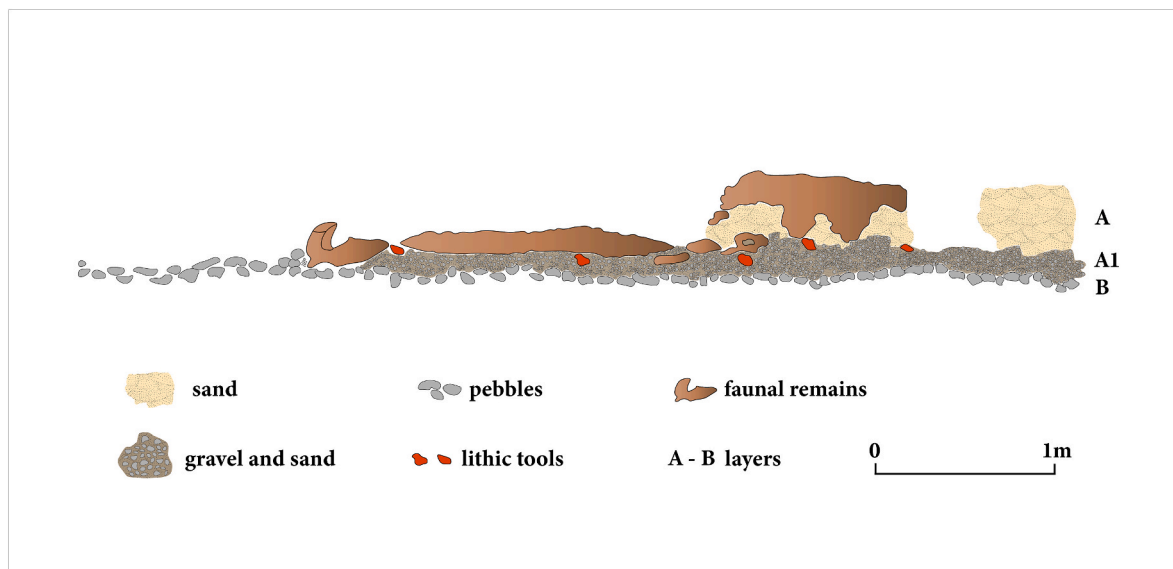


Fig. 2. Chart illustrating a section of the "elephant butchery area". The different levels of sediment deposition and the emplacement of lithic and faunal material can be seen.



Fig. 3. Faunal remains from the “elephant butchery area”. Most of the elephant remains, namely the skull (A), tusks (B), and vertebra (C), were found exposed above level A sands. Only the mandible (D) and sacrum were located at the base of level A. Fallow deer remains were found among the pebbles, including the shaft fragment (E) and metatarsal (F).

Remains of cervids are scarce, in a bad state of preservation or embedded among pebbles. This is a limiting factor in our observation. However, a fragmentary antler and a few postcranial elements possess features considered indicative of *Dama* (Lister, 1996; Di Stefano, 1996). These remains, though, do not display characteristics useful for specific distinction, and therefore we cannot confirm the presence of *Dama clactoniana* in this assemblage. It should be considered that other cervids, as well as additional large mammals, from the level A have been identified by Cassoli et al. (1999) based on fossils found in other areas of the site. The revision of these materials shall confirm or redefine the species present in the level A of Notarchirico, especially for the fallow deer that represents one of the best documented taxa in the upper levels of the succession. A revision of the faunal material from the Piperno's

excavations is undertaken but it is beyond the scope of this study.

4.3. Taphonomic analysis

Faunal remains uncovered at the “elephant butchery area” amounts to 85 (Supplementary Table 1; Supplementary Figure 1). Of the total remains, 62 relate to level A whereas 23 relate to level A1 (Table 1).

In level A, *Palaeoloxodon antiquus* (NISP = 38) is the most commonly identified taxon, joined by 17 remains assigned to the very large-sized category but not yet taxonomically defined, which were also uncovered at the same level. These remains mainly belong to the cranial skeleton, particularly identified as tusk fragments (NISP = 22), together with some flat bones, all derived from only one young adult individual.

