The Early Pleistocene paleontological site in the Sierra del Chaparral (Villaluenga del Rosario, Cádiz, Southwestern Spain)

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ABSTRACT

This article outlines the results obtained during the first study of the Chaparral site (Villaluenga del Rosario, Cádiz, Spain) situated in the karst area of the Sierra de Grazalema. The varied macro- and micro-vertebrate fauna include carnivores, herbivores and rodents, as well as reptiles and amphibians, suggesting an Early Pleistocene age. The taphonomic study of the fauna discovered on the site is underway.

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1. Background

This report outlines the results of the sedimentary and paleontological findings (macro-mammals, micro-mammals, amphibians, and squamata), as well as the taphonomic alterations of the fossils excavated in this first phase of the site investigation, which have been ascribed to the Early Pleistocene. In February 2009, in the Sierra del Chaparral within the limits of Villaluenga del Rosario (1080 m asl), a calcareous breccia was discovered that is rich in fossil bone remains. An initial evaluation of the findings carried out by a group of specialists with different specialties within the study of the Quaternary (Gibraltar Caves Project, Dept. of Geology of la Universidad de Huelva, Dept. of Prehistory of la Universidad de Granada, IPHES of la Universidad Rovira i Virgili de Tarragona, Mixed Centre UCM ISCIII of Investigation on Evolution and Human Behaviour) identified the findings as fossils from the Early Pleistocene of Andalusia and outlined the context of the site in relation to other sites of the same age which exist in the Iberian Peninsula.

Once the state of conservation of the osseous remains and of the brecciated deposit containing *terra-rossa* was evaluated, it was agreed that the site would be excavated during 2009 with a budget subsidized by the Direcciòn General de Bienes Culturales, the Office for Cultural Assets of the Junta de Andalucía, Andalusian Regional Government. The conditions in which the site was found, exposed to being destroyed or pillaged, with a track for all terrain vehicles having been created less than 2 m from its location as well as the erosive factors accelerated by the pressure caused by tourism in this sector of the Sierra de Grazalema favored the decision that the archaeological intervention was of an "urgent" character, to avoid the partial or total destruction of the site.

The site is located in the Western Sector of the Betic Cordilleras Mountain Range, in an area known as Manga de Villaluenga del Rosario (Cádiz), forming part of the Grazalema Natural Park. It is a deposit of endokarst origin located between 1000 and 1080 m above sea level, which forms part of the Jurassic limestone pavement of the Sierra del Chaparral (UTM coordinates X-286547, Y-4062771; Fig. 1). The paleontological findings are welded together by heavily crystallized calcite flow formations to large blocks of highly altered limestone rock, typical of Jurassic formations, which are now exposed due to loss through erosion of the red clays of karst origin which fill the dissolution fissures and holes of the endokarst and which mainly form part of a *terra-rossa* deposit which fills the fracture. The morphology of the terrain appears to correspond, in genesis, to a karst fracture. The fossils are covered by

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Fig. 1. Location of El Chaparral, Villaluenga del Rosario (Cádiz, Spain).

a dense impregnation of manganese as a result of having been in a very humid environment during their long period of fossilization.

The excavation area, limited by the internal surface area of the fracture (25 m^2), is bordered by the north-south oriented natural walls of fossiliferous deposits which have remained *in situ* and which fell into the cavern due to gravity (Fig. 2). The osseous remains display a high level of old breakage due to pressure exerted by the deposits themselves and new breakages due to the current fragmentation of the edaphic level, bioturbation, passing over by livestock, and temperature changes. In both the conglomerate deposits and the red clays (*terra-rossa*), it was ascertained that anatomical connections are present. Therefore, the fossils have remained *in situ* without suffering significant displacement.

2. Geological setting

The Penibetic and Subbetic ranges are found in the western sector of the Betic Cordillera Mountain Range. The Penibetic, which rises in the Sierra de Endrinal, in Ubrique and Líbar, in the Serranía de Grazalema, is characterized by a completely carbonate Jurassic and Cretaceous layer (Moreno Serrano, 1990), between 400 and 600 m in thickness. Superimposed on this are clays and silty marls, typically reddish, from the Cretaceous to the Oligocene (red layers). In tectonic contact with and covering these materials is a flysch layer which alternates between sandstones and shales, of Aquitanian-Burdigalian age (Sierra Peralto, Las Cumbres, Alcornocales).

To the south of the Boyar Tectonic Corridor, the penibetic domain consists of wide fan folds (Sierra de Líbar, and Sierra de Ubrique) and dilated anticlines (Sierra del Endrinal), affected by fracturing and folding. The general direction of these folds is NNE-SSW to NE-SW, with inclination towards the south, therefore conditioning the general orientation of the mountainous regions, the fluvial valleys and the drainage direction.

The structural layout plays an important part in the karstification and in the organization of the underground drainage (Delannoy, 1999). The alternation between deep fan folds and syncline furrows in the penibetic domain offers characteristics favorable to underground drainage, that is, infiltration of water in
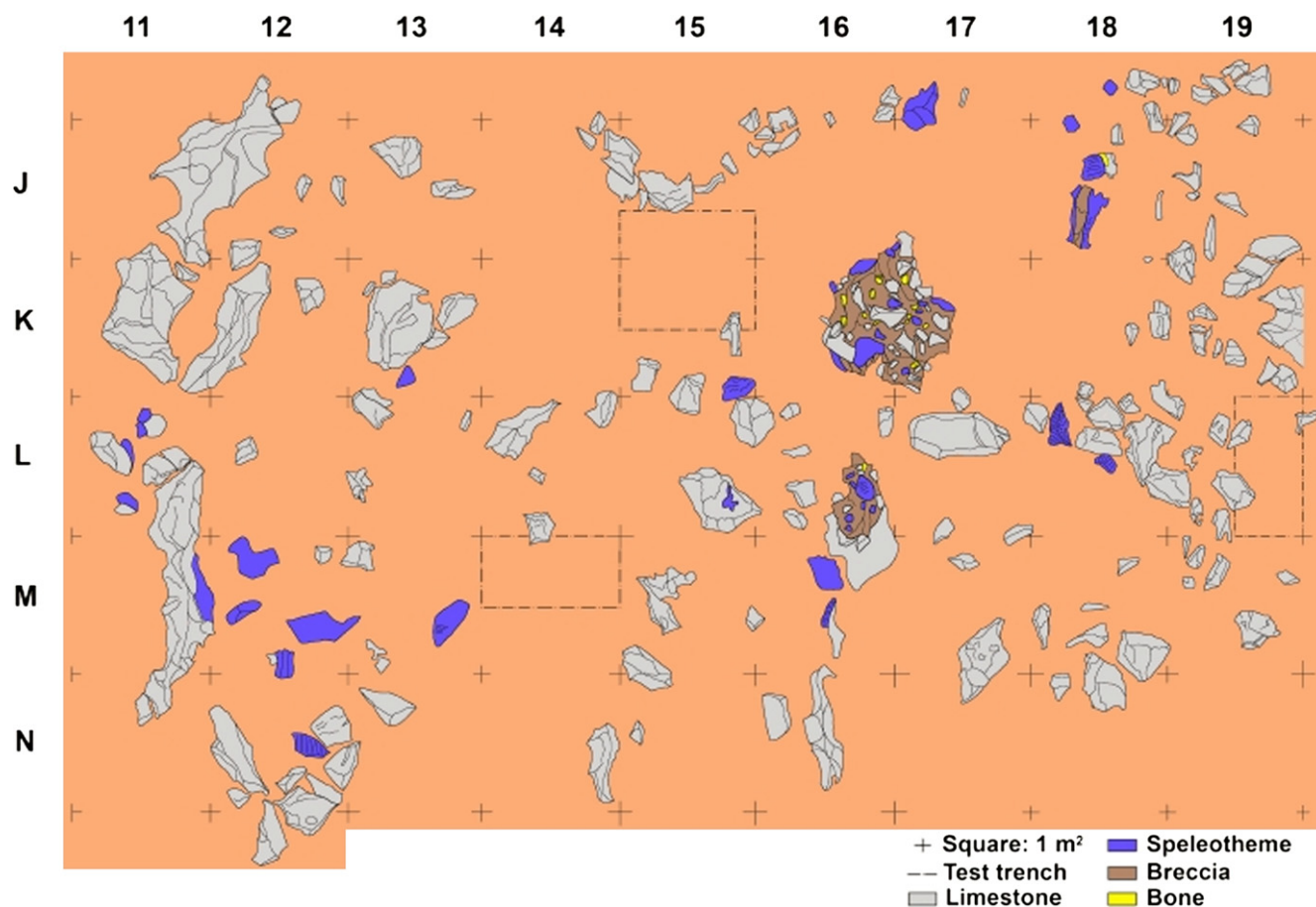
Fig. 2. Vr-Chp09, general planimetry with excavation grids.

anticline areas and concentration of the underground flow towards the syncline valleys, where the collecting infrastructure is to be found. It is also in the nucleus of these same synclines, in which the impermeable Cretaceous covering still remains, that the hydrographic network has developed (Gaduares, los Álamos stream, Villaluenga stream, Líbar stream), which is then immersed in the interior of the karst (Hundidero-Gato, Simas del Republicano, Villaluenga, Líbar, systems etc.).

The climate is typically humid Mediterranean, with dry summers and intense seasonal precipitation, with an average annual precipitation of 1500 mm for the whole of the Sierra de Grazalema, although there are areas with almost double the precipitation. These geological and climatic factors together result in karst formation in certain carbonate strata (Rodríguez Vidal et al., 1999, 2000a, 2000b), although the general line of evolution has been influenced by the exokarst fluvial network and its temporary base level changes. This means that the underground networks all trend towards the principal fluvial valleys such as the Guadiaro and the Guadalete, and they are spaced and evolve according to the engagement speed of the rivers. Therefore, a coordinated evolution of the fluvial networks and the endokarst networks does exist, with simultaneous engagement phases (canyons, abysses and wells) or horizontal stability (horizontal terraces and cavities).

La Manga de Villaluenga, situated between the towns of Benaocaz and Grazalema, to the south-west of the Sierra de Grazalema Nature Park, is a site of scenic interest made up of a long and narrow depression of abrupt walls and a flat base, through which no fluvial course of any importance flows, except some torrents which drain towards the Abyss of Villalengua due to the high degree of surface infiltration produced by the karstification of the Jurassic limestone

(Santiago and Pedroche, 2000). The valley is positioned on a fan syncline, in the nucleus of which are situated the silty marl of the upper Cretaceous (red layers). The sides (Sierra del Caillo-Sierra del Chaparral) are made up of Jurassic limestone and dolomite with almost vertical inclination. The direction of the valley coincides with that of the syncline axis, having been excavated by erosion to the core, in favour of the softer Cretaceous materials which are now only present in small amounts at the lowest points of the sides and base of the valley (Gutiérrez et al., 1991).

The karst system plays an important part in the area as a whole, offering abundant examples of nivokarst, exokarst and endokarst forms (Delannoy and Díaz del Olmo, 1986; Delannoy, 1987; Pedroche and Mendoza, 1992; Santiago and Pedroche, 2000). The Quaternary deposits in this sector are made up of calcium deficient red clays (terra-rossa), on which temporary streams flow and which, upon reaching the limestone substrate, go underground through abysses and fractures, getting lost in the interior of the massif. The depression's ponor is situated near the town of Villaluenga del Rosario, producing the well-known Abyss or Sima de Villaluenga (Santiago and Pedroche, 2000), which develops normal to the axis of the valley and acts as an outlet for various streams which drain towards it. Erosion is noted on the chalky materials of the bed which begins its initial stretch in a narrow canyon with "giant kettles" until losing itself inside the massif, where it continues its underground course until surfacing in the springs in Ubrique. No other significant fluvial course flows along the flat bottom of the depression.

