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PRELIMINARY DATA ON THE MIDDLE PLEISTOCENE SITE OF LUNEL-VIEL I (HÉRAULT, FRANCE).

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ABSTRACT: The archeo-paleontological site of Mas des Caves at Lunel-Viel (Hérault), in Southeastern France, is an important site, well-known for its diversified vertebrate remains dated to the second half of the Middle Pleistocene. Following a brief presentation of the historical context, preliminary data, collected through new research, are discussed, focusing on the general fossil distribution and new analyses of leporids, carnivores, rhinocerotids and cervids to better define their taxonomy, paleoecology and biochronology.

Keywords: Southeastern France, Lunel-Viel, Middle Pleistocene, mammals, paleontology, ecometry, biochronology.

1. INTRODUCTION

The caves of Mas des Caves in Lunel-Viel, between Montpellier and Nîmes, in Languedoc (South-East France) opens in a Miocene carbonate limestone, unlike many of the cavities in the South of France that developed in secondary Jurassic and Cretaceous limestones. Located in the plains of Bas-Languedoc, subject to the Mediterranean climate, the landscape consists of slopes and small hills rounded off at their summit and covered with alluvium (quartz and limestone pebbles - paleoRhône) (Fig. 1). The site is at low altitude (ca. 50 m a.s.l.) and ca. 9 km from the Mediterranean coast, bordered by brackish or salt ponds.

In recent years, a new research program has aimed to carry out both new fieldwork and new studies on the fossil material recovered during previous excavations (led by Bonifay E., from the 1960s to the early 1980s), using modern approaches and methods in order to redefine the paleoecology, taphonomy, climate and paleoenvironment, as well as to improve the chronology of the deposits. This paper presents the preliminary data on the composition and distribution of the material as well as information on the studies recently performed on the leporid, carnivore, rhinocerotid and cervid taxa.

2. GEOLOGICAL AND HISTORICAL BACKGROUND

In the 19th century, during the exploitation of a quarry of Miocene carbonate limestone (mollasse in French), a small opening was discovered revealing the first cave (named LV I). This is a relatively straight gallery, 150 m long, 10-12 m wide and nearly 6 m high (variable according to the different sectors of the cavity) oriented NE-SW. Other narrower galleries (LV II and III) run parallel to LV I. This discovery at the beginning of the 19th century was the focus of the first fieldwork from 1824 to 1827 by Marcel de Serres, professor at the University of Montpellier work which was subsequently published in monographs (Serres et al., 1828, 1839). The site fell into oblivion until 1962, when Eugène Bonifay (French National Scientific Research Centre; CNRS) conducted new research in the gallery during almost 20 years, until the beginning of the 1980s. This led him in 1971 to discover the sinkhole (doline) and cave n° 4 (LV IV). The latter is a gallery (approx. 90 m long), an extension of LV I, rich in speleothems, unlike LV I. LV IV was not excavated (but fossils were collected on the surface) and was closed in 1974. It remains to date inaccessible and intact. It is one single karstic network and the collapsed vault (sinkhole: 50m long by 20m wide) is the original entrance to LV I and IV (Bonifay, 1968, 176a; Bonifay & Bonifay, 1965; Bonifay & Combier, 1984). The filling is constituted of a base of finely varved red clays at the base of the sequence (approx. 6 m thick) on which deposits of pebble, gravel coated in a matrix of sands and clayey silts, develop. They come from the superficial formations overhanging the site, Rhodanian alluviums (quartz, quartzite, flint, metamorphic, limestone), that leach into the cavity. Their thickness varies from 2 m downstream to nearly 5 m towards the sinkhole (with a particle size gradient). Fourteen layers have been distin-