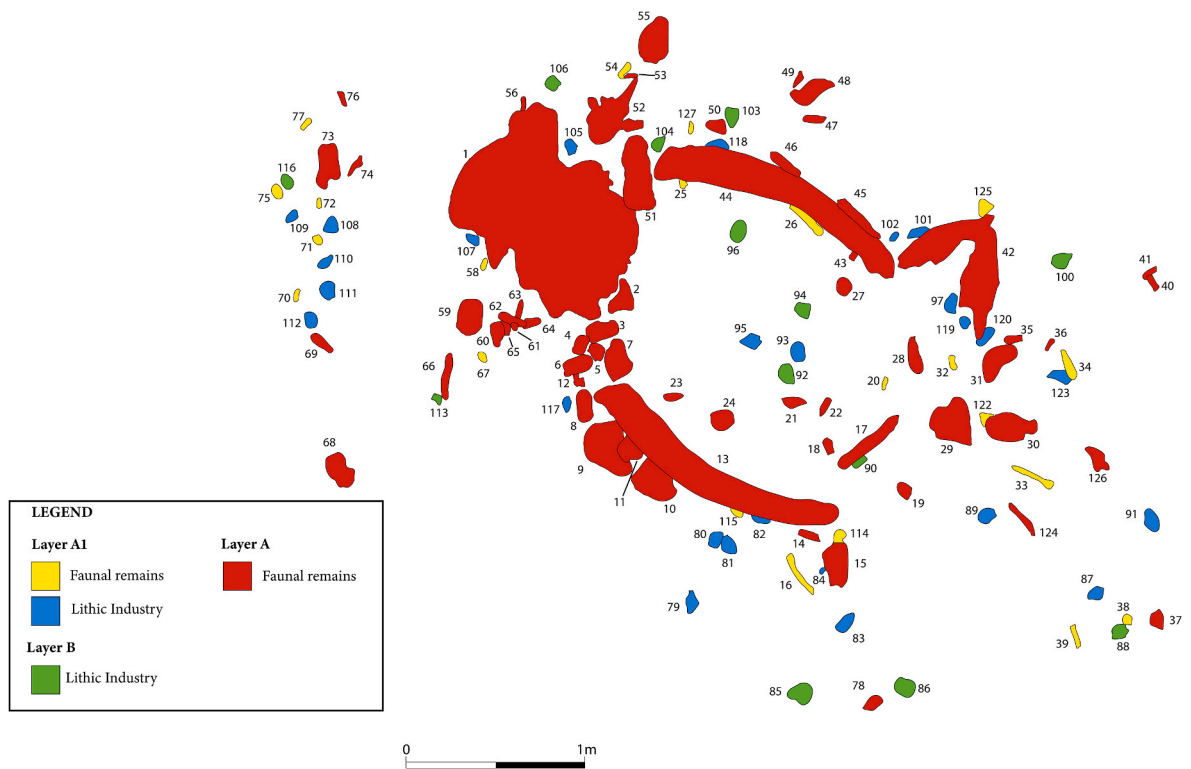


Fig. 4. The distribution of faunal and lithic remains from the “elephant butchery area” on the paleosurface categorized by levels. Adapted from Piperno and Tagliacozzo’s (2001 figure 11).