These deposits are notably developed on the slopes of the Sierras de Cadiz, characterized by slopes, erosions, slides and solifluction flowstones, as well as thermoclastic scree situated on the

cliff face of Jurassic limestone, due to the fracturing of rock in which the caving in and sliding of the substrate in the higher areas and the solifluction phenomena in the depressed areas and softer ground, such as Cretaceous silt and silty marl which form part of the filling of "La Manga" have an effect.

The deposit is situated in the western sector of the Betic Cordilleras, in Manga de Villaluenga del Rosario (Cádiz). It is a deposit of endokarst origin found between 950 and 1080 m asl in the Jurassic massif Sierra del Chaparral. It is a karst fracture, an abyss silted with calcium deficient *terra-rossa,* limestone blocks normal in Jurassic formations highly affected by the action of clays and speleothems (calcites) from the walls of the fracture.

The paleontological deposit is found in the interior of the fracture and is partially brecciated (conglomerate of fauna, highly altered limestone blocks, speleothems (calcites) covered in the matrix clay of *terra-rossa)* in some cases and in others there are only non-brecciated remains in the same clays. All seems to correspond to the same unit of red clays (*terra-rossa*).

3. Methodology and excavation process

The archaeological study was in line with the habitual methodology used in excavations controlled by Cartesian coordinates and three-dimensional planimetric leveling on X-Y-Z axes of the site. The axes are established as reference points to outline the grid squares of 1 m^2. The hypothetical north is traced with a deviation of 4° respective to geographical North. The paleontological remains were extracted and their spatial position located within each grid square in relation to the sedimentary deposit within which they were contained.

Given the sedimentological characteristics of the site, the prime aim was fixed as evaluation of the site's paleontological potential and calculation of the density of the fossil findings, as well as establishment of the age of the deposits and the analysis of the fossilized taxa in stratigraphical context. A series of grid squares which limited the areas with higher percentages of osseous remains and the peripheral areas in contact with the rocks which limit the area of the former cavity were excavated separately from the fossil remains of the breccia deposit which were extracted in individual blocks, and treated and excavated in the laboratory of the Museo Histórico de Villamartín due to their intense state of consolidation. Stratigraphic test drilling was done in grid squares J-

15 and M-16. Square J-15 was divided into two sectors. The space which is in contact with the north-easterly side of the gridded zone was excavated. This sampling provided abundant fossil remains (macrofauna and microfauna). Some of the pieces were in anatomical position and located vertically in the *terra-rossa* deposits, maintaining their original position, confirming their displacement due to gravity.

Various parts of square J-18 were also excavated in order to determine the concentration of fossilized remains and their position in the deposits of *terra-rossa* and the breccia. The highest concentration of osseous remains was detected in sector W which, in theory, corresponds to the interior of the cavity, the exterior area of the cave being separated by the vertical speleothems which limit the wall of this fracture and are void of paleontological findings (Fig. 3).

Squares K-16, K-17 and K-18, occupy the central part of the site around the ossified breccias. It is in this space where the highest number of fossils per m^2, both in horizontal surfaces as well as at depth has been detected. As regards the fossiliferous remains, the most representative parts correspond with fragments of diaphysis and epiphysis of extremities and a high number of pieces corresponding to parts of the post-cranial skeleton. The parts corresponding to the skull are represented by dental pieces, mainly fragments of jawbone of herbivorous, horns of caprini and jawbones of carnivores.

4. Description of the stratigraphic layers

The stratigraphy is based on the sedimentary units which mainly form the deposits called C1 and C2. Level C1, reaching 10–15 cm, is composed of an edaphic sublevel of *terra-rossa* integrated with sediments of red clays with organic elements and a high rate of bioturbation, mainly by vegetation. It contains macro and microfauna with some taxa associated with the Pleistocene (rodents from the Cricetidae family).

Level C2, reaching from 50 to 60 cm, is made up of an extremely homogenous multi-coloured compact *terra-rossa*. It does not show signs of significant bioturbation. The coarser elements of the deposit are predominantly limestone rock, completely smoothed on the surface by the slow erosive action of the *terra-rossa* and of angular calcite fragments. They contain the highest concentration of macro and microfauna (Fig. 4).
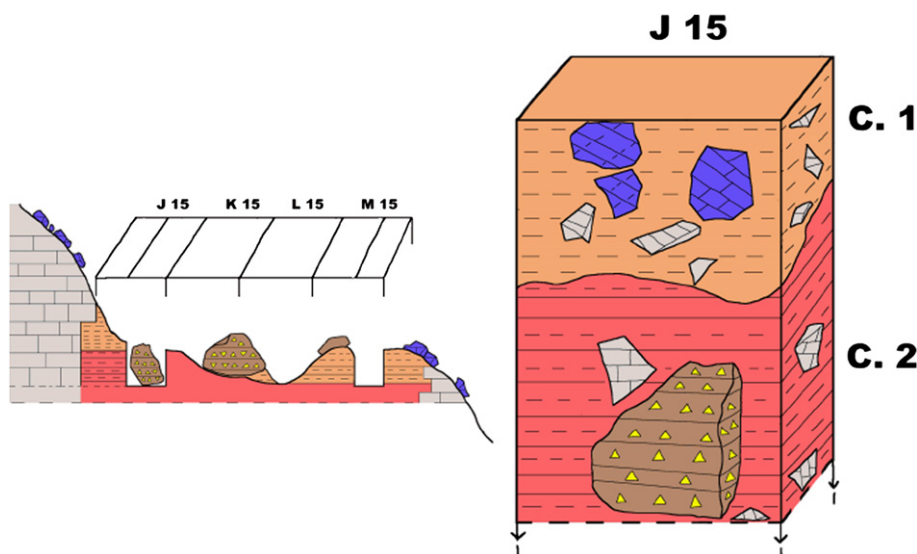

Fig. 3. Vr-Chp09, sketch cross section in J15-M15 grids.

Fig. 4. Vr-Chp09, C2 level, macro and microfauna.

A third level (C3) is considered not to be correlative with those previously described. The brecciated deposit is formed by accumulations of speleothems and calcite crystals, fragments of altered limestone, compacted clays and fossils. Three processes of dissolution are observed: a) central nucleus of the breccia; b) dissolved sector of the breccia; and c) nuclei of speleothems in stratigraphic connection and paleontological remains firmly welded together. This deposit formed from the clayey sediments of *terra-rossa* and appears to be unrelated to the clayey accumulations of layers C1 and C2.

Chronologically, these formations may have begun to originate prior to those of *terra-rossa*. Confirmation will have to wait for future chronosedimentary analysis of the deposits. The volume of the osseous conglomerates exhumed is ~1 m^3 (Fig. 5).

5. Paleontology

5.1. Carnivores

The carnivore fossil record from El Chaparral (Cádiz, Spain) site is mainly constituted by remains recovered during the 2009 field season from levels C1, C2 and C6. The fossil collection is limited in the number of specimens, restricting the taxonomic analyses. However, some of the elements are, at this preliminary level of

Fig. 5. Vr-Chp09, brecciated deposits.

study, of diagnostic relevance. A first paleontological approach to the study of the carnivore association from El Chaparral includes *Puma pardoides* ssp., *Lynx* sp., *Canis* cf. *mosbachensis*, *Vulpes praeglacialis*, and a mustelid of the size of a Polecat, which is assigned to *Mustela* sp. until further study is completed. This assemblage is characteristic of the late Early Pleistocene, with presence of the European Puma, a rare element that inhabited Europe from before 2.4 Ma to the Early Middle Pleistocene.

5.1.1. Puma pardoides ssp. (=Panthera schaubi = Viretailurus schaubi)

Several mandible and dental remains (*n* = 7) with the morphology and dimensions of a puma-like cat have been identified and likely belong to the same young individual. Left and right hemi-mandibles come from units C1 and C2 respectively: although the fossils come from two different levels, considering dimensions, morphology, ontogeny and wear stage criteria, it is considered that all remains belong to the same individual. The dimensions of the mandible and dentition fall within the *Puma pardoides* values from Untermassfeld (Mei.18376; Hemmer, 2001), Cueva Victoria and Vallparadís (Madurell-Malapiera et al., 2010). The morphology and metrics are almost identical to the specimen from Untermassfeld.

5.1.2. Vulpes cf. praeglacialis Kormos, 1932

An upper and a lower carnassial of a small fox have been recovered from levels C2 and C6 at El Chaparral. A small fox was first described at the Villány-Kalkberg (Hungary) Plio-Pleistocene site, and since then a number of Early and early Middle Pleistocene sites have also yielded remains of this species. The morphology and dimensions of the two dental elements recovered from El Chaparral are very similar to the specimens attributed by Kormos (1932) to *Vulpes (Alopex) praeglacialis*.

5.1.3. Canis cf. mosbachensis Soergel, 1925

One upper third premolar was recovered from level C2 at El Chaparral. The dimensions fall within the range of the Untermassfeld site collection analyzed by Sotnikova (2001). This P3 is posteriorly elongated with two posterior cusplets, a morphology also described for the Untermassfeld canid. However, the upper teeth morphology is similar to *Canis arnensis*, and only cranial features can help to distinguish both canid species (Sotnikova, 2001). Therefore, definite attribution to *Canis mosbachensis* cannot be yet established.

5.1.4. Carnivore biochronology

The carnivore assemblage from El Chaparral includes *Canis* cf. *mosbachensis*, *Puma pardoides* ssp. *Vulpes* cf. *praeglacialis*, *Lynx* sp., and a polecat-like mustelid, and is characteristic of the late Early Pleistocene. The first record of *Puma pardoides* is documented at Kavbebi (Georgia) dated to before 2.4 Ma, together with an associated mixed mammalian fauna from a region connecting Africa, Asia and Europe (Hemmer et al., 2004). Varshets (Bulgary) (MN 17zone; Spassov, 1997, 2003) and the Middle Villafranchian site of Saint-Vallier (France) are European sites with *Puma pardoides* (=Panthera schaubi = Viretailurus schaubi) placed between approximately 2.3 and 2.2 Ma. The Iberian fossil record of puma-like cats covers the whole known chronological distribution in Europe, from the Late Pliocene to the Early Pleistocene. Remains from Puebla de Valverde, Cueva Victoria and Vallparadís ranging from between 2.6 and 2.0 Ma (MNQ16-17) are referred by Madurell-Malapiera et al. (2010) to this felid. The Epivillafranchian record is covered by Untermassfeld (Germany) and Le Vallonnet (France), both placed within the Jaramillo subchron between 107 and 0.99 Ma., at an early part of the MNQ 20 (MIS 31-30).The youngest Eurasian puma record currently known is that from the Early Middle Pleistocene

Stránská Skála (Moravia, Czech Republic; identified as a puma by Hemmer, 2001: 728).

