Chronological, environmental, and climatic precisions on the Neanderthal site of the Cova del Gegant (Sitges, Barcelona, Spain)

Juan Manuel López-García [a,*], Hugues-Alexandre Blain [a], Gloria Cuenca-Bescós [b], Juan Luis Arsuaga [c,d]

[a] Institut de Paleoecologia Humana i Evolució Social. Área de Prehistòria de la Universitat Rovira i Virgili. Plaça Imperial Tarraco, 1. E-43005 Tarragona, Spain
[b] Departamento de Ciencias de la Tierra, Área de Paleontología de la Universidad de Zaragoza. C/ Pedro Cerbuna, 12. E-50009 Zaragoza, Spain
[c] Centro de Investigación (UCM-ISCIII) sobre la Evolución, y Comportamiento Humanos, c/Sinesio Delgado, 4 (Pabellón 14), E-28029 Madrid, Spain
[d] Dpto. Paleontología, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Ciudad Universitaria, E-28040 Madrid, Spain

Keywords:
Small-vertebrates
Biostratigraphy
Palaeoclimate
Palaeoenvironment
Upper Pleistocene

Introduction

The Cova del Gegant is a partially sea-flooded cave situated in the Massis del Garraf, in the Punta de les Coves (Cave's Point), some 40 km to the south of Barcelona (Fig. 1). The cave is part of a karst system in the Upper Jurassic to Lower Cretaceous marine limestones and dolomites of the Massis del Garraf, a low-relief mountain chain with maximum heights below 600 metres, in the Catalonian coastal range.

The Quaternary sequence (90 cm thick) includes four lithostratigraphic levels composed of red clays with lenticular bodies of dark mud (Masriera González, 1975; Viñas and Villalta, 1975). Level IV is sterile in archaeological and palaeontological material and level III is poor, while levels I and II are rich in faunal and archaeological remains.

The excavations were conducted in 1954 by Santiago Casanova (Casanova, 2004–2005), and in 1974 and 1975 at the insistance of the Section of Quaternary Ecology of the Institut Jaime Almera (Barcelona, C.S.I.C.). Several contributions came from this period (Viñas and Villalta, 1975), and in 1985 the members of the Paleo-Eco-Social Research Centre of Girona replaced the previous team (Martínez et al., 1985). The archaeological remains consist of silex stone tools of to the Mousterian technocomplex (Mir, 1975; Martínez et al., 1985). Also identified are fossils of large mammals such as *Equus caballus*, *Stephanorhinus hemitoechus*, *Crocuta crocuta,* and *Panthera pardus* (Viñas and Villalta, 1975). Mousterian stone tools and faunal remains are strongly associated, suggesting that the cave was occupied by Neanderthals (Viñas and Villalta, 1975; Daura et al., 2005). Nevertheless, as underlined by Martínez et al. (1985), the cave may have been secondarily used as a den by large carnivores, judging by the large bone-accumulation of herbivores and carnivores.

The recent description by Daura et al. (2005) of a Neanderthal mandible found in 1954 by S. Casanova (2004–2005) and preserved in the collections of the Sitges municipal archive, has resulted in renewed interest in the locality. The Neanderthal fossil remains are represented by three fragments of a mandible which comprise most of the mandiblular corpus. No teeth are preserved, but the mandible possesses some archaic anatomical characteristics that distinguish it from modern humans (Daura et al., 2005). Although the exact stratigraphical provenance of the mandible is unknown, because lithostratigraphy was only established during excavations in the 1970's, it has been argued that the mandible was associated with the Mousterian stone tools and the late Pleistocene faunal remains (Daura et al., 2005). Because the more recent excavations have recovered faunal remains from only levels I–III, we infer that the Neanderthal mandible likewise came from one of these layers. Remarkably, together with Cova Negra in Valencia (Arsuaga et al., 2007), Valdegoba in Burgos (Quam et al., 2001), Tossal de la Font in Castellón (Arsuaga and Bermúdez de Castro, 1984), El Sidrón in Asturias (Rosas et al., 2006), Camino in Madrid (Alférez Delgado, 1985), Cueva de los Moros de Gabasa in Aragón (Montes et al., 2000), and Banyoles in Catalonia (Grün et al., 2006); the Cova del Gegant is one of the few localities that have furnished ancient (i.e., > 40 ka) Neanderthal remains in the Iberian Peninsula.