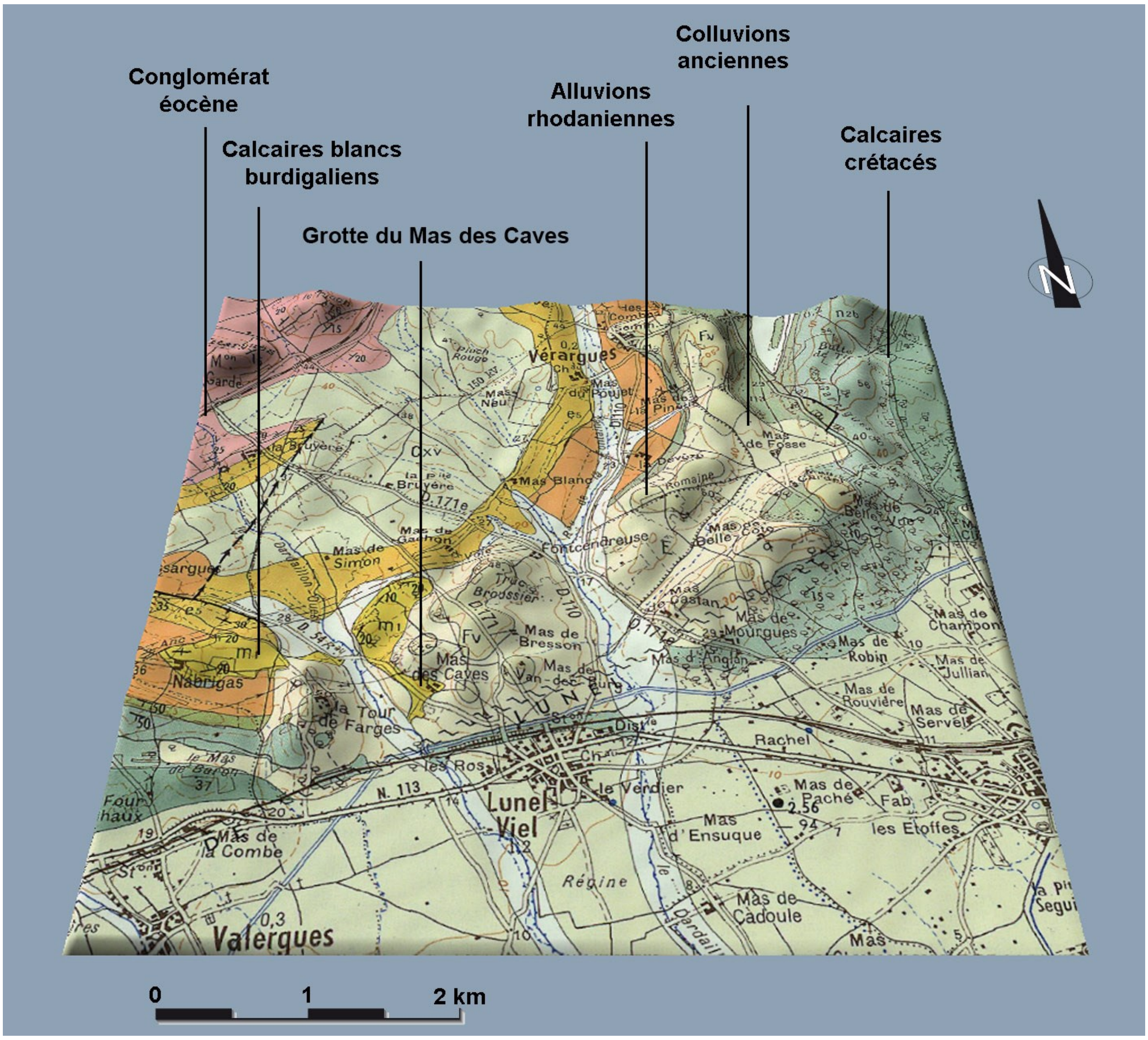


Fig. 1 - Geographical location of the caves of Mas des Caves (courtesy L. Bruxelles). Calcaires Crétacés: Cretaceous limestone; colluvions anciennes: old colluviums; alluvions Rhodaniennes: Rhodanian alluviums (quartz, quartzite, flint, metamorphic, limestone); calcaires blanc Burdigaliens: white Burdigalian limestone; conglomérat Eocène: Eocene conglomerate.

guished.

3. SHORT OVERVIEW OF THE 20th CENTURY STUDIES

Several studies were carried out in the fossiliferous deposits of Lunel-Viel I. They contain rich archeological material associated with very abundant paleontological remains (fauna, flora). Large mammals are well represented, often with complete skulls with mandibles, frequent long bones, often complete, and scarce short bones and appendicular elements (Bonifay, 1971, 1973, 1980, 1991; Brugal, 1985; Eisenmann et al., 1985; Noury, 1997).

Nearly 14 species of carnivores are present: *Cuon priscus*, *Canis lupus lunellensis*, *Vulpes vulpes*, *Lynx* cf. *pardina* and *Lynx spelaea* (see discussion below), *Panthera* (*Leo*) *spelaea*, *Panthera pardus*, *Crocuta spelaea intermedia*, *Hyaena prisca*, *Ursus deningeri*, *Mustela palerminea*, *Lutra* sp., *Meles thorali spelaeus* and pinnipeds. Herbivores are represented by eight taxa: *Bos primigenius trochoceros*, *Cervus elaphus*, *Euctenoceros mediterraneus*, *Capreolus* cf. *sussenbornensis*, *Sus scrofa*, *Dicerorhinus etruscus* (= *Stephanorhinus etruscus*: see below), *Equus mosbachensis palustris* and *Equus hydruntinus minor*. Several taxa (evolutive stage expressed at ssp. level) were identified for the first time in this deposit and are important for the biochronological framework of western Europe large mammal associations. Wolf and hyena, with great abundance of coprolites (*album graecum*), equines, bovines and deer are the most frequent taxa. These taxa are indicative of a rather temperate paleoenvironment (interglacial type) and link the entire deposit to the second half of the Middle Pleistocene ("Mindel-Riss", Bonifay, 1968, 1976a, 1989).

Meso- and micro-vertebrates are relatively abundant:

Fig. 2 - 3D view of sector 5 of LV I, the sector nearest to the naturally clogged entrance (at the bottom of the photo). Note the presence of pillars used to support the vault (in this case, only the base) © L. Pascal.

insectivores (*Talpa*, *Sorex*), leporids (*Oryctolagus cuniculus lunellensis*, Donard, 1982), chiropters, rodents [*Microtus brecciensis*, *Apodemus sylvaticus*, *Eliomys quercinus*, Pliomys *lenki*, *Pitymys duodecimcostatus*, *Microtus agrestis* (Jeannet, 1976)], birds (33 taxa, Mourer-Chauvire, 1975), reptiles (terrestrial tortoise: *Testudo* sp., Ophidia indet.), amphibians (*Rana*), fish and gastropods. The flora is known through the remains of hackberry seeds *Celtis australis* and charcoals *Cercis siliquastrum*, *Quercus* sp. (det. J.L. Vernet).

The study of several bone splinters, found with other faunal remains has suggested the possible use of these bones by hominins (Bonifay, 1976b, 1986), but also suggests that these caves were occupied by carnivores that used them as dens or lairs, especially the cave hyena (Diez, 1986; Fosse, 1992, 1994, 1996). The fossil population of *Crocuta* has served to establish a chart of age classes based on dental replacement and wear of the mandibular series (Brugal et al., 1997).

Lithic artifacts (flint, quartzite or quartz) and the possible existence of structures, in particular hearths, attest to the presence of humans (Bonifay, 1981, 1989; Le Grand, 1987, 1994). The tools are characterized by heavy artefacts (such as chopping tools), but also by blades and scrapers, and Levallois debitage has also been observed. This industry was attributed to the Acheulean Mediterranean facies (Bonifay, 1968, 1976a, 1989).

4. SHORT OVERVIEW OF THE 20th CENTURY STUDIES

In the 21st century, there have been several research projects which have included both fieldwork (excavations since 2019, dir. J.P. Brugal) and intensive studies of the old collections (stored at the *Musée National de Préhistoire*/ MNP, Les Eyzies-de-Tayac), some partly in the form of doctoral theses. These studies have revisited certain taxonomic points, and *in fine* clarified other taphonomical and geochronological issues. Two new genera have been identified, notably among the Lunel-Viel material, one cervid *Haploidoceros* (replacing *Euctenoceros*, Croitor et al., 2008) and one tortoise described as *Eurotestudo* (Lapparent de Broin et al., 2006).

The new excavations follow all the procedures now in place for modern fieldwork, adapted to a cave environment that appears as a simple elongated gallery, 'tube'-type, using numerical and 3D support (photogrammetry, lasergrammetry, tacheometry) (Fig. 2). Efforts are made to include the new data in those collected during the ancient excavations.

4.1. Nature and Distribution of Remains (E. Bonifay Collection)

The information recorded in the field-books during the excavations of E. Bonifay, such as the square, level, coordinates and the initial identification of the remains (bone with anatomical and taxonomical data, lithic with raw material), has been analyzed. The checking of the identifications is currently in progress. All items are recorded in a database.