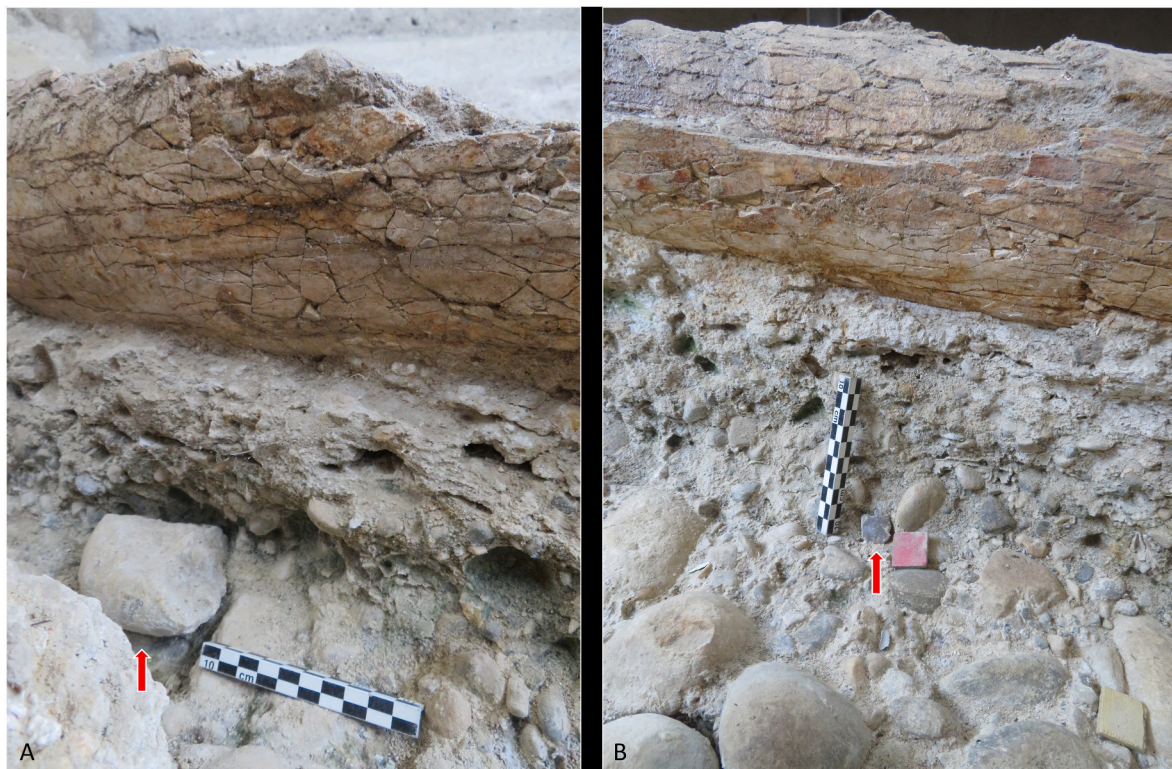


Fig. 5. Lithic remains from the “elephant butchery area”. Choppers (A) and flakes (B) were found at the base of A1, in contact with the pebbles of level B. Lithic materials are indicated with red arrows.

Table 1

Number of Specimens (NSP), Number of Identified Specimens (NISP) and Minimal Number of Individuals (MNI) provided for levels A and A1, accompanied by the ages at death of the individuals.

	Level A			
	NISP/NSP	MNI	Immature	Adult
<i>Palaeoloxodon antiquus</i>	38	1		1
<i>Dama</i> sp.	1	1		1
Cervidae	5	1	1	
Total NISP	44	3	1	2
Very large-sized	17			
Indeterminate	1			
Total (NSP)	62			
Level A1				
<i>Dama</i> sp.	7	1		1
Cervidae	4			
Total NISP	11	1		1
Medium-sized	2			
Indeterminate	10			
Total (NSP)	23			

Among the remains belonging to this weight-size category, only three fragments were identified as limb bones. Seventeen remains belonging to the Cervidae family were discovered in both the sands of level A (NISP = 6) and at the base of level A1 (NISP = 11). One of the remains of the level A, an immature femur, was assigned to *Dama* sp., whereas the other five remains were identified as an adult Cervidae indet. In level A1, those remains include a cranium and six post-cranial remains of an adult fallow deer and four remains identified as belonging to the Cervidae family. Finally, two indeterminate remains belonging to a medium-sized animal were identified in that level.