The aim of this paper is to propose new data regarding the biostratigraphic age, palaeoenvironment, and palaeoclimate of what we presume to be the Neanderthal occupations of the Cova del Gegant.

Palaeontology and biostratigraphy

According to Viñas and Villalta (1975), the fossils of the small vertebrates were recovered from the excavated sediments through

* Corresponding author.
E-mail address: jlopez@prehistoria.urv.cat (J.M. López-García).

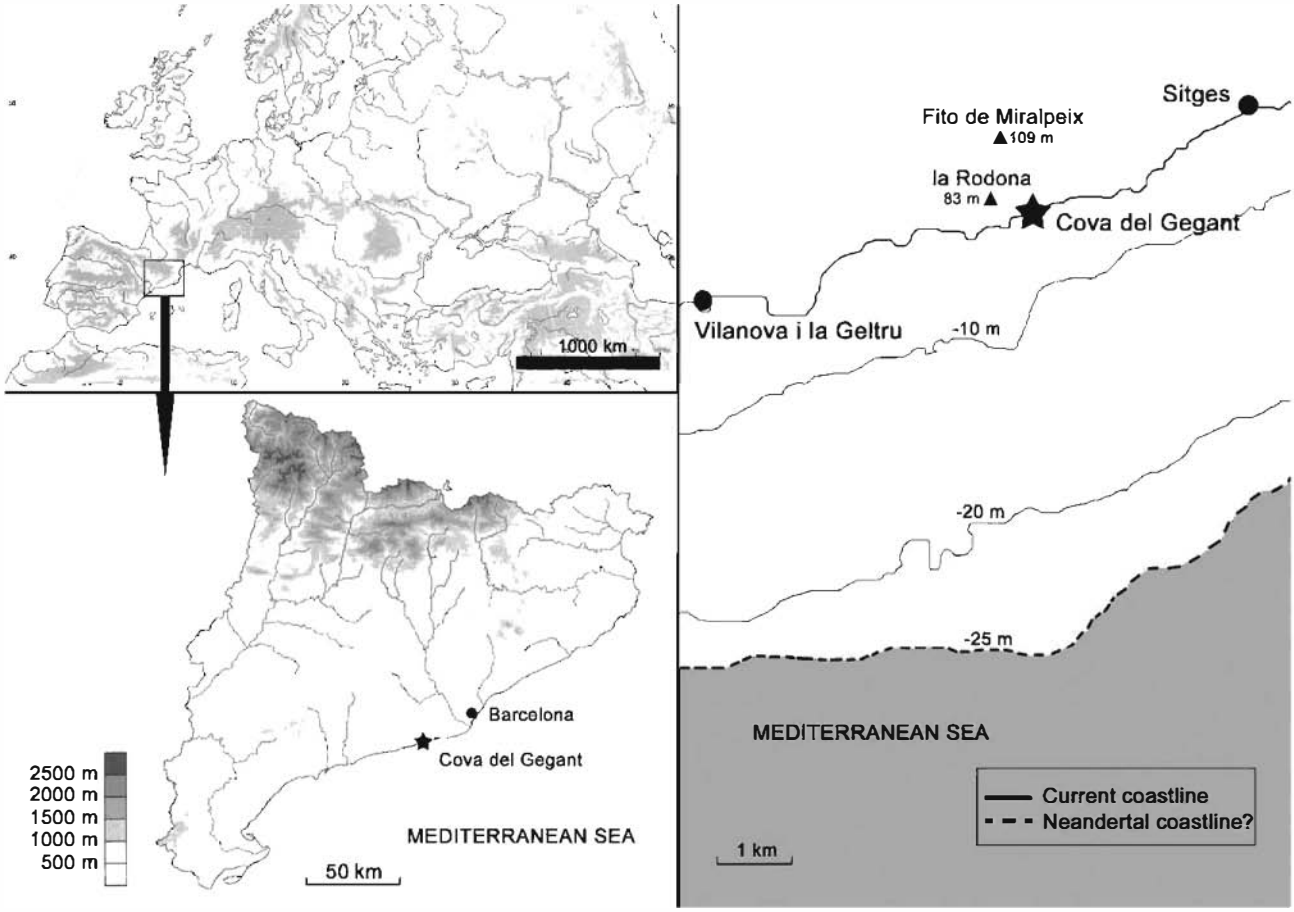

Fig. 1. Location of the Cova del Gegant (Sitges, Barcelona, Spain), with comparison between current coastline at the Cova del Gegant (continuous black) and Neanderthal coastline (discontinuous black). Bathymetric curves from various authors (VVAA, 2004).

wet-screening using two different mesh sizes, 2 mm and 5 mm. Here we analyse 225 vertebrate fossils from levels I, II, and III, corresponding to 151 small mammals, 37 squamate reptiles, and 37 amphibians from the excavations undertaken by Viñas in 1974–1975 (Fig. 2). Exact stratigraphical location of these remains is known by excavation label from each sample as listed in the catalogue of the collections of the Museu de Geologia de Barcelona (Blain and Bailon, 2006; López-García et al., 2007).

Previous studies (Viñas and Villalta, 1975; Daura et al., 2005) proposed a biostratigraphic date for the sediments of Cova del Gegant as "Würm II" (i.e., between 128–40 ka; Marine Isotopic Stages [MIS] 5e-3). Direct ^{14}C dating of the human mandible has proven unsuccessful (Daura et al., 2005). Here we consider the small mammal fauna and more specifically two rodent species, *Iberomys cabrerae* and *Hystrix brachyura vinogradovi,* to further restrict the age of the site.