The frequency, (number of identified specimens NISP; i.e., splinters and shaft fragments excluded), has also been reported as it reflects the faunal assemblages. Among the herbivores, cervids dominate, followed by equids and bovids (Fig. 3). Hyenids are over-represented among the carnivorans and include two species (see below). Two new species have been recently recorded and added to the faunal list: one large-sized cervid *Megaloceros* (Fig. 4) and an indeterminate Proboscid; the latter had already been identified by de Serres et al. (1839) but was absent from the Bonifay excavation records. The high frequency of reptile remains (essentially chelonid) is also

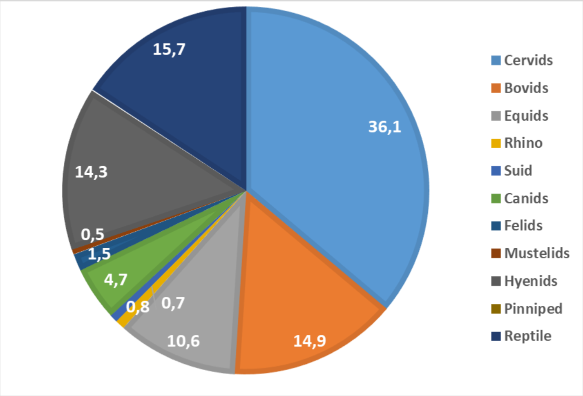


Fig. 3 - Pie-chart (% NISP) of the main mammal groups identified in Lunel-Viel I (ursids, microfaunas and coprolites exclud-

noteworthy. Furthermore, there are more than 750 coprolite remains with typical hyena morphology; their presence is an important criterion confirming the use of the cavity by this group of carnivorans.

The database combines different information and the distribution of the whole sequence is given here by categories (Fig. 5): identifiable bone, coprolites and lithic objects represent a total of 7,015 items. Faunal remains are the most abundant (ca. 83%) and most of this material (70%) predominantly comes from the median levels of the sequence, especially level 9 followed by levels 5-7.

Faunal and coprolite remains occur in every part of the cave, whereas the lithics are mainly distributed on the NW side of the gallery and are closer to the entrance. There is a clear difference in the distribution of bones *versus* coprolites. In the future, such spatial zonation needs to be further studied, in particular in relation to the origins of bone assemblages interpreted as the main result of a hyena den accumulation (Fosse, 1994, 1996) and to better understand the role of human groups in the cave.

Fig. 4 - Megaceros maxillary from Lunel-Viel I (9#23124), first identified by S. Madelaine (MNP) - Photo J.P.B.

4.2. The leporid material

A total of 364 remains are attributed specifically to the European rabbit (*Oryctolagus cuniculus*) and correspond to at least 44 individuals. This species is the only one of its genus to have occupied Western Europe from the Middle Pleistocene. The European rabbit has been found in 700-600 ky old deposits in southwestern Spain, the Cúllar de Baza (Andalusia) and Benisants (Valencia) deposits (López-Martínez, 1989; Pelletier, 2018), and in southeastern France at Balaruc 1 (Hérault) and the cave of l'Escale (Bouches-du-Rhône) (Pelletier, 2018). In more recent periods the number of fossil occurrences increases significantly in southeastern France (e.g., Caune de l'Arago, Terra Amata, Lunel-Viel I, Igue des Rameaux, Orgnac 3, Baume Baunne, Aubais, Lazaret and Les Cèdres). During the Middle Pleistocene, three subspecies of *Oryctolagus cuniculus* have been identified: *O. c. lunellensis* (Donard, 1982), defined precisely through the Lunel-Viel I material, *O. c. grenalensis* (Donard, 1982) and *O. c. baumensis* (Crégut-Bonnourre, 1995), described respectively from southwestern and southeastern French populations.

Osteometric analysis of the Lunel-Viel I population has revealed obvious differences with other populations in the region during the Middle Pleistocene (Pelletier, 2018). Indeed, the rabbits of Lunel-Viel I are characterized by a very small body size compared to those of Terra Amata (MIS 10), Orgnac 3 (MIS 9), Igue des Rameaux-Amont and -Aval (MIS 9), Baume Bonne (MIS 7), Aubais (MIS 6), Lazaret (MIS 6) and Les Cèdres caves (MIS 6). Although the data are relatively dispersed in time and space, the body size of populations in southeastern France has significantly varied over time. This can be explained by the fact that in Western Europe, there is a strong correlation between the body size of rabbits and geographical location and local environmental conditions (Sharples et al., 1996; Callou, 2003; Davis, 2019; Pelletier, 2019). Populations are distributed according to several known factors, including latitude and temperature (which are often directly related). The small body size of Lunel-Viel I individuals would then indicate relatively favorable climatic conditions.

The third lower premolar (p3) analysis, a tooth commonly used to distinguish leporid species, is characterized by a subtriangular occlusal surface. The entoconid and the paraflexid are relatively marked and the protoflexid shows an angle of approximately 90°. The lingual and vestibular anteroconids are similar in size and shape, separated by a relatively deep anteroflexid. The 2D geometric morphometrics study of this tooth in Lunel-Viel I rabbits revealed greater morphological similarities with the Orgnac 3 and Igue des Rameaux populations (MIS 9) than with those of Terra Amata (MIS 10) or Baume Bonne, Vaufrey, Aubais, Lazaret and Les Cèdres cave (MIS 7 and 6) (Pelletier, 2018).

The rabbits of Lunel-Viel I were initially identified as a new subspecies, *O. cuniculus lunellensis*, in particular due to their very small stature and large dental dimensions (Donard, 1982). However, the reduction or increase in the size of dental and postcranial elements is not a reliable criterion for specific (or subspecific) identification but rather is to be linked to local conditions. In this case, this reflects very mild climatic conditions (i.e., interglacial), close to those currently observed in the region. In addition, the