Regarding the MNE, a minimum of 12 elements that belong to *P. antiquus* were identified in level A (Table 2). These remains include three isolated molars, both tusks, two vertebrae, the cranium, the mandible, a rib, the sacrum, and a limb bone. In level A, the fallow deer element identified (MNE = 1) was a femur, whereas a mandible, femur, tibia, and metatarsal were counted as belonging to an indeterminate Cervidae (MNE = 4). In level A1, two tibiae, two metatarsals, a cranium, a humerus and a radius of fallow deer (MNE = 7), and a coxa belonging to an indeterminate Cervidae (MNE = 1) were quantified.

One of the most important taphonomic modification documented was weathering (Table 3). Weathered remains from medium-sized carcasses were primarily classified to stage 1 (66.7%), with a lesser

Table 2

Number of Identified Specimens (NISP) and Minimal Number of Elements (MNE) by anatomical elements and levels.

	A			A1	
	<i>P. antiquus</i>	<i>Dama</i> sp.	Cervidae	<i>Dama</i> sp.	Cervidae
	NISP/ MNE	NISP/ MNE	NISP/ MNE	NISP/ MNE	NISP/ MNE
Skull	2/1			1/1	1/-
Mandible	2/1		1/1		
Isolated tooth	25/5				
Vertebra	3/2				
Rib	3/1				
Humerus				1/1	
Radius				1/1	
Coxa					1/1
Sacrum	1/1				
Femora		1/1	1/1		
Tibia			1/1	2/2	1/-
Metatarsal			1/1	2/2	
Metapodial indet.					1/-
Limb	1/1		1/-		
Flat	1/-				
Total	38/12	1/1	5/4	7/7	4/1

occurrence in stage 2 (26.7%). As for the remains of very large animals, i.e. the elephant, the bones show low levels of stage 1 (7%), with stages 1–2 (44.2%) and 2 (48.8%) being the most commonly identified.

No anthropic (cut marks or anthropic breakage) or carnivore modifications (tooth marks or other taphonomic signs of carnivore activity) were identified on the faunal remains. Regarding the other taphonomic modifications, a similar pattern is documented in both groups, characterized by a high presence of manganese and iron oxides (>90% of the remains). The other documented modifications comprise cracking, chemical dissolution, and root action. The erosion documented on the upper surface of the elephant cranium (Fig. 3A) and the trampling notches observed on the vertical branch of the mandible (Fig. 3D) are notable (Table 4).

4.4. Stone tools

Most of the lithic material consists of pebble tools (n = 21) and bifaces (large duty tools). The number of bifaces (n = 9) is high. The pieces are attributed either to the level B (bed of pebbles), or along level A1 (close to the level B or to the surface of level A1). Evidences of the flaking process documented were one core and five small tools/products (see type of artifacts and their distribution in Supplementary Figure 2).

For the twenty-one pebble tools described by Piperno (1999) (Supplementary Table 2), except two pebbles in flint/chert, the others tools were made in limestone or siliceous limestone. Nine pebble tools were found on the top of level B, on the bed of pebbles. However, the majority of tools are located in the level A1 into white and grey sediments, between 3 and 10 cm above level B. These tools are either made by unifacial or bifacial removals, on one side of the pebble or on the entire pebble periphery. Some tools are pointed. The removals do not modify the form of the thick pebbles, measuring between 50 and 120 mm long. Only 12 pebbles described by Piperno (1999) have been observed *in situ*.

Among the nine bifaces, seven were found in level A1 (Supplementary Table 3). They were made in limestone, flint/chert and quartzite. The shaping is variable, above all by large removals followed rarely by a second series of removals and secondary retouches. The cortex remains on some pieces and allows determining the use of pebbles. No clear evidence of large flakes is attested. The form is mainly cordiform. Only one core is mentioned by Piperno (1999), included in level A1 (Supplementary Table 4). The core is multidirectional and in flint/chert. It measures more than 100 mm long.

Five small tools were described by Piperno (1999), located mainly in level A1 (Supplementary Table 5). They were described as denticulates mainly, on a flake or a fragment/nodule. On the palaeosurfaces, two new pieces (one tool and one flake) have been found. The analysis indicates that some tools can be described as convergent tools made on a thick blank.