If it the occurrence of *C. mosbachensis* is confirmed, then a first appearance of this canid at Untermassfeld (Jaramillo Subchron between 1.07 and 0.99 Ma) (Kahlke, 1997; Sotnikova, 2001) would mark an older age limit. The age of Villány 3 (Villány-Kalkberg-Nord), where *V. praeglacialis* first occurs, marks an early time limit for this species, ranging from 2.0 to 1.5 Ma (Jánossy, 1986). Probably the fossil-bearing strata correspond to a rather long period of time with more than one faunal association (Spassov, 2000). It is broadly accepted that the Villány 3 assemblage matches with the Saint-Vallier Unit (MN 17–18). *Vulpes* cf. *praeglacialis* is coincident at two Sierra de Atapuerca sites of late Early Pleistocene age: Trinchera Elefante lower levels (TE7-14) (Carbonell et al., 2009) andTrinchera Dolina, (TD4, TD5, TD6) (García, 2003). Also, the Iberian Early Pleistocene record has yielded *V. praeglacialis* remains at Quibas and Venta Micena (Calero et al., 2006). Directly above the Matuyama-Bruhnes boundary, it is present in Stránska Skála (MIS 16–18), and at La Caune de L'Aragò (France) (Crégut Bonnoure, 1979), a Middle Pleistocene site of uncertain age, which might represent the last occurrence of this small-sized fox.

The last occurrences of *Puma pardoides* and *V. praeglacialis* at Stránska Skála (MIS 16–18, shortly after Brunhes–Matuyama transition at 0.78 Ma) bracket the likely age of El Chaparral. The evolutionary stage of the *Puma* remains from Chaparral is almost undistinguishable from the Untermassfeld specimen described by Hemmer (2001), suggesting a date for El Chaparral layers around 1 Ma, within the Jaramillo subchron.

Pumas are nowadays well adapted to a variety of landscapes in the American continent, although they prefer mountainous or rocky environments. In view of its somewhat shorter hind limbs (Hemmer, 2001) *Puma pardoides* was possibly more restricted to the forest, woodland and bush.

5.2. Ungulates from El Chaparral

5.2.1. Equus cf. suessenbornensis

Some remains from unit C2 include a proximal metacarpal and a first phalanx, but no teeth. The first phalanx is large and robust (Fig. 6). Different authors have different opinions on the classification, evolution and stratigraphic distribution of the European *Equus* (Azzaroli, 1990; Alberdi et al., 1998; Eisenmann, 1991; Forstén, 1998; Musil, 2001, etc.) and the scheme given in Fig. 6 can at most be considered to be an attempt to represent the major features. A group or lineage of gracile and mostly small forms is that of *Equus altidens*, *E. wuesti* and *E. hydruntinus*. *Equus stenonis* and related forms tend to be more robust and larger. Still larger robust forms include the "stenonid" (with v-shaped linguaflexid in the lower cheek teeth) *Equus livenzovensis*, *E. major*, *E. bressanus* and *E. suessenbornensis* and the caballoid (with different linguaflexids) *Equus ferus* (as well as its domestic descendant *E. caballus*). The proportions of the specimen from El Chaparral best fit the latter group. Material attributed to *Equus suessenbornensis* dates from the late Early Pleistocene to the earlier part of the Middle Pleistocene (about 600 ka), a temporal range which probably encompasses El Chaparral, while remains attributed to *E. ferus* (or other caballoid species or subspecies, such as *Equus mosbachensis* or *E. ferus mosbachensis*) date from about 500 ka onward. The preferred habitat of all these large robust forms is probably an open landscape.

5.2.2. Stephanorhinus etruscus

Some remains of rhinoceros from units C1 and C2 include a first abaxial phalanx (from toe II or IV) (Fig. 7) and fragments of
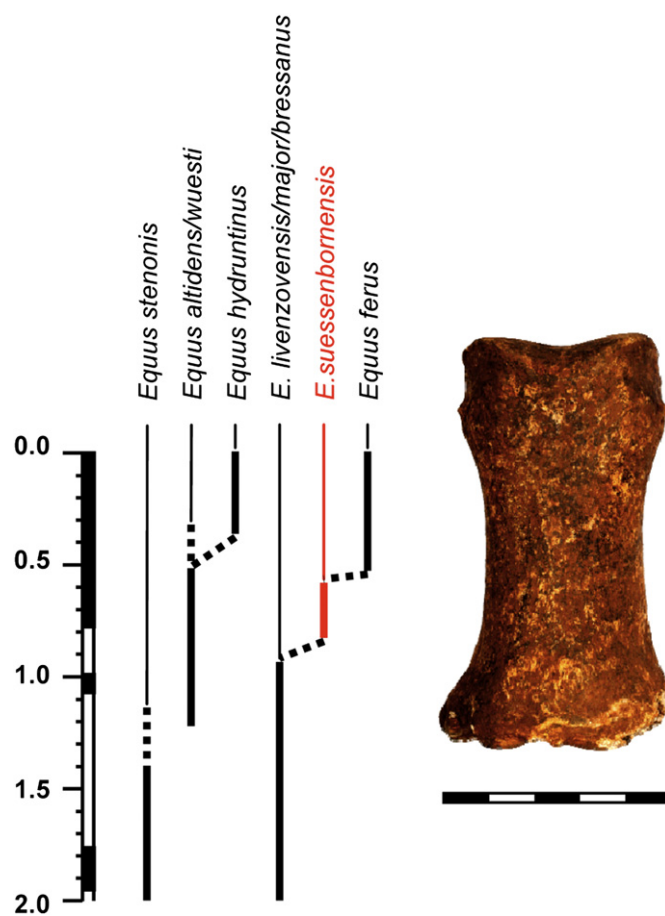

Fig. 6. Equidae. The temporal distribution of the European species of *Equus* mentioned in the text (left) and left first phalanx Vr-Chp09, C2, K-17, 358, dorsal view. The scale bar represents 5 cm.

a calcaneum, fibula, femur and a metapodial, probably a third metatarsal. The first phalanx is very small for a rhinoceros. Apart from the very rare and gigantic *Elasmotherium*, the temporal distributions of the European rhinoceroses are indicated in Fig. 7, but it should be noted that *Coelodonta* arrived considerably later in Spain (around 100 or 200 ka), while *Stephanorhinus kirchbergensis* even may not have reached Spain (van der Made, 2010; van der Made and Gruber, 2010). The latter species is very large (Fig. 7), while the former was large or robust in most cases. *Stephanorhinus etruscus*, *Stephanorhinus hundsheimensis*, and *S. hemitoechus* have dentitions of more or less similar size (e.g. M3 size in Fig. 7).

Fortelius et al. (1993) recognized a small late Early Pleistocene form, which they considered similar or closely related to *S. hundsheimensis*, but which Lacombat (2006) believed to be more closely related to the large early Late Pliocene *S. jeanvireti*. Material from Atapuerca TD4 and TD7 shows that this form is dentally similar to *S. etruscus*, but the post-cranial skeleton appears to be smaller than either *S. hundsheimensis* or the typical *S. etruscus* as from Valdarno and Olivola (Fig. 7, phalanx 1). The material from El Chaparral belongs to this form, first documented from Pietrafitta (Mazza and Sala Fortelius, 1993; about 1.4 Ma) and last from Atapuerca TD8 (slightly younger than 0.78 Ma).

5.2.3. Bison sp.

Some remains of a large bovid have been recovered from units C1 and C2. An upper molar has well marked buccal ribs and styles and a well-developed interlobular column, typical of most Bovini.
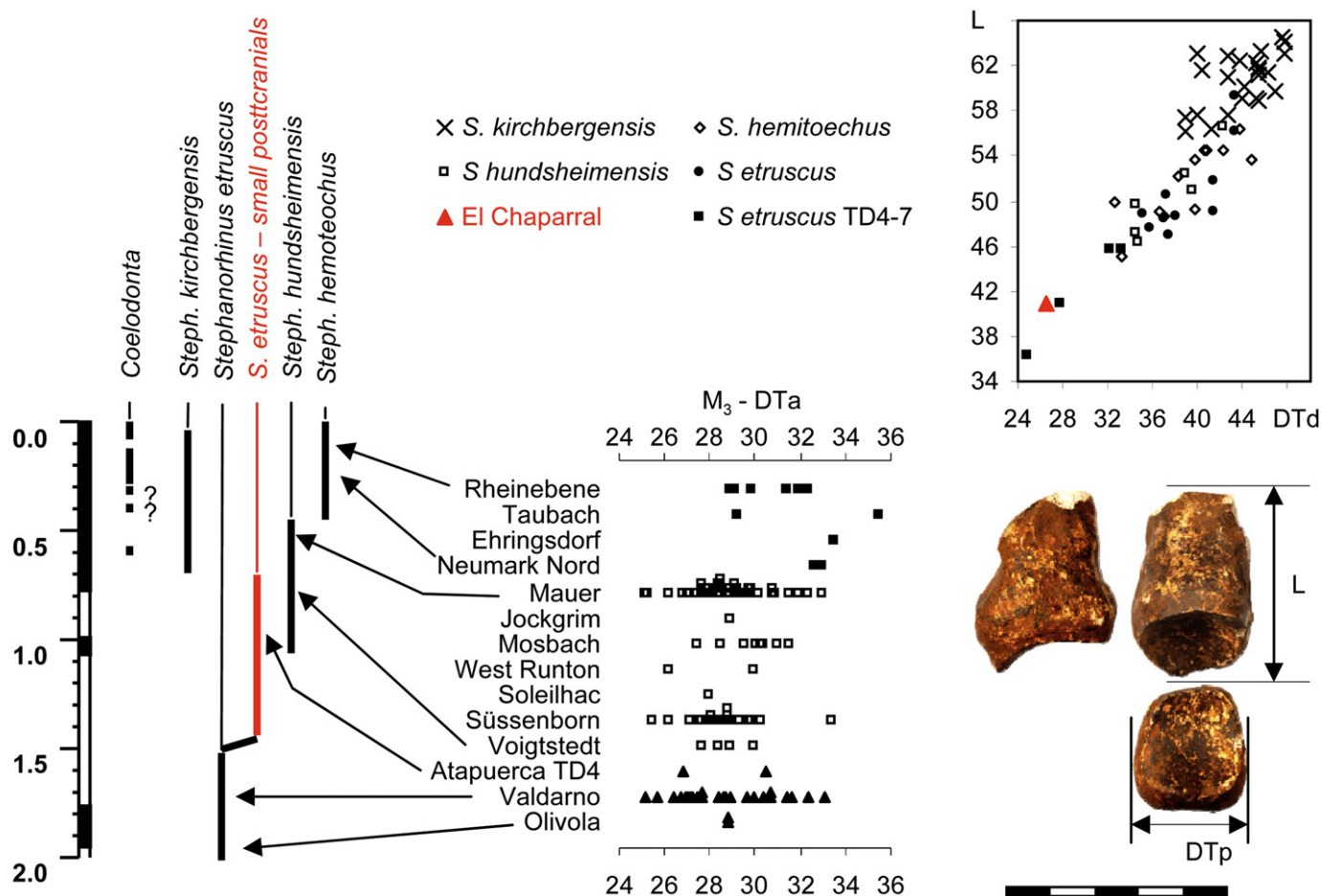
Fig. 7. Rhinocerotidae. The temporal distribution of the European Rhinocerotidae mentioned in the text after van der Made (2010) and van der Made & Gruber (2010) (left). The size of three of the species as indicated by the width of the first lobe (DTa) of the third lower molar (M₃); localities in approximate chronological order with arrows indicating approximate age. Provenance of data: Olivola - Geological Institute, Florence (IGF); Valdarno - IGF; Atapuerca TD4 - Centro Nacional de Investigación Investigación sobre la Evolución Humana, Burgos (CENIEH); Voigtstedt - Senckenberg Forschungsinstitut und Naturmuseum, Forschungsstation für Quartärpaläontologie, Weimar (IQW); Süssenborn (IQW); Soleilhac - Musée Crozatier, Le Puy en Velay (MCP); West Runton - Natural History Museum, London (NHM); Mosbach - Naturhistorisches Museum, Mainz (NMM); Jockgrim - Staatliches Naturkunde Museum, Stuttgart (SMNS); Mauer - Staatliches Naturkunde Museum, Karlsruhe (SMNK); Neumark Nord - Landesmuseum für Vorgeschichte, Halle (LVH); Ehringsdorf - IQW; Taubach - IQW; Rheinebene (sediments of the Rhine) - NMM. Bivariate plot (upper right side; length L versus proximal width DTp) of the first abaxial phalanx of *Stephanorhinus etruscus* from Valdarno (IGF) and Atapuerca TD4, TD6 and TD7 (CENIEH), *Stephanorhinus hundsheimensis* from Mauer (IQW) and Miesenheim - Römisch-Germanisches Zentralmuseum, Forschungsinstitut für Vor- und Frühgeschichte, Forschungsbereich Altsteinzeit Schloss Monrepos, Neuwied (Monrepos); *Stephanorhinus hemitoechus* from Bilzingsleben - Friedrich Schiller-Universität, Jena (FSUJ) and LVH, and Neumark Nord (LVH; van der Made, 2010); *Stephanorhinus kirchbergensis* from Bilzingsleben (FSUJ, LVH). *S. etruscus* from El Chaparral: Vr-Chp09, C1, K-17, 195 - abaxial first phalanx, left of the axis of the foot (abaxial, dorsal, and proximal views). The scale bar represents 5 cm.