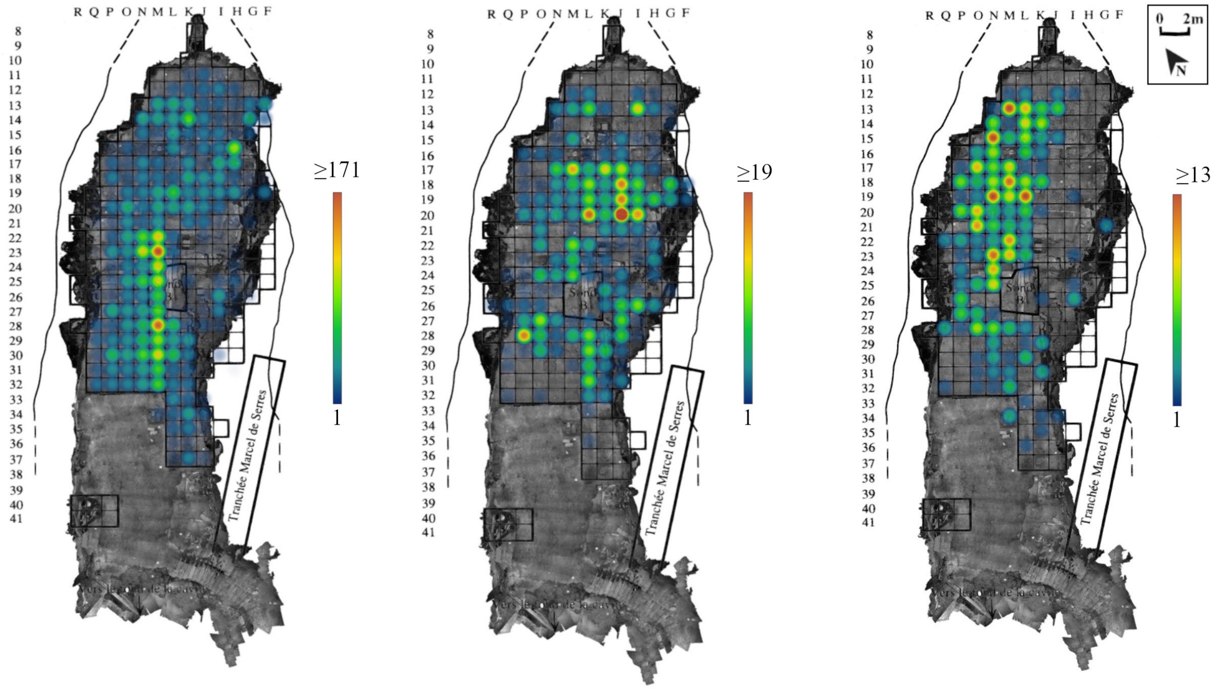


Fig. 5 - Density map and global distribution of faunal remains (left), coprolites (middle) and lithic material (right) at Lunel-Viel I. The top on the image is close to the original entrance of the cavity (sinkhole).

overall morphology of the p3 shows strong phenotypic similarities with other rabbit populations from MIS 9, and this may be an important point when detailing the chronology of the deposit.

4.3. The carnivoran material

The carnivorans of Lunel-Viel I are a much-diversified guild (Fig. 6). The hyenids and the canids, represented by *Crocuta spelaea intermedia*, *Hyaena prisca*, and *C. lupus lunellensis* (Bonifay, 1971), dominate the medium-to-large-sized predators. When *Hyaena* remains are less common, *Crocuta* is dominant. The medium-sized wolf sample is composed of about 213 crania, mandible and postcranial remains representing at least 18 individuals and corresponding to an evolutionary stage in the wolf lineage, characteristic of Middle Pleistocene times (Boudadi-Maligne, 2010). The remains of the canid genus *Cuon* underwent biometrical analysis to improve the definition of this lineage in order to refine its biochronology (Brugal & Boudadi-Maligne, 2011). In the proposed phyletic scheme, the dhole material from Lunel-Viel is identified as *C. priscus fossilis.*

Among the hyenids, *Hyaena prisca* has been considered so far as an ancestral form of the extant striped hyena *Hyaena hyaena* (Kurten, 1968; Werdelin & Solounias, 1991; Turner, 1990; Turner et al., 2008), although recent research suggests a potential phyletic relationship with the extant brown species *Parahyaena brunnea* (Arribas & Garrido, 2008; Brugal et al., 2012). *Hyaena prisca* is present in some Pleistocene sites especially in Southern Europe and seems more characteristic of the Middle Pleistocene (Kurten, 1968; Brugal et al., 2020). This species is never abundant in the sites, except in the early Late Pleistocene site of Furninha in Portugal where this taxon persists (Cardoso, 1996; Brugal et al., 2012). It was first instituted by de Serres, (1828) based on the Lunel-Viel material (Figs. 6-7). Its main dental morphological features are (Figs. 6-7): a vestigial M1, less thicker premolars than in *Crocuta* while the m1 has a stronger talonid and a shorter trigonid (paraconid + protoconid) flanked posteriorly by a prominent metaconid, behind the protoconid (de Serres et al., 1938; Kurten, 1956; Bonifay, 1971). The relative size of the premolars and the talonid are more developed than in *Crocuta*, as seen in the extant scavenging specialized brown and striped hyenas. *H. prisca* was probably a scavenging hyena well equipped for bone-cracking activities.

Felids are usually rarely found in Quaternary sites, probably due to their social (solitary) and dietary behaviors. However, the fossil cave lynx from Lunel-Viel is represented by 38 remains from 5 individuals which, along a few other Pleistocene series (Escale, Campefiel, Observatoire), are quantitatively important. Fosse et al. (2020, 2021) redefined its taxonomical status through biometrical and morphological reanalyzes, suggesting that the cave lynx could be an ancestral (Pleistocene) sub-specific form of the extant Iberian lynx, *Lynx pardinus spelaeus*. Accordingly, almost all the Pleistocene lynxes from the Mediterranean area should now be considered as belonging to this (sub-)species, while *Lynx lynx* only appears at the end of the last Glacial (Fosse et al., in prep; Mecozzi et al., 2021).

Finally, this new assessment of the collection confirms the presence of a marine mammal, cf. *Phoca* sp.?, through three teeth (one canine, one upper incisive and one PM/M). The presence of seal remains within a continental paleontological sample in a carnivoran den suggests the exploitation of marine environments and the