Finally, six hammerstones/pebbles with percussion marks were described by Piperno (1999) (Supplementary Table 6). They belong either to the level B, or the level A1. Only one was observed *in situ* and, if we take in account the number marked in Piperno (1999), it is a pointed bifacial tool and not an entire pebble.

5. Discussion

The re-analysis and re-interpretation of the faunal and lithics materials recovered in the so-called “elephant butchery area” of Notarchirico has found no reliable proofs to consider these remains as result of a butchery event, in contrast with the first interpretations made by Piperno and his team (Cassoli et al., 1993; Piperno and Tagliacozzo, 2001).

Most of the components of the head (including the cranium, molars and tusks) were found in an anatomical position, but they were inverted. The only recognized example in the archaeological record comes from the Israeli site of Geshen Benot Ya’aqov (MIS 19), where a *Palaeoloxodon antiquus*/*Palaeoloxodon recki* cranium was found in an inverted position

Table 3

Weathering stages observed on bones from the elephant butchery site. *According to the stages described by Behrensmeyer (1978); ** According to the stages described by Haynes and Wojtal (2023); *** Those stages only described for elephant remains, according to Haynes and Wojtal (2023).

	Weathering stages					
	W0	W0-1***	W1	W1-2***	W2	W3
Middle size*	1 (6.7%)	–	10 (66.7%)	–	4 (26.7%)	0 (0%)
Very large size**	0 (0%)	0 (0%)	3 (7%)	19 (44.2%)	21 (48.8%)	0 (0%)
Indeterminate*	3 (27.3%)	–	3 (27.3%)	–	4 (36.4%)	1 (9.1%)

Table 4

Taphonomic modifications on the bones from the elephant butchery area.

	Very large size		Middle size		Indeterminate	
	Presence	Absence	Presence	Absence	Presence	Absence
Root etching	6 (14%)	37 (86%)	2 (13.3%)	13 (86.7%)	0 (0%)	11 (100%)
Trampling (notches)	1 (2.3%)	42 (97.7%)	0 (0%)	15 (100%)	0 (0%)	11 (100%)
Fissures	15 (34.9%)	28 (65.1%)	6 (60%)	4 (40%)	2 (18.2%)	9 (81.8%)
Chemical dissolution	10 (23.3%)	33 (76.7%)	3 (20%)	12 (80%)	0 (0%)	11 (100%)
Mn oxide	40 (93%)	3 (7%)	15 (100%)	0 (0%)	3 (27.3%)	8 (72.7%)
Fe oxide	41 (95.3%)	2 (4.7%)	15 (100%)	0 (0%)	6 (54.5%)	5 (45.5%)
Concretions	1 (2.3%)	42 (97.7%)	1 (6.7%)	14 (93.3%)	0 (0%)	11 (100%)
Deformations	3 (7%)	40 (93%)	0 (0%)	15 (100%)	0 (0%)	11 (100%)
Erosion	1 (2.3%)	42 (97.7%)	0 (0%)	15 (100%)	0 (0%)	11 (100%)

in association with Acheulean stone tools, a boulder and an oak tree, which Goren-Inbar et al. (1994) suggest would have been used to turn the cranium upside down. The absence of the base of the skull and the palatal region, together with the damage below the nasal aperture, suggested that both the brain and the trunk had been deliberately removed (Goren-Inbar et al., 1994, 2011). However, this explanation seems far-fetched for the case of Notarchirico. Firstly, it is unlikely that any hominin group would have been able to overturn the skull with its attached tusks, given its considerable size and weight. Furthermore, despite the presence of fractures in the cranium and missing components (including the occipital and basal regions), there is no evidence of anthropic breakage to support this conclusion. In fact, it is plausible that erosion could be a reason for the loss of bone tissue that would have been more exposed to the surface. In the ethological descriptions of other carnivores, such as hyenas or lions, there are no reports of these animals inverting entire elephant craniums with both tusks (Kruuk, 1972; Schaller, 1972). It has not even been recorded in elephants themselves, which typically move the bones of their own species (Haynes, 1988, 1991, 2005). It has been shown that elephants are capable of placing large limb bones in a vertical position under certain circumstances (Haynes et al., 2020). However, this behavior cannot be compared to that of Notarchirico.