The Iberian vole, *Iberomys cabrerae,* is the sole extant representative of the *Iberomys* lineage. The Iberian vole is descended from the *Iberomys brecciensis*, which appears in the middle Pleistocene. The extant Iberian vole is characterized by several features that are also present in the Cova del Gegant specimens: a relatively long and wide lower molar (M_1), the reduction of the triangles of the anteroconid complex (ACC), a noticeable labio-lingual asymmetry (Cuenca-Bescós et al., 1995), a fourth buccal salient angle (BSA4) with a quadrangular form, and enamel completely covering the labial wall of the ACC (Ayarzagüena and López Martínez, 1976; Fig. 3). An analysis of the variability in size of the M_1 of the Cova del Gegant specimens, in comparison with other specimens from the middle Pleistocene (Galería in Cuenca-Bescós et al., 1999), the late Pleistocene (Abric Romaní), and the Holocene (Cova Foradada), establishes that the size falls within the variation of the extant *Iberomys cabrerae* (Fig. 3).

On the other hand, the porcupine (*Hystrix*) is currently extinct in Spain, whereas it survives in Italy, the north of Africa, and in the Middle East. According to van Weers (2005), the Pleistocene *H. (Acanthion) vinogradovi* is considered to be a synonym of the extant *H. (A). brachyura.* Unfortunately, in the Cova del Gegant, *Hystrix* is represented by only four teeth, although we can compare them with several isolated teeth that are scattered across the middle and late Pleistocene of Spain. A comparison of the length of the two fourth premolars in our specimens with the data of van Weers (2005) for *H. refossa*, *H. brachyura,* and *H. vinogradovi*; the data of Cuenca-Bescós et al. (1999) for the *H. vinogradovi* of Galería (Atapuerca); and the compilation of Montoya (1993) for *H. cristata*; shows that the *Hystrix* of Cova del Gegant are similar in length to that in *Hystrix (A) vinogradovi* and to the extant species *H. (A). brachyura* (Fig. 3). Due to the scarcity of the remains from Cova del Gegant, we consider our specimen to be *H. (A).* cf. *brachyura vinogradovi.*