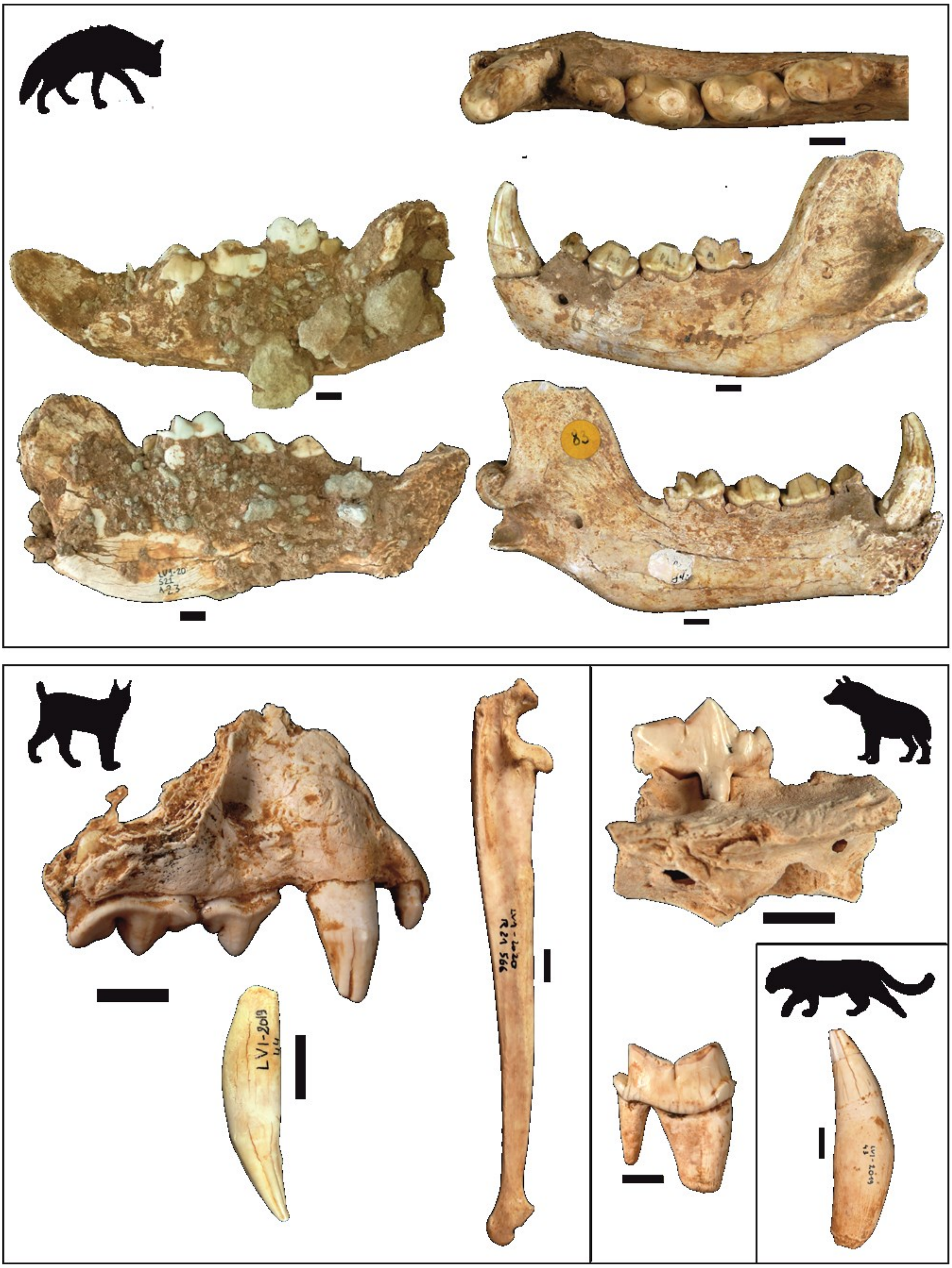


Fig. 6 - Carnivore remains from 2019 and 2020 excavations at Lunel-Viel I (except holotype *H. prisca* of M. de Serres, top right). Scale: 1cm. Photos P.F. and mandible *H. prisca* LV1-20 S21-A23 by JPB.

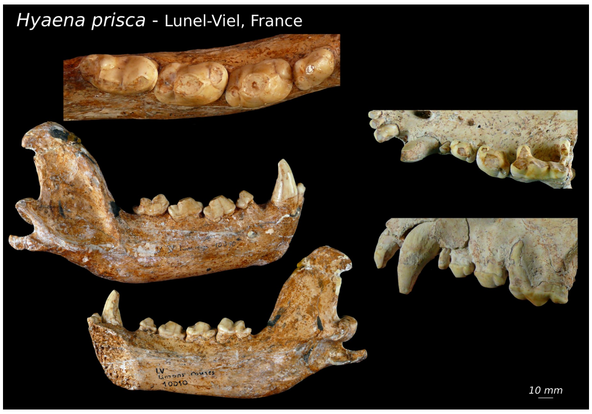


Fig. 7 - Upper and lower dental features of *H. prisca* from Lunel-Viel. Photos J.B. Fourvel.

seashore by predators such as hyenas. These predator-prey interactions between seals and hyenas are well-known from an extant context in southern Africa, particularly brown hyenas which live along the Namib seashore (for more details on ecology and taphonomy see Wiesel, 2006; Kuhn, 2011; Fourvel, 2012).

4.4. The rhinocerotid material

The rhinoceros remains of Lunel-Viel were first attributed to *Rhinoceros minutus* by de Serres et al. (1838) due to misidentification of the dental remains. *Rhinoceros minutus* Cuvier, 1822 is a small Oligocene rhinoceros and many small specimens have been attributed to this species during the 19th and the beginning of the 20th centuries (Viret, 1961). The Lunel-Viel rhinoceros' teeth were finally ascribed to a juvenile individual; the same authors in fact reassigned this taxon to *R. africanus* Blumenbach, 1799 (Gervais et de Serres in Edwards et al., 1846), synonymous with *Diceros bicornis*, thus arguing that the specimens from Lunel-Viel were not distinguishable from the black rhino of the Cape (southern Africa). In 1849, Gervais proposed the creation of a new species, *Rhinoceros lunellensis* (de la Rive et al., 1849), related to *R. etruscus* (Gervais, 1867). In 1854, Duvernoy associated the Lunel-Viel rhinoceros with *Rhinoceros protichorhinus*. This species can be considered synonymous to *Stephanorhinus kirchbergensis* (Depéret, 1923). However, this idea was not accepted and new studies were carried out. In 1867, Dawkins proposed the attribution of these remains to *Rhinoceros leptorhinus* according to an idea already mentioned by de Blainville (Gervais, 1867). The definition of this taxon posed many problems at the time since it actually corresponded to two distinct taxa described by Cuvier (1822) and Owen (1846). In the same year, Lartet (1867) associated the rhinoceros of Lunel-Viel with *Rhinoceros merckii*. Finally, Falconer, after establishing in 1860 the new taxon *Dicerorhinus hemitoechus*, noticed the great resemblance between the rhinoceros of Gower Caves and the one from Lunel-Viel (Falconer & Murchison, 1868).

Following the excavations of the 1960s, new studies on the rhinoceros were carried out by Bonifay (1973) who attributed this taxon to *Dicerorhinus etruscus*. Later, Guérin (1973; 1980), followed by Lacombat (2003), classified these specimens as *Dicerorhinus hemitoechus* without justifying this change, classification possibly made on the basis of the plates published by de Serres (1838) and Falconer (1868).