This unusual occurrence may be related to the context of the site. Many deposits identified as butchery sites in the Early and Middle Pleistocene have been found in fluvial-lacustrine deposition contexts. Examples of such sites include Kooby Fora (Leakey, 1971), Torralba and Ambrona (Villa, 1990; Villa et al., 2005; Pineda and Saladié, 2019), Geshen Benot Ya'aqov (Rabinovich et al., 2012b), Fuente Nueva 3 (Espigares et al., 2013), Pit 1 of Barranc de la Boella (Vallverdú et al., 2014; Mosquera et al., 2015), several sites in the valleys of the Manzanares and Jarama rivers (Yravedra et al., 2010, 2012, 2014), Fontana Ranuccio and Castel di Guido (Boschian and Saccà, 2015; Boschian et al., 2019) or the nearby site of Cimitero di Atella placed 10 km near the Monte Vulture Volcano (Rocca et al., 2023). Their identification in fluvial-lacustrine environments is not a coincidence, as these animals often wandered into muddy swamps where they eventually became trapped (Haynes, 1991). Indeed, Coe (1978) noted that only elephants deceased in this particular environment have a real chance of being fossilized. In the absence of evidence for the involvement of a biotic agent in the inversion of the cranium, it cannot be ruled out that its position could have been affected by mud displacement without biotic

intervention.

The limited disturbance in the so-called “elephant butchery area” has been taken as evidence for its interpretation as a butchery site (Cassoli et al., 1993; Piperno and Tagliacozzo, 2001). However, it should be noted that Piperno (1999) suggest the possibility of low intensity water currents that could have carried away the smaller elements. Although the lacustrine environment described is consistent with the possible influence of water currents, there are no clear signs of water erosion, even in the recovered lithic remains. It is important to bear in mind that in such open and lacustrine environments, the natural tendency of remains is to disperse in the absence of accumulating agents (Domínguez-Rodrigo and de la Torre, 1999). In the case of Notarchirico, the postcranial and mandibular remains could potentially have been displaced by carnivores (Haynes, 1991; Haynes and Hutson, 2020) and even by elephants themselves (Haynes et al., 2020). The identification of a trampling notch in the vertical branch fragment of the lower jaw could be a result of this, as described by Haynes and Hutson (2020). It is also true that there is a partial anatomical connection between the cranium, tusks and molars. Refits, mainly of tusk fragments, confirm this connection, although they are generally dry and flaky. Given that larger elephant remains can remain on the surface for several decades, exposed to meteorological and atmospheric agents that cause drying, cracking and fragmentation of bones (Haynes and Klimowicz, 2015; Haynes and Wojtal, 2023), there appears to be no evidence linking the assemblage to hominin activity.

Despite the plethora of evidence, the crucial evidence cited by Cassoli et al. (1993), Piperno (1999), and Piperno and Tagliacozzo (2001) in support of the notion that the accumulation should be considered as a butchery site is the spatial association between elephant remains and the lithic assemblage. Nowadays, it is widely understood that the mere proximity of the bones of an individual elephant to lithic tools is not a synonym of past relationships between these two elements (Domínguez-Rodrigo, 2008; Palombo and Cerilli, 2023). Perhaps, one of the most paradigmatic cases in that sense is the Middle Pleistocene Spanish site of Ambrona, from which Villa et al. (2005) described the recovery of the remains of an adult male associated with Acheulean tools. After a thorough analysis of the collection, it has been determined that elephant bones, remains of other species, and stone tools were sporadically mixed in different successive events, excluding the butchery of the elephant carcass (Villa et al., 2005). A similar scenario has been documented in FLK North 6, where the re-examination of the distinct elements' unique