The temporal distribution of the European Bovini is indicated in Fig. 8. The small *Bubalus murrensis* is known from stage 5 and 9 localities in Germany and is assumed to have dispersed twice during an interglacial from China to Western Europe (von Koenigswald, 1986). Material from Megalopolis that has been assigned to *Bubalus* (Sickenberg, 1976) might be even slightly older. No post-cranial or dental material is known. Older material from southern Spain was assigned to *Bubalus* (Martínez-Navarro, 1992), but the dental and post-cranial morphology published (Moyà Solà, 1987) is very similar to that of *Leptobos*. This limits the comparison of the material from El Chaparral to *Leptobos*, *Bison* and *Bos*.

Though the molar from El Chaparral is worn, its crown seems to have been higher than in *Leptobos*. The P4 has a metaconid that is placed far behind the protoconid, but is better developed than in most *Leptobos*. The bones and teeth have sizes in the upper ranges of that genus, well below those of *Bos primigenius*, and are comparable to those of the smaller species of *Bison*, such as *Bison voigtstedtensis* and the earlier forms of *Bison schoetensacki*.

5.2.4. Cf. Hemitragus bonali

Some bones from unit C-4 have the morphology of the Caprinae: the medial side of the distal articulation of the humerus has a small radius of curvature, the metacarpal is robust and the articulations with the phalanges have the abaxial portion with an extensive dorsal surface and a very small radius of curvature, and the first phalanx is dorso-plantarly compressed (Fig. 9). The size of the specimens is inferior to that of *Soergelia*, *Praeovibos*, *Ovibos* (Ovibovini), but superior to that of *Rupicapra*. No (or little) post-cranial material is known from the Early Pleistocene Caprini. The robusticity of the metacarpal from El Chaparral cannot be calculated, but seems to be much more than in *Ovis*. The sizes of the metacarpal and phalanx are roughly in the upper ranges of *Hemitragus*, *Capra ibex* and *Capra caucasica*. The first phalanx of *Hemitragus* seems to have a wider range of robusticity than in *Capra* (at least in the specimens studied), which probably means that the anterior phalanges are clearly more robust than the posterior ones. The specimen from El Chaparral is also relatively robust as may occur in *H. bonali*.
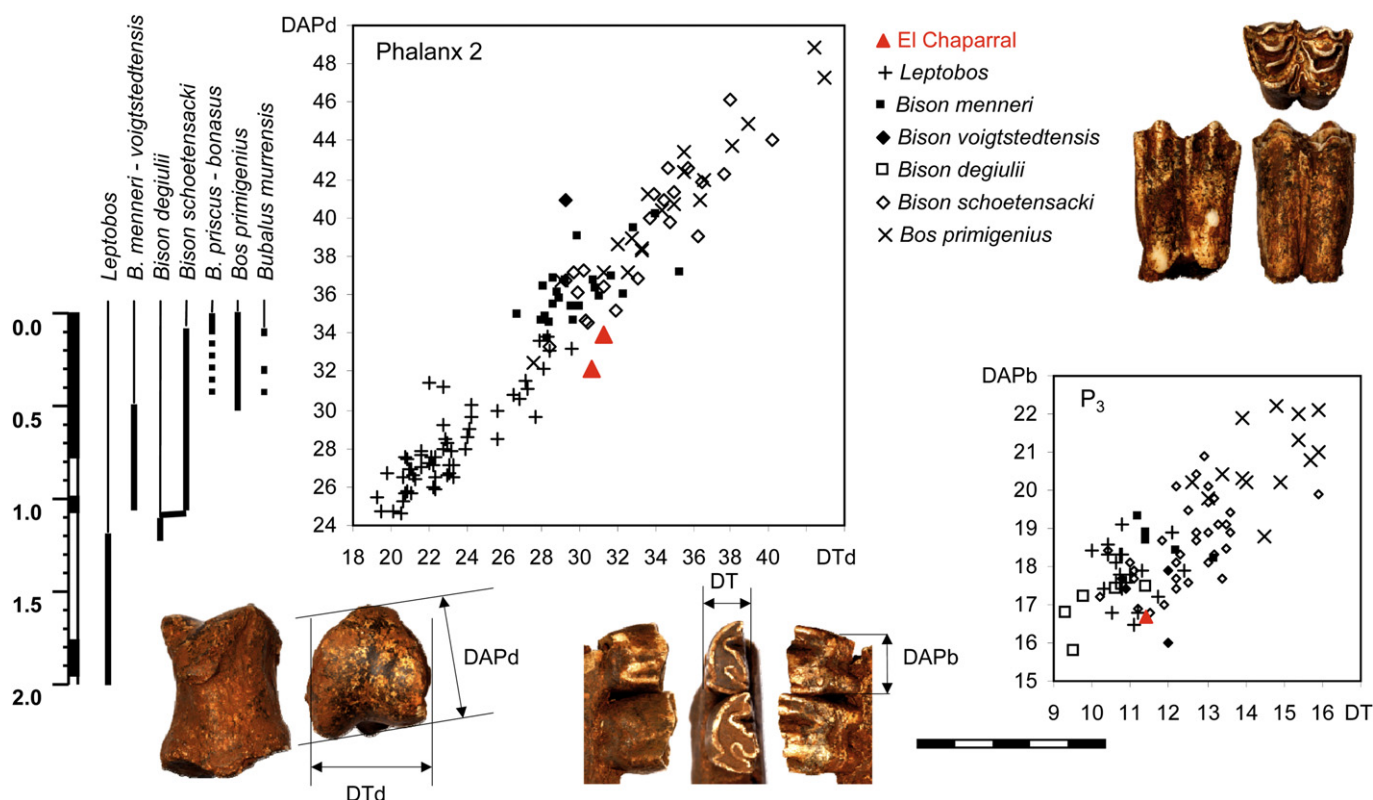
Fig. 8. Bovini. The temporal distribution of the European Bovini mentioned in the text largely after van der Made (2005). Bivariate diagrams of the distal width (DTd) and distal antero-posterior diameter (DAPd) of the second phalanx and of the maximum width (DT) and basal length (DAPb) of the third lower premolar (P₃). Provenance of data: *Leptobos* from Montopoli - IGF, Olivola - IGF, Lachar - MNCN and Pyrgos -Instituut voor Aardwetenschappen, Utrecht (IVAU), presently National and Capodistrian University of Athens (NCUA). *Bos primigenius* from Miesenheim (Monrepos), Torralba (MNCN); Neumark Nord - LVH, and Lehringen (Historisches Museum, Verden). *Bison menneri* from Untermassfeld (IQW). *Bison voigtstedtensis* from Voigtstedt (IQW). *Bison schoetensacki* from Bilzingsleben (FSUJ, HLV). *Bison* from El Chaparral: Vr-Chp09, C1, K-18, 45 - right M¹/² (occlusal, bucal and lintual views); Vr-Chp09, C2, K17, 235 - second phalanx right of the axis of the foot (dorsal and distal views); Vr-Chp09, C1, L-18, 5 - left P₃₋₄ (bucal, occlusal and lingual views); scale bar represents 5 cm.

Crégut-Bonnoure (2006) was of the opinion that *Capra dalii* from Dmanisi and *H. bonali* from Vallonnet might belong to *Hemitragus orientalis*. However, the material from Vallonnet (Jaramillo Subchron) is very similar to the accepted *H. bonali* from Hundsheim, and here it is taken as the first record of that species.

The Caprini are well adapted to mountainous or rocky environments. As was the case with other mountainous species, their distribution may have been wider during interglacial periods.

5.2.5. Capreolus sp.

A small unciform (width 11.7 mm and height 9.6 mm; Fig. 10) belongs to a ruminant of the size of *Capreolus*. The next largest deer are the *Dama*-like deer, which are clearly larger. The temporal distribution of *Capreolus* in Europe is indicated in Fig. 10, while *Procapreolus cusanus* is omitted (2 Ma). *Capreolus* appeared first in Europe in Untermassfeld (Kahlke, 1997; Jaramillo Subchron). The number of species recognized differs from author to author, but is irrelevant here, since a sole unciform does not allow for a more precise assignation.

5.2.6. Dama cf. vallonnetensis

A deer of approximately the size of the extant fallow deer is by far the most abundant large mammal. The surface texture of the antler and the pearling of the burr (Fig. 10) are similar to that of *Dama* and different of that of *Cervus* (Lister, 1996). There are widely different opinions on the late Early Pleistocene European *Dama*-like deer: they are considered to belong to *Euraxis, Axis, Rusa, Dama* or *Pseudodama*, and in particular to *Cervus* (s.l.) *nestii vallonetensis*,

Dama "nestii" vallonettensis or simply *Dama vallonnettensis* (e.g. Croitor, 2006; Kahlke, 1997; van der Made, 1999, 2005). There is a size increase in the *Dama*-like deer from about 1.4–0.4 Ma, and the position of the first bifurcation in the antler becomes lower from the earliest Pleistocene to recent (van der Made, 1999, Fig. 11,12). The small size and the position of the bifurcation of the antler (100 Hext/DAPb = 83) are compatible with *Dama vallonnetensis*, which is known between about 1.2 and 1.4 and 0.6 Ma and especially with the earlier samples.

5.2.7. Biochronology-ungulates

The first occurrence of *H. bonali* (at Vallonnet, Jaramillo Subchron, between 1.07 and 0.99 Ma) and *Capreolus* (at Untermassfeld, Jaramillo Subchron) and the last occurrences of *S. etruscus* (at Atapuerca TD8, shortly after the Brunhes–Matuyama transition at 0.78 Ma) bracket the likely age of El Chaparral.

5.3. Small mammals: materials, methods, biochronological and environmental data

The small-vertebrate fossil remains used for this study consist of disarticulated bone fragments collected by water-screening during the 2008 and 2009 excavation campaigns at El Chaparral. All the sediment (approximately 2000 kg) was water screened using superimposed 5 and 0.5 mm mesh screens, and bagged by layer.