The Lunel-Viel rhino material was recently re-examined (Uzunidis-Boutillier, 2017). It is represented by a total of 66 bone and dental remains: 56 from LV I, nine from LV IV. All skeletal parts are represented, although the smallest bones (carpals, tarsals and sesamoids) are rare. Two distinct morphologies could be observed on the talus which is the most abundant post-cranial element (Fig. 8). They concern the specimens from LV I (level-number: 9#2554; 9#2740; 3#3117; 2#4023; 9#9028; #10089) and LV IV (#14079).

Specimen 10089: In this specimen the pulley is wide showing asymmetrical lips due to the steep slope of the inner lip, while on the other six, the pulley is narrower but asymmetrical and deep. The pulley is limited downwards by an overhang followed by a depression. On the medial face, the distal tuber is well separated, and is located in the middle of the face, above the distal edge. On the distal face, the anterior edge of the joint is concavo-convex. The facet for the cuboid is very elongated and its anterior edge protudes. Additionally, the median height of the talus helps discriminate between different *Stephanorhinus* species (Lacombat, 2003). In this specimen the talus is very high, such as in the *S. kirchbergensis* specimens from Taubach or Ehringsdorf (Kahlke, 1975; 1977) (Fig. 8).

Specimens 2554, *2740*, *3117*, *4023*, *9028*, *14079*: On the medial face, the transition between the tuber, placed more posteriorly, and the body is more progressive. On the distal face, the anterior edge of the joint is fairly straight. The facet for the cuboid is offset but is as long as that of the navicular. In height, these tali are more developed than the ones from *S. etruscus* or *S. hundsheimensis* and similar to the Arago talus of *S. hemitoechus* (Lacombat, 2003) (Fig. 8).

Given these two distinct morphologies (Fig. 9), it is possible there are two species of rhinoceros in Lunel-Viel. Specimen #10089 could correspond to *Stephanorhinus*

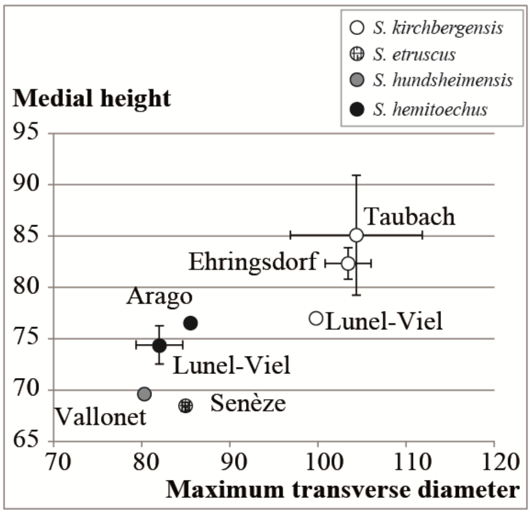


Fig. 8 - Biplot comparing the medial height and the maximum transverse diameter of the talus from several cohorts of *Stephanorhinus*. References in Table 1.

Taxon	Site		1	2	3	4	5	6	7	8	9	10	11	12	13
S. hemitoechus	Lunel-Viel	n	6	6	6	5	6	5	6	6	6	5	6	6	6
		m	81,98	74,40	39,38	66,60	56,15	71,26	73,44	55,20	58,29	54,94	51,79	76,61	38,83
		s	2,65	1,87	1,20	1,61	4,61	3,57	3,28	3,00	3,40	2,62	4,52	2,71	1,81
		min	77,84	71,41	37,23	64,49	51,53	67,11	69,22	51,92	51,50	52,09	44,63	73,99	35,25
		max	84,86	76,34	40,54	68,84	62,46	75,67	77,27	60,45	60,45	58,97	57,92	80,62	40,14
	Arago	n	1	1	1	1	5	1	1	1	3	1		4	
		m	85,53	76,50	42,26	68,06	57,16	71,24	69,90	42,58	51,10	56,00		77,81	
		min					53,99				47,94			72,16	
		max					62,45				54,06			81,40	
	La Fage	n	2		2	2	3	1				2		3	
		m	82,50		44,50	62,50	55,67	65,00				59,50		78,50	
		s	0,71		0,71	0,71	0,58					2,12		1,32	
		min	82,00		44,00	62,00	55,00					58,00		77,00	
		max	83,00		45,00	63,00	56,00					61,00		79,50	
	Pinilla del Valle	n	4		4	3	4	3				4		3	
		m	86,73		44,08	69,00	56,50	72,60				54,93		84,13	
		s	2,17		0,85	2,00	4,65	0,53				1,08		0,81	
		min	84,70		43,00	67,00	50,00	72,00				53,60		83,40	
		max	88,70		44,80	71,00	61,00	73,00				56,20		85,00	
S. kirchbergensis	Lunel-Viel	n	1	1	1	1	1	1		1	1	1			1
		m	99,76	76,99	56,41	82	58,64	87,56		68,96	60,04	62,33			42,24
	Ehringsdorf	n	5	4	5			5	5						
		m	103,40	82,33	47,96			85,26	90,92						
		s	2,61	1,54	0,65			4,57	4,47						
		min	99,80	81,00	47,00			77,50	84,40						
		max	106,60	84,30	48,60			89,30	95,30						
	Taubach	n	10	10	9			10	10						
		m	104,34	85,09	55,68			85,42	92,07						
		s	7,48	5,84	4,43			7,68	7,12						
		min	87,70	76,10	49,30			67,30	80,40						
		max	114,00	90,80	60,30			92,90	100,50						
S. etruscus	Senèze	n	2	2	2	2	2	2	2	2	2	2	2	2	2
		m	84,91	68,36	43,12	64,79	56,64	68,54	68,28	44,65	46,88	56,02	54,21	76,63	35,94
		s	0,34	0,44	0,04	0,98	1,01	0,25	0,04	0,49	0,84	1,35	0,92	0,69	0,05
		min	84,67	68,05	43,09	64,10	55,92	68,36	68,25	44,30	46,28	55,06	53,56	76,14	35,90
		max	85,15	68,67	43,15	65,48	57,35	68,72	68,31	45,00	47,47	56,97	54,86	77,12	35,97
S. hundsheimensis	Vallonet	n	6	5	1	2	7	4	5	2	4	3	4	5	4
		m	80,28	69,61	38,02	66,31	55,84	68,57	70,18	42,36	50,50	49,44	56,89	77,96	38,53
		min	75,59	66,25		65,93	53,45	67,00	67,41	41,81	47,30	47,38	52,81	74,00	33,99
		max	87,65	71,80		66,69	59,46	69,38	74,70	42,91	52,00	51,78	60,25	82,50	40,72