correlation revealed that the stone tools and bones had no functional association, and their spatial correlation is by chance (Domínguez-Rodrigo et al., 2007). In this assemblage, as seen in Mwanganda and Karonga and other similar sites, it has been observed that the elephant bones are overlaid by artifacts. This suggests that these artifacts were deposited independent of the deposition of the elephant remains (Domínguez-Rodrigo et al., 2007; Domínguez-Rodrigo, 2008). A comparable scenario was witnessed at the Notarchirico elephant butchery site, where lithic remains were discovered in levels A1 and B, situated beneath the elephant remains in level A.

The presence of lithic refits and the documentation of traces of the use of animal resources processing (skin, meat ...) on the edges of the tools associated to the faunal remains have been described as the unequivocal evidences to be in front of a butchering site (Marinelli et al., 2019; Palombo and Cerilli, 2023; Lemorini et al., 2023). At Notarchirico, most of the stone tools were realized in limestone and their bad state of preservation prevent use-wear analysis. No refits were found in the current revision of the material, nor were described in the first works (Cassoli et al., 1993; Piperno et al., 1999; Piperno and Tagliacozzo, 2001). In fact, the lithic record of the area is mainly composed by pebble tools and large duty tools with few flaking evidences (one core and five small products). This lithic assembly differs to what is typically found in butchering sites, consisting mostly of numerous flakes alongside some cores, percussion materials, or large cutting tools (e.g. Isaac, 1978; Potts, 1989; Aureli et al., 2012; Rabinovich et al., 2012a; Espigares et al., 2013; Vallverdú et al., 2014; Boschian and Saccà, 2015; Mosquera et al., 2015; Marinelli et al., 2023; Yravedra et al., 2019; Haynes, 2022; Lemorini et al., 2023). Just one research has suggested that bifaces were often in deep relationships with elephant, and were a tool efficient for managing the meat resources belonging to this animal (Agam and Barkai, 2018). Regardless of whether this claim was true or not, presence of bifaces could be in relation with flakes, not in substitution of it. In Notarchirico, the number and density of bifaces is high in this part of the site compared to the corpus found in the other levels and this density compared to the size of the excavated area raises question. The almost total absence of flakes was justified by Piperno (1999) as consequence of post-sedimentary alterations, although in our revision there are no evidences to support this assumption. However, our revised study indicates that the Elephant area records several phases of deposit. The bifaces are for most of them related to the layer B without clear relationships with the Elephant. The rare flake-tools and flakes are found into the layer A1, which is punctually preserved around the Elephant remains. It is thus possible that a part of the light-duty tools has disappeared by erosion and the lithic series does not reflect the real composition of the material that has been abandoned on the site during these successive phases of deposit.

From a taphonomic point of view, cut marks on bone surfaces could be clear evidence, although their identification in earlier periods presents difficulties (Palombo and Cerilli, 2023). No cut marks have been detected in Notarchirico in previous studies nor in our systematic revision. This may be due to several factors, such as the absence of carcass processing, poor preservation of bone surfaces, or curator intervention in the exposure of the bones in palaeosurfaces. In any case, Domínguez-Rodrigo (2008) considers the traditional view of using cut marks as a sole means to identify a butchery site to be reductionist, since ethnological observations of elephant and hippopotamus carcass butchery have shown that a complete individual may be butchered without leaving a single cut mark. In the case of Notarchirico, the absence of cut marks could be taken as an indication of the absence of a relationship between fauna and lithics. The archaeostratigraphic study that has made it possible to document that the materials possibly come from different levels, seems to support this interpretation.