The preliminary paleontological study of the small mammal of El Chaparral comprises at least 13 species (Fig. 11): 5 insectivores (*Erinaceus* sp., *Talpa* sp., *Crocidura* sp., *Sorex* sp., and *Asoriculus*
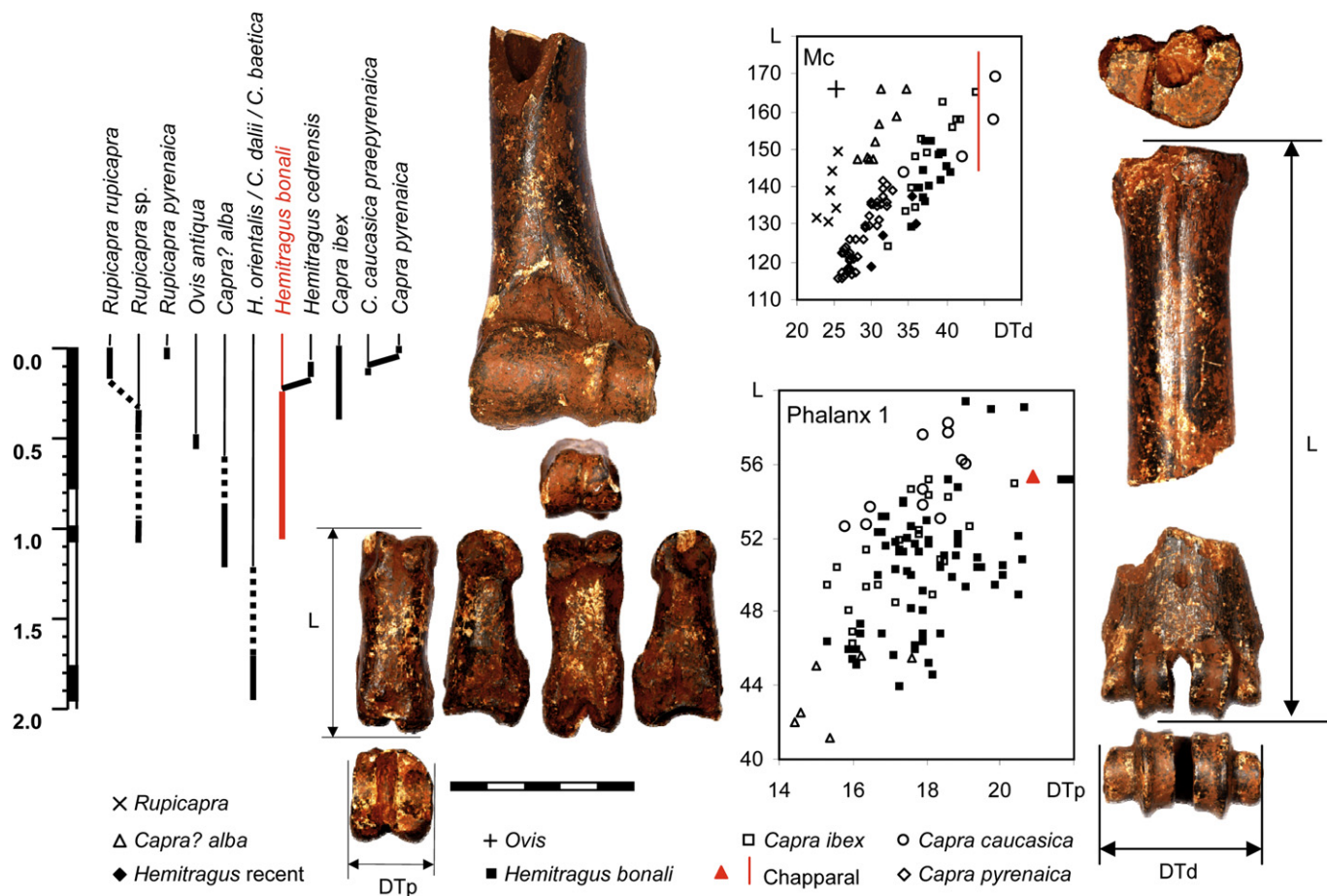
Fig. 9. Caprinae. The temporal distribution of the European Caprinae (excl. Ovibovini) (modified after Arribas & Garrido, 2008; Bukhsianidze and Vekua, 2006; Crégut-Bonnoure, 2006; van der Made, 2005). Bivariate diagrams of the distal width (DTd) and length (L) of the metacarpal (Mc) and proximal width (DTp) and length (L) of the fire phalanx. Provenance of data as from van der Made et al. (2008), save for Mc of *Rupicapra*, which is *R. pyrenaica parva* - MNCN, and first phalanx: all *C.? alba* is from Quibas, *Capra caucasica* is from Ortvala (GSM) and Sakazia (GSM) and Azykh V (Medical University, Baku). Cf. *Hemitragus bonali* from El Chaparral: Vr-Chp09, C4, K15, 3 - right proximal metacarpal (proximal and anterior views); Vr-Chp09, C4, I15, 4 - distal metacarpal (anterior and distal views) and first phalanx right of the axis of the foot (distal, medial, dorsal, lateral, plantar, and proximal views); Vr-Chp09, C4, J15, 2 - left distal humerus (anterior view); scale bar represents 5 cm.

gibberodon), 1 bat (*Rhinolophus ferrumequinum*) and 7 rodents (*Sciurus* sp., *Hystrix* sp., *Apodemus* sp., *Allophaiomys lavocati*, *Allophaiomys chalinei*, *Iberomys huescarensis* and *Pliomys episcopalis*). As a whole, this small mammal assemblage is indicative of wet and open Mediterranean woodland areas, with the presence of *Apodemus* sp. *Sciurus* sp., *Hystrix* sp., *R. ferrumequinum*, *Erinaceus* sp., *Talpa* sp. and *Sorex* sp. *Crocidura* sp. is indicative of dry areas and *A. gibberodon* of aquatic environments. The species *A. gibberodon*, *A. lavocati*, *A. chalinei*, *I. huescarensis* and *P. episcopalis* became extinct before the end of the Early Pleistocene, and therefore these are the most characteristic elements in biochronological terms. The association of *A. lavocati* and *A. gibberodon* appears in other Iberian Early Pleistocene sites such as Trinchera Elefante 7–14 (TE7–14) in the Sierra de Atapuerca (Cuenca-Bescós et al., 2010; Rofes and Cuenca-Bescós, 2006; Rofes, 2009) and Barraco León D (BL-D) and Fuente Nueva 3 (FN3) in Orce (Agustí et al. in press, 2009; Furió, 2003; Furió, 2007). These localities are situated in a pre-Jaramillo chronology between ∼1.1–1.5 Ma in the *Allophiomys lavocati* bio-zone which may be included in the early Biharian of the mammal ages of the European biozonation (Cuenca-Bescós et al., 2001, 2010). The *A. chalinei*, *I. huescarensis* and *P. episcopalis* association is present in the Early Pleistocene layers of the Gran Dolina (TD3-4) () in the Sierra de Atapuerca. These layers are situated in a Jar-amillo-Matuyama-Brhunes chronology between ∼0.9–0.78 Ma in the *A. chalinei* biozone (Cuenca-Bescós et al., 2010), which may be

included in the late Biharian mammal age, correlated with the Galerian. The absence in the small mammal assemblage of El Chaparral of advanced microtine species such as *Stenocranius gregaloides* and *Terricola arvalidens*, together the nonappearance of ancient rodents forms such as *Allophaiomys nutiensis* and *Castillomys rivas*, also differentiates El Chaparral from TD3-4, TE7-14, BL-D and FN3. This association therefore suggests that the El Chaparral is older than TD3-4 and younger than TE7-14, BL-D and FN3, making it more similar to Cueva Victoria in Murcia (Gibert et al., 2006; Blain et al., 2008; Agustí et al., 2009) and Huescar-1 in Granada (Mazo et al., 1985; Agustí et. al., in press), suggesting a date for El Chaparral layers around 1 Ma, in the Jaramillo subchron (Table 1).

5.4. Fossil amphibians and squamate reptiles: taxonomic classification; palaeobiogeographical and palaeoecological implications

To date, the palaeontological locality of El Chaparral has revealed a few fossil remains of amphibians and squamate reptiles. This association of herpetofauna is constituted of the fire sala-mander (*Salamandra salamandra*), a painted frog (*Discoglossus* sp.), a parsley frog (*Pelodytes* sp.), the common toad (*Bufo bufo*), the natterjack toad (*Bufo calamita*), the worm lizard (*Blanus cinereus*), some indeterminate lacertids (Lacertidae indet.), the southern
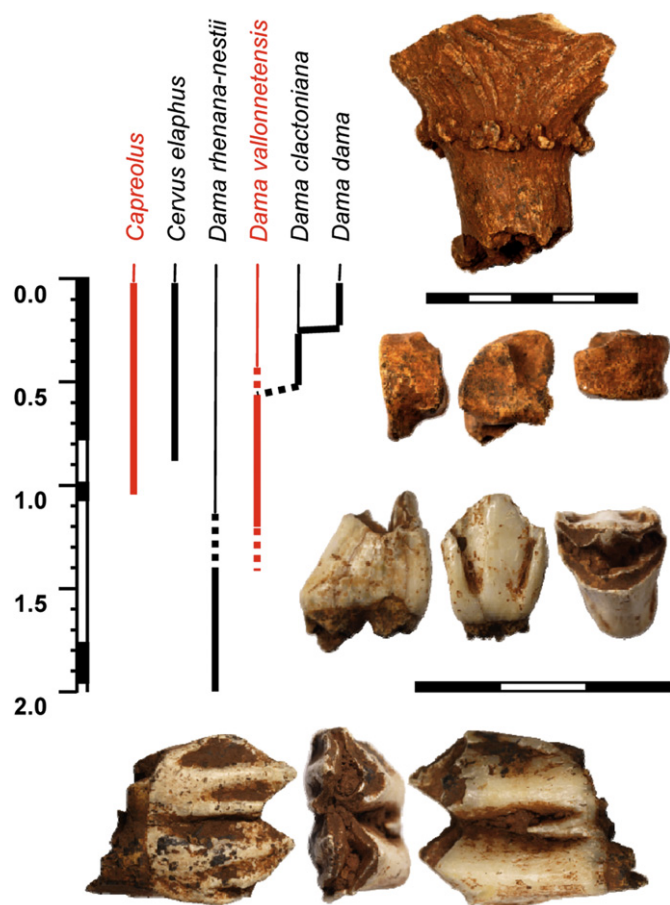
Fig. 10. Cervidae. The temporal distribution of the European Cervidae mentioned in the text (left) after van der Made (2005). Deer fossils from El Chaparral (right, from top to bottom): Vr-Chp09, C2, K17, 151 - right antler of *Dama vallonnetensis* (medial view, scale bar represents 5 cm); Vr-Chp09, C2, K17, 291 - left unciform of *Capreolus* sp. (lateral, proximal and anterior views; scale bar 3 cm); Vr-Chp09, C1, K17, 128 - right P^4 of *D. vallonnetensis* (anterior, buccal and occlusal views; scale bar 3 cm); Vr-Chp09, C2, L17, 356 - right $M_{1/2}$ of *D. vallonnetensis* (lingual, occlusal and buccal views; scale bar 3 cm).

Fig. 11. Some small mammals of the Sierra del Chaparral. **1**: left first lower molar (m1) *Iberomys huescarensis* (occlusal view), **2**: m1 left *Allophaiomys chalinei* (occlusal view), **3**: m1 right *Allophaiomys lavocati* (occlusal view), **4**: m1 left *Pliomys episcopalis* (occlusal and labial view). Scale 1 mm.

smooth snake (*Coronella girondica*), the Montpellier snake (*Malpolon monspessulanus*) and Lataste's viper (*Vipera latasti*). Noticeable is the abundance of a large size *Salamandra salamandra* in El Chaparral.