Tab. 1 - Measurements of the talus of *S. kirchbergensis* and *S. hemitoechus* from Lunel-Viel compare to several cohorts of *Stephanorhinus*. 1: Maximum transverse diameter of the bone (Guérin, 1980); 2: Medial height (Mazza, 1988); 3: Distal anterior-posterior articular diameter (Guérin, *op. cit.*); 4: Distal articular transverse diameter (Guérin, *op. cit.*); 5: Transverse diameter between the edges (Guérin, *op. cit.*); 6: Maximum distal transverse diameter (Guérin, *op. cit.*); 7: Lateral height (Mazza, *op. cit.*); 8: Maximum distal antero-posterior diameter (Mazza, *op. cit.*); 9: Height of the medial trochlea (Mazza, *op. cit.*); 10: Medial anterior-posterior diameter (Guérin, *op. cit.*); 11: Height of lateral trochlea (Fortelius et al., 1993); 12: Maximum height of the bone (Guérin, *op. cit.*); 13: Anterior-posterior lateral diameter. (1): Uzunidis-Boutillier, 2017; (2): Lacombat, 2003; (3): Guérin, 1973; (4): Alférez & Inigo, 1990; (5): Kahlke, 1977; (6): Kahlke, 1977.

kirchbergensis, whereas the others are closer to *Stephanorhinus hemitoechus*, in accordance to the already known morphological descriptions for these taxa (Guérin, 1973; 1980; 2010; Antoine, 2002). The metric features also confirm these attributions (Tab. 1; Fig. 8).

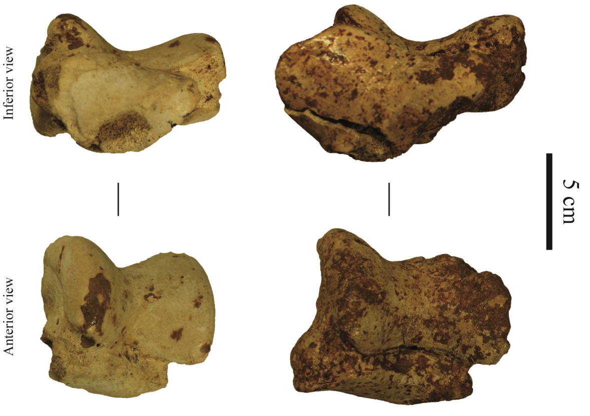
4.5. The cervid material

Cervids are mainly represented by two species: *Cervus elaphus* and *Haploidoceros mediterraneus*, which dominate the osteological series (MNI of 158, Fosse, 1996) and are associated with a few roe and giant deer remains. The latter's fossil material has been recently established as a new genus (Croitor et al., 2008), replacing the previous identification of *Euctenoceros* (Bonifay, 1967). A study on all the mandibular material from the LV I deposits gives a first glimpse of the age structure and mortality curve for these two species. The age estimation methods follow published studies and the dental wear chart proposed for modern red and fallow deer, based on both tooth replacement and the use-wear of the occlusal surface (e.g., Chapman & Chapman, 1970; Riglet, 1977; Brown & Chapman, 1991a, b, c; Magniez, 2010; Bowen et al., 2016). Six age-categories have been distinguished: J1 for first year individuals, J2 for second year individuals, A1 for individuals aged between ca. 30 and 60 months, A2 for those aged between ca. 60 to 80 months, AA for the older individuals, between 80 and 120 months, then ATA for the very old adults (over 120 months old).

From the Bonifay E. excavations, 55 mandibular series of *C. elaphus*, more or less complete, were analyzed for a minimum number of individuals (MNI) of 41 and 100 mandibular series for *H. mediterraneus* for a MNI of 62. Most of the fossil material comes from level 9. Moreover, the observation of the mandibles of the young and prime adults suggests seasonality factors, especially for the red deer remains where such material is more frequent.

The mortality profiles are relatively similar for the two taxa, prime-adults and adults dominate (Fig. 10). All age categories are represented, and such a pattern would indicate a predatory curve as observed for large carnivores and human groups (e.g., Stiner, 1990, 2012). According to the context of the cave, the bone assemblages recovered and its interpretation as a hyena den (Fosse, 1994, 1996), such cervid accumulation could be the result of hunting or scavenging behaviors as those observed in modern hyenas (Kruuk, 1972). According to eruption and tooth-wear patterns, red deer deaths would occur in summer and fall, whereas the Mediterranean deer data are indicative of acquisition during the winter period.

The mortality profiles are relatively similar for the



S. hemitoechus
9#2740

S. kirchbergensis
limon rouge#10089

Fig. 9 - Rhinoceros talus from Lunel-Viel (MNP). Photos A. Uz-

two taxa, prime-adults and adults dominate (Fig. 10). All age categories are represented, and such a pattern would indicate a predatory curve as observed for large carnivores and human groups (e.g., Stiner, 1990, 2012). According to the context of the cave, the bone assemblages recovered and its interpretation as a hyena den (Fosse, 1994, 1996), such cervid accumulation could be the result of hunting or scavenging behaviours as those observed in modern hyenas (Kruuk, 1972). According to eruption and tooth-wear patterns, red deer deaths would occur in summer and fall, whereas the Mediterranean deer data are indicative of acquisition during the winter period.

A complementary approach, microwear analysis, was applied to the cervid teeth material of the two species (n=36 teeth for *C. elaphus* and n=86 for *H. mediterraneus*) and of giant deer *Megaloceros* (n=1). The material concerns the Lunel-Viel I assemblage and was separated into upper (LV I sup) and lower (LV I inf) units of deposit. Some teeth come from LV IV. The micro-wear analysis followed the method described by Solounias & Semprebon (2002) and Semprebon et al. (2004). Observations were made on a standard surface of 0.16 mm² from the paracone of the upper teeth and the protoconid of the lower teeth of adult individuals. There is a clear difference between the species (Fig. 11) but there is a homogeneity for the three sets of *Cervus* teeth observed in terms of the mean number of scratches and pits. The mean number of scratches (NS= 16.67 to 17.25) indicates a mixed-feeder diet of both monocotyledonous and dicotyledonous grasses. *Megaloceros* (NS=18.5) appears closer to the grazers but is still within the range of the red deer samples. *Haploidoceros* is very distinct and the NS mean of its three samples is lower, corresponding to a browser adaptive diet. This Mediterranean cervid was probably flexible and use-wear analysis on the specimens from the Spanish site of Cova del Rinoceronte indicates a more mixed-feeder diet behavior (Rivals et al., 2016). The two dominant cervid species present at Lunel-Viel do not occupy the same ecological niche and, consequently, the accumulation of their remains in the cave seems to be seasonal. Further use-wear analysis on the equids and bovids from Lunel-Viel was also performed (Uzunidis, 2020), indicating respectively grazer and browser diets. Thus, the hypothesis proposed by Bonifay, (1980) that this form of *Equus* inhabited a wetland biotope, justifying the subspecies name *palustris*, can be dismissed. The paleobiodiversity present in the Lunel-Viel associations suggests a relative high competition for vegetal resources among herbivores, which would push a medium-size cervid as *Haploidoceros* towards a more vegetated landscape and turn it into more of a browser (dicot plants).