Despite the extensive list of Eurasian Pleistocene archaeological sites where remains of megaherbivores have been recovered and where these practices have been suggested (see lists proposed by Domínguez-Rodrigo, 2008: Table 1 or, more recently, Konidaris and Tourloukis, 2023:

Appendix 3.1 and Appendix 3.2), Notarchirico represents, following our results, a new study in which evidence of hominin exploitation of megaherbivores does not seem to be proven. This site adds to the gradually expanding number of sites where these early hypotheses have been questioned and/or discarded (Villa et al., 2005; Domínguez-Rodrigo et al., 2007; Domínguez-Rodrigo, 2008; Pineda and Saladié, 2019). However, this does not mean that hunting capabilities of Lower Paleolithic hominins should be entirely questioned. We are fully aware that the archaeological record of the Paleolithic might be limited in reflecting this type of hunting strategies and that only some findings may be clearly associated with those activities (Agam and Barkai, 2018).

Undoubtedly, megaherbivores provided an important source of food for Pleistocene hominins, dating back at least 1.5 million years ago. It has been proposed that this rise in consumption may be tied to a demographic increase of the groups, which had a greater impact and increased their reliance on this resource (Domínguez-Rodrigo et al., 2014). Ethnographic studies provide several cases of elephant hunting, showcasing a range of skills and technological items. These include hunting animals naturally trapped in muds and even driving them into those areas from which they might not be able to escape, as well as technological elements like spears or projectiles, which would have existed in early chronologies and could have been used to undertake those activities (Bunn and Ezzo, 1993; Agam and Barkai, 2018). The identification of megaherbivores hunting is crucial for making behavioral inferences. In the light of recent methodological approaches, it is necessary to review traditionally described butchery sites and ensure a more robust search for the remaining fauna and logical connections. As lately have been shown the opposite, where re-evaluation of old elephant collections revealed butchery signs, challenging our conceptions on Neanderthals abilities to gather and store food (Gaudzinski-Windheuser et al., 2023a, 2023b).

6. Conclusions

Notarchirico is a key open-air archaeological site for the study of the evolution of Acheulean technology in southern Europe, as well as the behavior of the Middle Pleistocene hominin population. The 24 m² area excavated in 1990 and 1991 in the so-called “elephant butchery area” yields 85 faunal remains, mostly from a single young-adult male elephant, and 41 stone tools. Although there was no evidence of hominin processing of the elephant, initial interpretations suggested that hominins may have consumed the soft parts of the elephant’s cranial skeleton, interpreting the area as a butchery site. In this work a re-evaluation of the original archaeological materials was carried out in terms of taphonomy and technology, as well as a re-analysis of their stratigraphic distribution, taking advantage of the fact that most of the palaeosurface materials are still preserved *in situ* in the Notarchirico Archaeological Park. This re-examination of the sample confirmed the lack of evidence for a relationship between the faunal materials and the lithics. Furthermore, the re-evaluation of the stratigraphic distribution of the elephant remains and the stone tools suggests that there were at least two separate depositional events involving these materials. On the basis of present data, it is not possible to confirm the Notarchirico “elephant butchery area” as a butchery site, along with cranium exploitation by Middle Pleistocene hominin groups who inhabited the Venosa Basin. The cranial inversion could be attributed to mud displacement rather than biotic agents. Furthermore, the lithic assemblage is different from those documented in other butchery sites. And there are no direct or indirect evidences of anthropic intervention. The strongest evidence that led to the rejection of hominin involvement in the carcass exploitation is the re-analysis of the stratigraphic distribution. This analysis showed that there were at least two separate depositional events involving archaeological materials: one event contained elephant remains, while the other contained the majority of the fallow deer remains and stone tools. After careful examination, no evidence supports the claim that the so-called “elephant butchery area” of Notarchirico really was a butchery

event, being the current accumulation of fauna and stone tools consequence of at least two diverse and unrelated depositional events.

Author contributions

AP conceptualized the paper. AP, BM and MHM wrote the paper. AI, BM, AP, MC, RR, and MHM made the fieldworks. AI, BM, RS, and RR worked on systematic palaeontology. AP and MC prepared the figures. AP and RR worked on taphonomy. MC and MHM worked on lithics. All authors exchanged ideas and reviewed the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.quascirev.2024.108603>.

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