Today, the fire salamander populations of the Cádiz and Málaga Provinces (Sierra de Grazalema and Sierra de Ronda) correspond to a subspecies *S. salamandra longirostris* that is geographically isolated from the other Iberian salamanders. According to García-París et al. (1998), the Guadalquivir valley may serve as a geographical barrier between *S. s. longirostris* and the *morenica-crespoi* group, and divergence between these two clades may have be due to the formation of the Guadalquivir valley, during the Pliocene. For the other Iberian subspecies, the sub-speciation may have occurred in Pleistocene times (Joger and Steinfartz, 1994; Montori and Herrero, 2004).

From a palaeoenvironmental point of view, the large abundance of *S. salamandra* as well as of *V. latasti* may be indicative of a landscape mainly composed by a lateral variation of rocky areas (favorable to *V. latasti, C. girondica, Pelodytes, B. calamita*) and moist (mean annual precipitation higher to 800 mm) woody areas (deciduous trees) (favorable to *S. salamandra, B. bufo*, and in a minor way to *B. cinereus*). The occurrence of *Discoglossus* suggests the presence of still-water environment with good insolation.
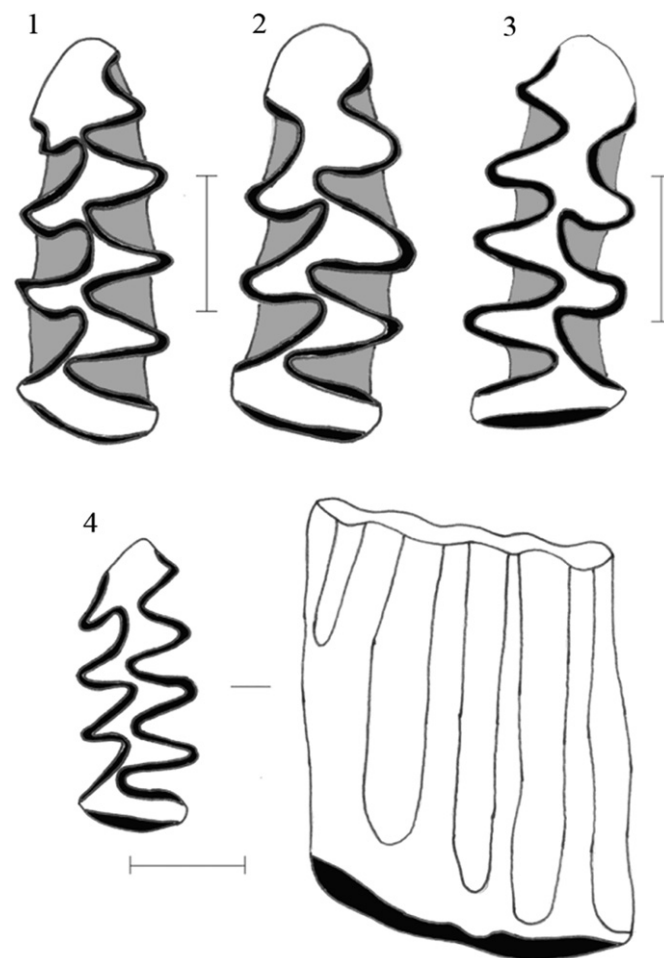
Such an association of amphibians and squamate reptiles suggests a warm and humid climate, similar to the current one in Western Andalusia and to that in other Spanish Early Pleistocene localities such as the Sima del Elefante of Atapuerca, Burgos (Agustí et al., 2009; Cuenca-Bescós et al., 2010; Rodríguez et al., 2010), Barranco León D and Fuente Nueva 3, Granada (Agustí et al., 2009, in press; Blain et al. in press) and Quibas in Murcia (Montoya et al., 2001; Mancheño et al., 2009).

To conclude, the locality of el Chaparral in the future will contribute some knowledge on the amphibians and squamates from the Early Pleistocene of the province of Cádiz and may furnish the first palaeontological data on the speciation phenomena that took place after the formation of the Guadalquivir valley at the end of the Pliocene and during the beginning of the Early Pleistocene in genus *Salamandra, Discoglossus, Alytes, Pleurodeles, Lacerta lepida* and *Psammodromus* (Carranza and Amat, 2005).

6. Taphonomic approach

The fossil association of El Chaparral is under study, and more than 500 fossils have been analyzed. Though a preliminary macroscopic observation was done, all surfaces were analyzed using stereomicroscope (Olympus EUROPE SZ11 ×110 magnification) and, when necessary, an ESEM (FEI-QUANTA 600). The

Table 1
Biochronological proposed location of the Sierra del Chaparal.

Chronology		MA	Biozones	Archeo-Paleontological sites	Mammalian Chronology M&S07			
					Small Mammal			Large Mammal
Early Pleistocene	Matuyama-Brunhes	~0.78 ~0.9	Allophaimoys chalinei	TD3-TD4,Cal Gardiola, Amenara Casablanca 3	Biharian	Mimomys-Microtus	M. Savini	Galerian
	Jaramillo			Cueva Victoria, El Chaparral, Huescar-1			savini-pusillus	
	Pre-Jaramillo	~1.1 ~1.5	Allophaiomys lavocati	Quibas, TE7-14, BL-D, FN3				

Correlation of the European Chronology (Gibbard and Kolfschoten, 2004; Gibbard and Marakova, 2007; Maul et al., 2007) with the principal Early Pleistocene archeo-paleontological sites in the Iberian Peninsula (TD3-TD4: Cuenca-Bescós et al., 1995; 2001; 2010; Cal Guardiola: Berastegui et al., 2000; Agustí et al., 2009; Amenara Casablanca 3: Agustí and Galobart, 1986; Agustí et al., 2009; Cueva Victoria: Gibert et al., 2006; Blain et al., 2008; Agustí et al., 2009; El Chaparral: from this work, Huescar-1: Mazo et al., 1985; Agustí et al., in press; Quibas: Montoya et al., 2001; Agustí et al., 2009, TE7-TE14: Cuenca-Bescós and García, 2007; Cuenca-Bescós et al., 2010; BL-D and FN3: Agustí et al., 2009; in press), the biozones established by Cuenca-Bescós et al. (2010) and the mammalian chronology (last synthesized by Masini and Sala, 2007).

modifications identified were recorded in a database which includes information on the location of each alteration on the surface, its organization, as well as its arrangement. All anatomical segments (head, axial and appendicular) are represented. Different species and age cohorts have been identified.

A total of 13.5% of remains have been recovered entire. These are mainly articular bones and phalanges. Some bones have been recovered in anatomical position, particularly metapodials and phalanges.

In general, the fossils show a very good preservation, although with the involvement of different taphonomic agents and mechanisms. These include manganese coatings, chemical corrosion, cracks, fissures, breakage and the carnivore activity. No modifications have been observed related to water or gravitational transport and no evidence of weathering. No evidence of human activities was found.

The presence of manganese coatings, cracks and fissures suggest the existence of a karst environment, characterized by high humidity and dark conditions. The manganese oxides are also related to bacterial activity (Shahack-Gross et al., 1997; López-González et al., 2006). The chemical corrosion may be related to the genesis of the deposit formation and dissolution of limestone walls. Part of the chemical corrosion has been produced by plant root action.

The carnivore activity was moderate (8%) and has been identified through the presence of toothmarks, including grooves and depressions. Other typical damage produced by carnivores as puncture marks, diaphyseal cylinders, scooping out, crenulated edges, or digestion, are absent in the association (Blumenschine et al., 1996; Capaldo and Blumenschine, 1994; Selvaggio and Wilder, 2001; Pobiner and Blumenschine, 2003; Pobiner, 2007).

The grooves are scarce (4%) and appear in phalanges, carpal and tarsal, vertebrae and metapodials. The dimensions of grooves are small, ranging from 1 to 1.3 mm. Depressions (6.8%) are more abundant than the grooves. They are located mainly in articular and epiphyseal areas. Their dimensions range from 1.79 mm to 3.93 mm. Toothmarks identified and their dimensions, together with the absence of other damage produced by carnivores, mainly breakage, suggest the involvement of a small carnivore. The intervention of carnivores is related to activities of marauding and late access to the animals.

The bone breakage is characterized by transversal outline, right and mixed angles and irregular edges. These features suggest that fractures occurred when the bones were dry or semi-dry (Villa and Mahieu, 1991). This indicates that the bone breakage was due to post-depositional processes such as sediment pressure or falling blocks.

The absences of taphonomical modification that indicate water or gravitational transport, or weathering suggest the animals came to the cavity whole. Probably the fissure would work as a natural trap through which the animals would have fallen accidentally. The carnivores could enter the cavity attracted to the carcasses accumulated there and also could be trapped.

7. The Chaparral in the context of biological refuge in the south of the Iberian Peninsula in the Early Pleistocene

The well-known Milankovich cycles have had important effects on the distribution of flora, fauna and early humans (Menocal, 1995; Shackleton, 1995; van der Made, 2010). Between 1.2 and 0.9 Ma the eccentricity cycle became more important in global climate, causing glacial cycles of approximately 100 ky duration. This changed the North Eurasian and North American biogeography in a fundamental way: during the cold periods the taiga disappeared and the tundra and steppe fused into a habitat called the "mammoth steppe", which extended from France to Alaska (Guthrie, 1990), and which was inhabited by the "glacial fauna" consisting of mammoths, musk oxen, reindeer, woolly rhinoceroses, lemmings, etc. During warm periods, these animals survived in a variety of habitats, including tundra, steppe and mountainous habitats, while the "interglacial fauna", including fallow deer, boars (Sus scrofa), and straight-tusked elephants (Elephas antiquus), spread from their refugia into extensive areas of mid-latitude Eurasia. A number of "interglacial" species are known from western but not from eastern Eurasia (like Dama), which proves that their refugia were in western Eurasia. The Iberian Peninsula, Italy and the Balkans were such refugia.

This change from a more stable biogeography to an alternation of cold and temperate environments with their respective faunas is related to a major faunal turnover with dispersals of new taxa during each cycle, and often twice per cycle. The dispersal of Homo antecessor into Western Europe seems to have coincided with the onset of this series of dispersals (van der Made, 2011). There has been discussion on whether human presence in Europe may have been continuous during the late Early and early Middle Pleistocene (e.g. Dennell and Roebroeks, 1996), and it has been suggested that if Spain was a refugium for interglacial mammals, it also may have been a refugium for early humans (van der Made, 1999).

The data which allows establishment of an approximate age of the karst filling of the Chaparral paleontological site proceeds mainly from the study of the association between micro mammalian and amphibian fossils, typified in the Early Pleistocene of the Iberian Peninsula and their relation to the rest of the macrofauna. This provides parallel ages for the different macrofauna taxa (Agustí et al., 2009; Furió, 2003, 2007, Gibert et al., 2006; Rofes and Cuenca-Bescós, 2006; Blain et al., 2008; Cuenca-Bescós et al., 2009; Furió, 2007; Rofes, 2009; Agustí et al. in press; Montoya et al. 2001). The chronology of these species, confirmed by the vertebrate microfauna, in the context of the Early Pleistocene corroborates the biographical and bioclimatic role that the south of the Iberian Peninsula – particularly the basins of the hydrographical network of the Guadalquivir, Guadalete and the "Arch of Gibraltar", played as a biological refuge when faced with the climatic cooling in the

Iberian Peninsula from the Early Pliocene to the Holocene (Giles and Finlayson, 2000; Finlayson et al., 2007).

References

Agustí, J., Galobart, A., 1986. La sucesión de micromamíferos en el complejo cárstico de Casablanca (Almenara, Castellón): problemática biogeográfica. Paleontologia i Evolució 20, 57–62.