5. CONCLUSIVE REMARKS

The caves of Mas des Caves at Lunel-Viel (Hérault) in Southern France are exceptional Middle Pleistocene sites. They have yielded an important rich and well-preserved fossil record, which has become the foundation for a new systematic framework helping to redefine evolutionary forms. The renewed interest in these caves has mobilized a large interdisciplinary team of specialists in geology, sedimentology (including archaeomagnetism), geochronology (OSL, ESR/U/Th, Be/Al, racemization), animal and vegetal palaeontology, paleoecology, ecometry, taphonomy, archaeology, traceology, biochemistry (isotopes), framed within systematized photographic or lasergrammetric supports.

This preliminary work already presents several results. First, thanks to the rich fossil series of wolf and leporids, it has been possible to better establish their morphological stage and their evolutionary dynamics. Second, the taxonomic status of lynxes and rhinocerotids has been redefined. Third, new species have been identified or confirmed: megacerine deer, proboscidean, pinniped. Fourth, the analysis of dental meso- and micro-wear provided new data on the paleodiet of ungulates and on Middle Pleistocene environments in the region. Finally, complementary taphonomic studies, which included the old collections, were also performed and helped explain the structure *s.l.* and condition of the biological and anthropic assemblages.

The future prospects and research for this important Pleistocene site in Western Europe are still many. Further studies are needed, especially to understand the role and actions of humans. Currently, it appears that the bone accumulation was mainly the consequence of non-human predator activity. Notwithstanding, human activities cannot

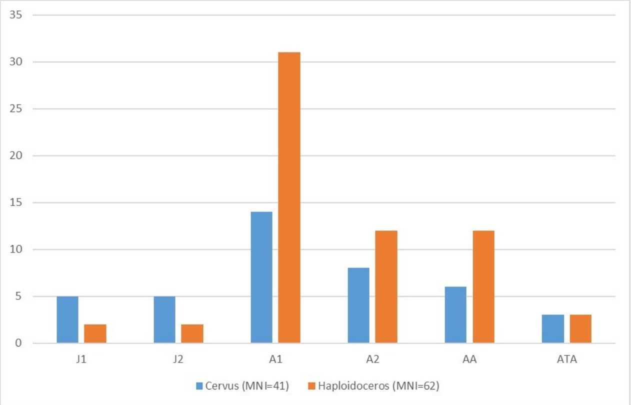


Fig. 10 - Age mortality profile for the two most represented cervid species, Cervus and Haploidoceros, at Lunel-Viel I.

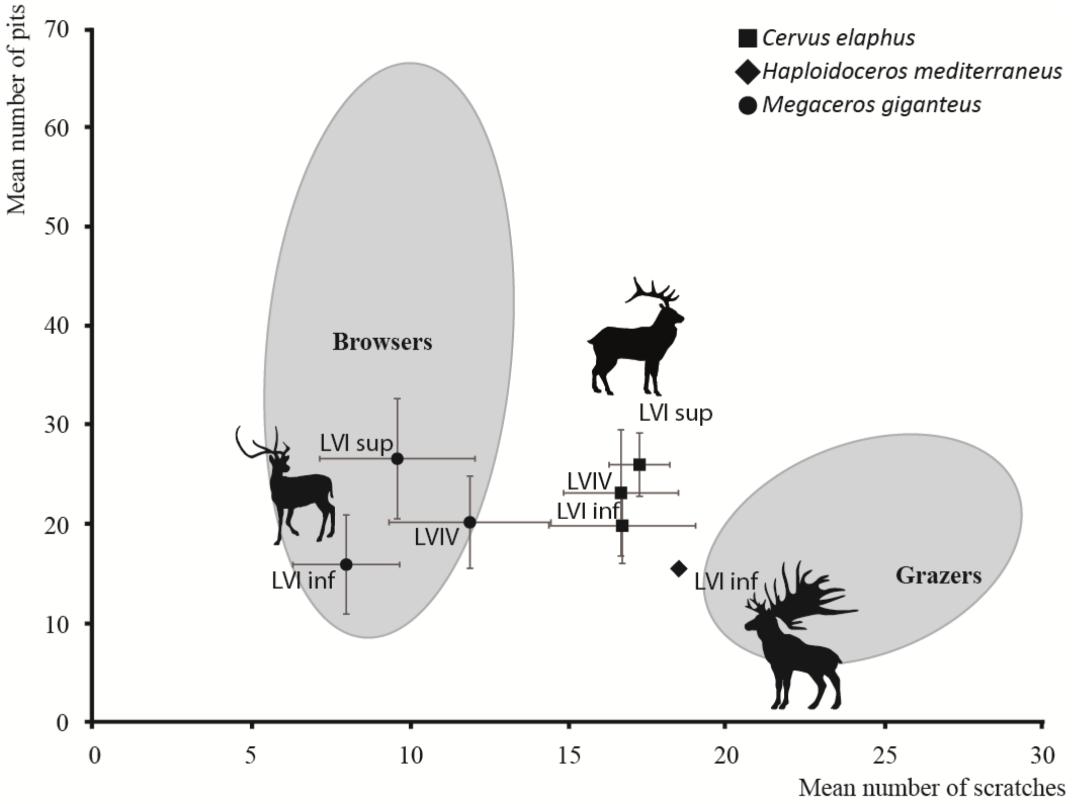


Fig. 11 - Biplot diagram comparing the mean number of scratches and pits in the cervid teeth from Lunel-Viel. The error bars correspond to the standard deviation (±1 SD). The ellipses correspond to the Gaussian confidence ellipses (p= .95) of the centroids for current grazers and grazers published by Solounias & Semprebon (2002).

be completely dismissed as demonstrated by the presence of various lithic industries and possible anthropic structures (hearths). These can be attributed to an early phase of the Middle Paleolithic. From a biochronological and paleoenvironmental point of view, the faunal assemblage is clearly temperate and the deposit could be ascribed to MIS 9 (e.330-300 kya) or to MIS 7 (e.240-186 kya).

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