The first appearance datum (FAD) of *Iberomys cabrerae* in the Iberian Peninsula is from level 5 of Camino (Pinilla del Valle), dated by TL to around 90.961 ±7.881 ka, while the last appearance datum (LAD) of *Hystrix vinogradovi* is from level 3 of Cueva de la Buena Pinta (Pinilla del Valle), dated by OSL to around 63.451 ±5.509 ka (Arsuaga et al., in press). These data suggest that level III should be younger than 90 ka and level I older than 60 ka. Thus, if the small mammal fauna can be considered indicative of the age of the hominin occupation of Cova del Gegant, then this would limit the age of the occupation to between MIS5 and MIS4.

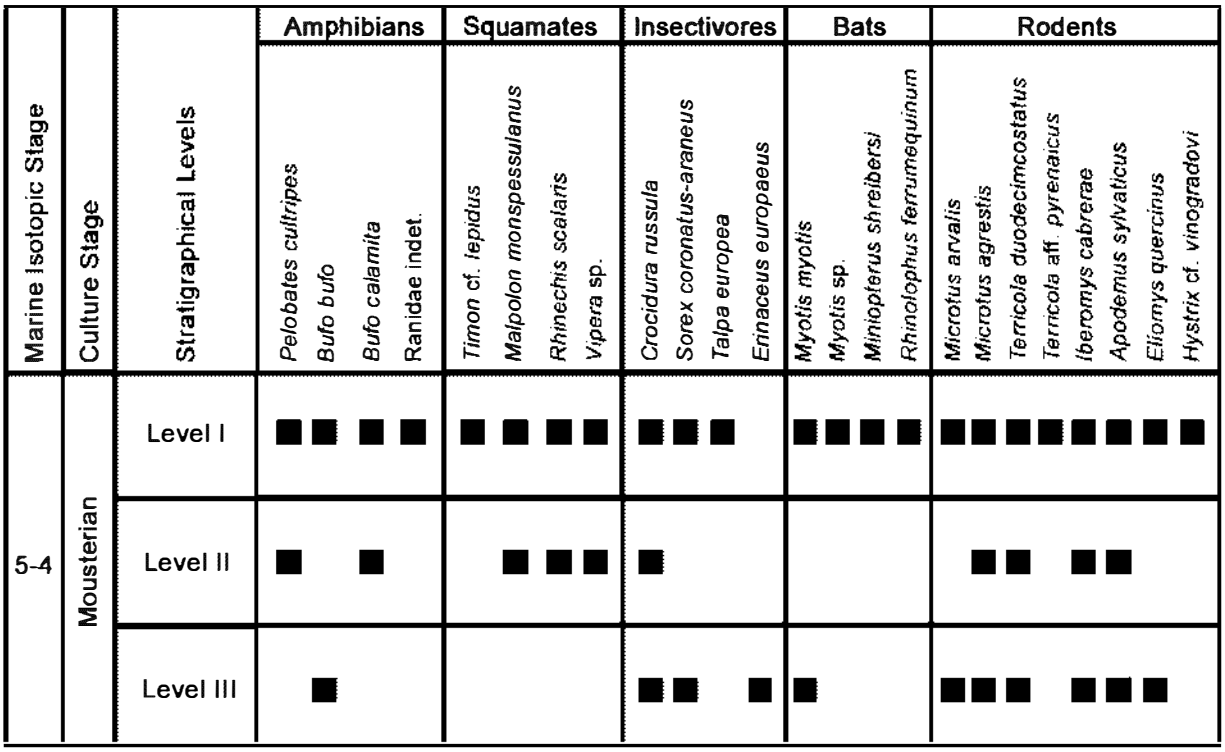

Fig. 2. Distribution of the small-vertebrates from the Cova del Gegant excavations of the 1970's by species and level.