Agustí, J., Blain, H.A., Cuenca-Bescós, G., Bailon, S., 2009. Climate forcing of first hominid dispersal in Western Europe. Journal of Human Evolution 57 (6), 815–821.

Agustí J., Blain H. A., Furió M., Marfá R. de, Santos-Cubedo, A., in press. The early Pleistocene small vertebrate succession from the Orce region (Guadix-Baza Basin, SE Spain) and its bearing on the first human occupation of Europe. Quaternary International.

Alberdi, M.T., Ortiz-Jaureguizar, E., Prado, J.L., 1998. A quantitative review of European stenonoid horses. Journal of Paleontology 71 (2), 371–387.

Arribas, A., Garrido, G., 2008. Los representantes más antiguos del género *Capra* (Bovidae, Artiodactyla, Mammalia) en el registro Eurasiático (Fonelas P-1, Cuenca de Guadix, España). In: Arribas, A. (Ed.), Vertebrados del Plioceno superior terminal en el sureoeste de Europa: Fonelas P-1 y el Proyecto Fonelas. Cuadernos del Museo Geominero, 10. Instituto Geológico y Minero de España, Madrid, pp. 461–473.

Azzaroli, A., 1990. The genus Equus in Europe. In: Lindsay, E.H., Fahlbusch, V., Mein, P. (Eds.), European Neogene Mammal Chronology. Plenum Press, New York, pp. 339–356.

Berastegui, X., Moya-Sola, S., Casanovas, S., 2000. El jaciment paleontològic de Cal Guardiola: una finestra oberta al plistocè inferior de Catalunya: contextualizació geològica. Tribuna Arqueol 1997–1998, 255–278.

Blain, H.-A., Bailon, S., Agustí, J., 2008. Amphibians and squamate reptiles from the latest early Pleistocene of Cueva Victoria (Murcia, southeastern Spain, SW Mediterranean): paleobiogeographic and paleoclimatic implications. Geologica Acta 6, 345–361.

Blain, H.-A., Bailon, S., Agustí, J., Martínez-Navarro, B., Toro, I., 2011. Paleoenvironmental and paleoclimatic proxies to the Early Pleistocene hominids of Barranco León D Fuente Nueva 3 (Granada, Spain) by means of their amphibian and reptile assemblages. Quaternary International 243 (1), 44–53.

Blumenschine, R.J., Marean, C.W., Capaldo, S.D., 1996. Blind tests of inter-analyst correspondence and accuracy in the identification of cut marks, percussion marks, and carnivore tooth marks on bone surfaces. Journal of Archaeological Science 23, 493–507.

Bukhsianidze, M., Vekua, A., 2006. *Capra dalii* nov. Sp. (Caprinae, Bovidae, Mammalia) at the limit of plio-Pleistocene from Damanisi (Georgia). Courier Forschungs-Institut Senckenberg 256, 159–171.

Calero, J.A., Montoya, P., Mancheño, M.A., Morales, J., 2006. Presencia de *Vulpes praeglacialis* (Kormos, 1932) en el yacimiento pleistoceno de la Sierra de Quibas (Abanilla, Murcia). Estudios Geológicos 62 (1), 395–400. enero-diciembre 2006.

Capaldo, S.D., Blumenschine, R.J., 1994. A quantitative diagnosis of notches made by hammerstone percussion and carnivore gnawing on bovid long bones. American Antiquity 59 (4), 724–748.

Carranza, S., Amat, F., 2005. Taxonomy, biogeography and evolution of *Euproctus* (Amphibia: Salamandridae), with the resurrection of the genus *Calotriton* and the description of a new endemic species from the Iberian Peninsula. Zoological Journal of the Linnean Society 145, 555–582.

Crégut Bonnoure, E., 1979. La faune de mammifères du Pleistocene moyen de la Caune de l'Arago à Tautavel (Pyréneés Orientales). Lab. De Paléontologie Humaine et de Prehistorie. Universite de Provence, Marseille. 381.

Crégut-Bonnoure, E., 2006. European Ovibovini, Ovini and Caprini (Caprinae, Mammalia) from the Plio-Pleistocene: new interpretations. Courier Forschungs-Institut Senckenberg 256, 139–158.

Croitor, R., 2006. Early Pleistocene small-sized deer of Europe. Hellenic Journal of Geosciences 41 (1), 89–117.

Cuenca-Bescós, G., Canudo, J.I., Laplana, C., 1995. Los arvicólidos (Rodentia, Mammalia) de los niveles inferiores de Gran Dolina (Pleistoceno Inferior, Atapuerca, Burgos, España). Revista Española de Paleontología 10 (2), 202–218.

Cuenca-Bescós, G., Canudo, J.I., Laplana, C., 2001. La séquence des rongeurs (Mammalia) des sites du Pléistocène inférieur et moyen d'Atapuerca (Burgos, Espagne). L' Anthropologie 105, 115–130.

Cuenca-Bescós, G., García, N., 2007. Biostratigraphic succession of the early and Middle Pleistocene mammal faunas of the Atapuerca cave sites (Burgos, Spain). Courier Forschunginstitut Senckenberg 259, 99–110.

Cuenca-Bescós, G., Rofes, J., López-García, J.M., Blain, H.-A., Marfà de, R.J., Galindo-Pellicena, M.A., Bennàsar-Serra, M.Ll., Melero-Rubio, M., Arsuaga, J.L., Bermúdez de Castro, J.M., Carbonell, E., 2010. Biochronology of Spanish quaternary small vertebrate faunas. Quaternary International 212, 129–136.

Delannoy, J.J., Díaz del Olmo, F., 1986. La Serranía de Grazalema (Málaga-Cádiz). In: Delannoy, J.J., Lhenaff, R. (Eds.), Karst et Cavitès d'Andalousie. Karstologia Mémories, 1. Casa de Velázquez and C.N.R.C. Association Fraçaise de Karstologie. Muséum d'Histoire Naturelle, Nímes, pp. 54–70.

Delannoy, J.J., 1987. Reconocimiento Biofísico de Espacios Naturales de Andalucía: Serranía de Grazalema y Sierra de las Nieves. Agencia de Medio Ambiente/ Servicio de Evaluación de Recursos Naturales. Memoria y dos mapas 1:30.000/ 1:40.000. Junta de Andalucía y Casa de Velázquez, Sevilla. 50.

Delannoy, J.J., 1999. Contribución al conocimiento de los macizos kársticos de la Serranía de Grazalema y de Ronda. In: Durán, J.J., López Martínez, J. (Eds.), Karst en Andalucía. IGME, Madrid, pp. 93–129.

Dennell, R., Roebroeks, W., 1996. The earliest colonization of Europe, the short chronology revisited. Antiquity 70, 535–542.

Eisenmann, V., 1991. Les Chevaux Quaternaires européens (Mammalia, Perissodactyla). Taille, typologie, Biostratgraphie et taxonomie. Geobios 24 (6), 747–759.

Finlayson, C., Giles, F., 2000. The Southern Iberian peninsula in the Late Pleistocene: geography, ecology and human occupation. In: Stringer, C.B., Barton, R.N.E., Finlayson, J.C. (Eds.), Neanderthals on the Edge. Oxbow Books, Oxford, pp. 139–153.

Finlayson, C., Rodríguez-Vidal, J., Giles Pacheco, F., Stringer, C., Carrión, J.S. (Eds.), 2007. Where the Neanderthals lived. A study of Neanderthal and Modern Human behavioural ecology in a glacial refugium (Gorham's Cave, Gibraltar). Oxbow Books (submitted).

Forstén, A., 1998. *Equus* species as stratigraphic markers. Reality or wishful thinking? Quaternary Science Reviews 17, 1097–1100.

Fortelius, M., Mazza, P., Sala, B., 1993. *Stephanorhinus* (Mammalia: Rhinocerontidae) of the western European Pleistocene, with a revision of *S. etruscus* (Falconer, 1868). Palaeontographia Italica 80, 63–155.

Furió, M., 2003. Los insectívoros (Mammalia) del Pleistoceno inferior de Fuente Nueva 3 y Barranco León (Orce, Granada). In: Toro, I., Agustí, J., Martínez-Navarro, B. (Eds.), El Pleistoceno inferior de Barranco León y Fuente Nueva 3, vol. 17. Arqueología Monografías, Orce (Granada), pp. 147–157.

Furio M.. 2007. Los Insectívoros (Soricomorpha, Erinaeceomorpha, Mammalia) del Neógeno superior del Levante Ibérico. Phd. Thesis, Universitat Autónoma de Barcelona, Barcelona, 299 pp.

García, N., 2003. Osos y otros carnívoros de la Sierra de Atapuerca. Fundación Oso Asturias, Oviedo. 560.

García-París, M., Alcobendas, M., Alberch, P., 1998. Influence of the Guadalquivir river basin on mitochondrial DNA evolution of Salamandra salamandra (Caudata: Salamandridae) from Southern Spain. Copeia, 173–176.

Gibbard, P., van Kolfschoten, T., 2004. The Pleistocene and Holocene epochs. In: Gradstein, F.M., Org, J.G., Smith, A.G. (Eds.), A Geologic Time Scale, pp. 441–452.

Gibbard, P., Markova, A., 2007. Pleistocene chronostratigraphic subdivisions and stratigraphic boundaries in the mammal record. Quaternary International 160, 1–3.

Gibert, J., Gibert, L., Fernández-Canyadell, C., Robot, F., Iglesias, A., Gibert, P., 2006. Cueva Victoria: Geología, Paleontología, restos humanos y edades. Memória Arqueológica de la Región Murcia 14, 37–62.

Guthrie, R.D., 1990. Frozen Fauna of the Mammoth Steppe. The Story of Blue Babe. University of Chicago Press, Chicago. 323.

Gutiérrez Mas, J.M., Martín Algarra, A., Domínguez Bella, S., Moral Cardona, J.P., 1991. Introducción a la Geología de la Provincia de Cádiz. Servicio de Publicaciones de la Universidad de Cádiz. 315.

Hemmer, H., 2001. Die Feliden aus dem Epivillafranchian von Untermassfeld. In: Kahlke, R.D. (Ed.), Das Plesitozän von Untermassfeld bein Meiningen (Thüringen). Römisch-Germaisches Zentralmuseum, Bonn, pp. 699–782.

Hemmer, H., Kalhke, R.-D., Vekua, A., 2004. The old world puma - Puma pardoides (Owen, 1846) (Carnivora: Felidae) − in the lower Villafranchian (Upper Pliocene) of Kvabebi (East Georgia, Transcaucasia) and its evolutionary significance. Neues Jahrbuch für Mineralogie Geologie und Paläontologie 233 (2), 197–231.

Jánossy, D., 1986. Pleistocene Vertebrate Faunas of Hungary. Akadémiai Kiadó, Budapest. 208.

Joger, U., Steinfartz, S., 1994. Zur subspezifischen Gliederung der südiberischen Feuersalamander (Salamandra salamandra-Komplex). Abhandlungen und Berichte für Naturkunde und Vorgeschichte 17, 83–98.

Kahlke, H.-D., 1997. Die Cerviden-Reste aus dem Unterpleistozän von Untermassfeld. Dr Rudolf Habelt GMBH, Bonn. In: Kahlke, R.D. (Ed.), Das Pleistozän von Untermassfeld bei Meiningen (Thüringen), pp. 181–275.

von Koenigswald, W., 1986. Beziehungen des pleistoänen Wasserbüffels (Bubalus murrensis) aus Europa zu den asiatischen Wasserbüffeln. Zeitschrift für Säugetierkunde 51, 312–323.

Kormos, T.H., 1932. Neue Wühlmäuse aus dem Oberpliocän von Püspökfürdö. Neues Jahrbuch für Mineralogie Beilage München 69B, 323–346.

Lacombat, F., 2006. Morphological and biometrical differentiation of the teeth from Pleistocene species of Stephanorinus (Mammalia, Perissodactylas, Rhinocerotidae) in Mediterranean Europe and the Massif Central, France. Palaeontographica, Abt. A 274, 71–111.

Lister, A., 1996. The morphological distinction between bones and teeth of fallow deer (Dama dama) and Red Deer (Cervus elaphus). International Journal of Osteoarchaeology 6, 119–143.

Lopez-Gonzalez, F., Grandal-d'Anglade, A., Vidal-Romani, J.R., 2006. Deciphering bone depositional sequences in caves through the study of manganese coatings. Journal of Archaeological Science 33 (5), 707–717.

van der Made, J., 1999. Ungulates from Atapuerca-TD6. Journal of Human Evolution 37 (3–4), 389–413.

van der Made, J., 2005. La fauna del Pleistoceno europeo. In: Carbonell, E. (Ed.), Homínidos: las primeras ocupaciones de los continentes. Ariel, pp. 394–432.

van der Made, J., Carlos Calero, J.A., Mancheño, M.Á, 2008. New material of the goat Capra alba from the Lower Pleistocene of Quibas (Spain) − notes on sexual dimorphism, stratigraphic distribution and systematics. Bolletino ella Società Paleontologica Italiana 47 (1), 13–23.

van der Made, J., 2010. The rhinos from the Middle Pleistocene of Neumark Nord (Saxony-Anhalt). Veröffentlichungen des Landesamtes für Archeologie 62, 432–527.

van der Made, J., 2011. Biogeography and climatic change as a context to human dispersal out of Africa and within Eurasia. Quaternary Science Reviews 30 (11–12), 1353–1367.

van der Made, J., Gruber, R., 2010. The rhinoceroses from Neumark-Nor and their nutrition. In: Hönhe, G., Schwarz, W. (Eds.), Elephantenreich- Eine Fossilwelt in Europa. Landesamt für Denkmalpflege und Archälogie Sachsen-Anhalt and Landesmuseum fúr Vorgeschichte, Halle, pp. 383–394.

Madurell-Malapiera, J., Alba, D.M., Moyá-Solá, S., Aurell-Garrido, J., 2010. The Iberian record of the puma-like cat Puma pardoides (Owen, 1846) (Carnivora, Felidae). Comptes Rendus Palevol 9, 55–62.

Mancheño, M.A., Agustí, J., Blain, H.-A., Laplana, C., Sevilla, P., 2009. The small vertebrate association from Quibas (Murcia, Spain) and the environmental context of the early human dispersal in Western Europe. Journal of Vertebrate Paleontology 29 (3), 141A.

Martínez Navarro, B., 1992. Revisión sistemática de la fauna de macromamíferos del Yacimiento de Venta Micena (Orce, Ganada, España). In: Gibert, J. (Ed.), Proyecto Orce-Cueva Victoria (1988–1992), Presencia humana en el Pleistoceno inferior de Granada y Murcia. Museo de Prehistoria Josep Gibert, Orce, pp. 21–85.

Masini, F., Sala, B., 2007. Large and small mammal distribution patterns and chronostratigraphic boundaries from the Late Pliocene to the Middle Pleistocene of the Italian Peninsula. Quaternary International 160, 43–56.

Maul, L.C., Heinrich, W.D., Parfitt, S.A., Paunescu, A.C., 2007. Comment on the correlation between magnetostratigraphy and the evolution of Microtus (Arvicolidae, Rodentia, Mammalia) during the early and early Middle Pleistocene. Courier Forschunginstitut Senckenberg 259, 243–263.

Mazo, A., Sesé, C., Ruiz-Bustos, A., Peña, J., 1985. Geología y paleontología de los yacimientos plio-pleistocénicos de Huéscar (Depresión de Guadix-Baza, Granada). Estudios Geológicos 41, 467–493.

Mazza, P., Sala, B., Fortelius, M., 1993. A small latest Villafranchian (late early Pleistocene) rhinoceros from Pietrafitta (Perugia, Umbria, central Italy), with notes on the Pirro and Westerhoven rhinoceroses. Palaeontographia Italica 80, 25–50.

de Menocal, P.B., 1995. Plio-Pleistocene African climate. Science 270, 53–59.

Montori, A., Herrero, P., 2004. Caudata. In: García-París, M., Montori, A., Herrero, P., Ramos, M.A. (Eds.), Amphibia, Lissamphibia. Fauna Ibérica. Museo Nacional de Ciencias Naturales, vol. 24. CSIC, Madrid, pp. 43–275.

Montoya, P., Alberdi, M.T., Blázquez, A.M., Barbadillo, L.J., Fumanal, M.P., Van der Made, J., Marín, J.M., Molina, A., Morales, J., Murelaga, X., Peñalver, E., Robles, F., Ruiz-Bustos, A., Sánchez, A., Sanchiz, B., Soria, D., Szyndlar, Z., 2001. Une faune très diversifiée du Pléistocène inférieur de la Sierra de Quibas (province de Murcia, Espagne). Comptes Rendus de l'Académie des Sciences. série II 332, 387–393.

Moreno Serrano, F., 1990. Mapa Geológico de España a E. 1:50.000. Hoja de Ubrique (1050). + 1 mapa. Instituto Tecnológico y Geominero de España, Madrid. 55.

Moyà Solà, S., 1987. Los bóvidos (Artiodactyla, Mammalia) del yacimiento del Pleistoceno inferior de Venta Micena (Orce, Granada, España). Paleontologia i evolució, Mem. Esp. 1, 181–236.

Mussil, R., 2001. Die Equiden-Reste aus dem Unterpleistozän von Untermassfeld. In: Kahlke, R.D. (Ed.), Das Pleistozän von Untermassfeld bei Meiningen (Thüringen). Teil 2 Dr Rudolf Habelt GMBH, Bonn: 557-588.

Pedroche Fernández, A., Mendoza, D., 1992. Estudio descriptivo de cavidades kársticas de la Manga de Villaluenga (Cádiz). AEQUA-GAC. A.M.A, Jerez de la Frontera. 80.

Pobiner, B. L., 2007. Hominin-carnivore interactions: evidence from modern carnivore bone modification and early Pleistocene Archaeofaunas (Koobi Fora, Kenya; Olduvai Gorge, Tanzania). PhD Thesis, Rutgers University, New Brunswick, NJ. 595 pp.

Pobiner, B.L., Blumenschine, J.R., 2003. A Taphonomic Perspective on Oldowan hominid encroachment on the carnivoran paleoguild. Journal of Taphonomy 1, 115–141.

Rodríguez, J., Burjachs, F., Cuenca-Bescós, G., García, N., van der Made, J., Pérez González, A., Blain, H.A., Expósito, I., López-García, J.M., García Antón, M., Allué, E., Cáceres, I., Huguet, R., Mosquera, M., Ollé, A., Rosell, J., Parés, J.M., Rodríguez, X.P., Díez, C., Rofes, J., Sala, R., Saladié, P., Vallverdú, J., Bennasar, M.L., Blasco, R., Bermúdez de Castro, J.M., Carbonell, E., 2010. One million years of cultural evolution in a stable environment at Atapuerca (Burgos, Spain). Quaternary Science Reviews. doi:10.1016/j.quascirev.2.010-02.021.

Rodríguez Vidal, J., Álvarez, G., Cáceres, L.M., Martínez Aguirre, A., Alcaraz, J.M., 1999. Espeleotemas y morfogénesis exokárstica. El ejemplo de la Sierra del Endrinal (Grazalema, Cádiz). In: Andreo, B., Carrasco, F., Durán, J.J. (Eds.), Contribución del estudio científico de las cavidades kársticas al conocimiento geológico I Simposio de Geología Cueva de Nerja. Patronato Cueva de Nerja, Málaga, pp. 185–194.

Rodríguez Vidal, J., Álvarez, G., Cáceres, L.M., Martínez Aguirre, A., Alcaraz, J.M., 2000a. Morfogénesis en el karst de la Sierra del Endrinal (Grazalema, Cádiz). XXXV Aniversario de la Sociedad Espeleológica GEOS 1962-1997. Sociedad Espeleológica GEOS, Sevilla. 435–448.

Rodríguez Vidal, J., Álvarez, G., Cáceres, L.M., Martínez Aguirre, A., Alcaraz, J.M., 2000b. Morfogénesis y fases de karstificación cuaternarias en la Sierra del Endrinal (Grazalema, Cádiz). Cuaternario y Geomorfología 13 (1–2), 7–17.

Rofes, J. 2009. Los Soricidos (Mammalia, Eulipotyphla) del Pleistoceno Inferior de los yacimientos de la Sierra de Atapuerca, Burgos, España. PhD. Thesis, Universidad de Zaragoza, Zaragoza, 268 pp.

Rofes, J., Cuenca-Bescós, G., 2006. First fossil evidence of the Soricidae (Mammalia) Asoriculus gibberodon (Petényi, 1864) in the Pleistocene of north Iberia. Rivista Italiana di Paleontologia e Stratigrafia 112, 301–315.

Santiago, A., Pedroche, A., 2000. Principales cavidades verticales de la Provincia de Cádiz. Actividades del Grupo de Investigaciones Espeleológicas de Jerez. GIEX. Andalucía Subterránea n° 14, 49–59.

Shackleton, N., 1995. New data on the evolution of Pliocene climatic variability. In: Vrba, E.S., Denton, G.H., Partridge, T.C., Buckle, L.H. (Eds.), Palaeoclimate and Evolution with Emphasis on Human Evolution. Yale University Press, New Haven, pp. 242–248.

Shahack-Gross, R., Bar-Yosef, O., Weiner, S., 1997. Black-coloured bones in Hayonim cave, Israel: differentiating between burning and oxide staining. Journal of Archaeological Science 24 (5), 439–446.

Sickenberg, O., 1976. Eine Säugetierfauna des tiererefern Bihariums aus dem Becken von Megalopolis (Peloponnes, Griechenland). Annales Géologiques des Pays Helléniques. 1e Série 28, 25–73.

Selvaggio, M.M., Wilder, J., 2001. Identifying the involvement of multiple carnivore taxa with archaeological bone assemblages. Journal of Archaeological Science 28 (5), 465–470.

Sotnikova, M., 2001. Remains of Canidae from the Pleistocene deposits of Untermassfeld. In: Kahlke, R.-D. (Ed.), Das pleistozän von Untermassfeld bei meiningen (Thüringen) (Teil 2). Römisch-Germanischen Zentralmuseums Mainz, Band 40, pp. 607–632.

Spassov, N., 1997. Villafranchian succession of mammalian megafauna from Bulgaria and the biozonation of South-East Europe. In: Aguilar, J.-P., Legendre, S., Michaux, J. (Eds.), BiochronM'97. Inst. Montpellier, Montpellier, pp. 669–676.

Spassov, N., 2000. Biochronology and zoogeographical affinities of the Villafranchian faunas of Bulgaria and south Europe. Historia Naturalis Bulgarica 12, 89–128.

Spassov, N., 2003. The Plio-Pleistocene vertebrate fauna in South-Eastern Europe and the megafaunal migratory waves from the east to Europe. Revue Paléobiologie 22, 197–229.

Villa, P., Mahieu, E., 1991. Breakage patterns of human long bones. Journal of Human Evolution 21 (1), 27–48.