Palaeoenvironmental and palaeoclimatic reconstruction

During MIS5b-a and MIS4 (ca. 90–60 ka), the climate is thought to have been rapidly fluctuating and harsher than the present day (Sánchez-Goñi and d'Errico, 2005). During this unstable period, the sea level was around 25–75 metres lower than at present (Chappell and Shackleton, 1986); therefore, the coast line was roughly 4–12 km further away (Fig. 1). This landscape might have provided a large

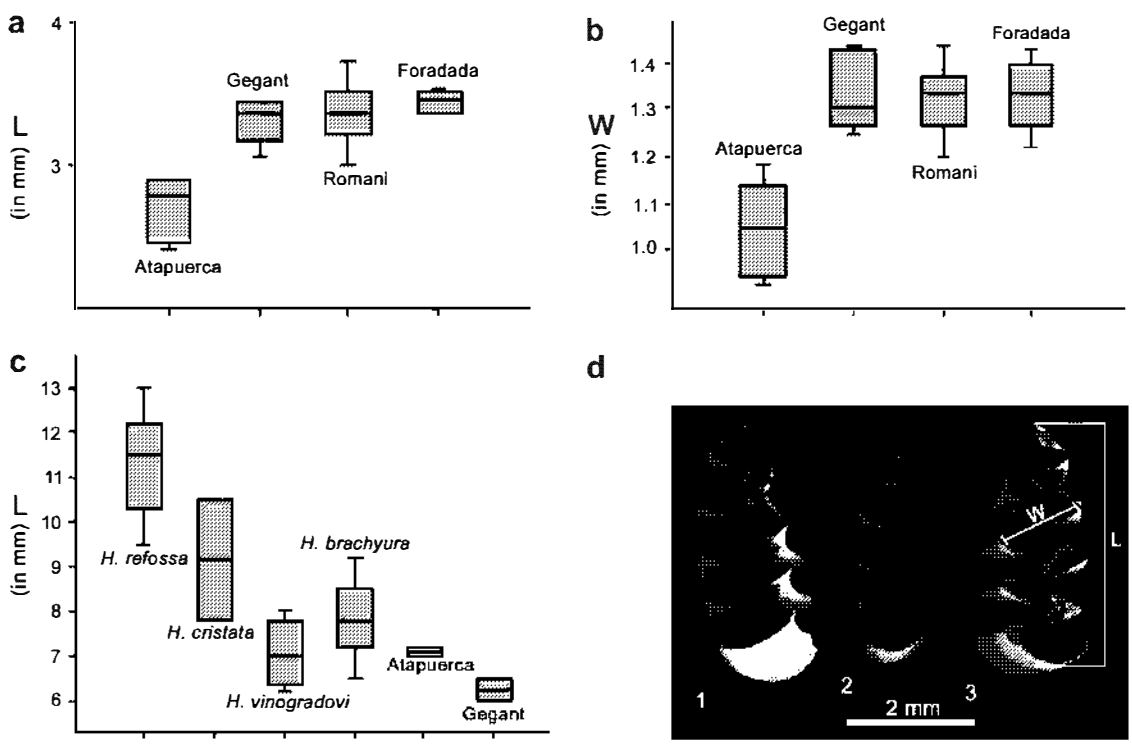

Fig. 3. a-b: Comparison of the length (up-left) and width (up-right) of the first lower molars (M_1) of *Iberomys cabrerae*, from the Cova del Gegant (n = 7), with the *Iberomys cabrerae*, from the Abric Romaní (n = 27) and Cova Foradada (n = 5), and with *Iberomys brecciensis*, from the middle Pleistocene of Atapuerca Galeria (n = 9; Cuenca-Bescós et al., 1999). c: Comparison of the length of the two fourth premolars of *H. (A).* cf. *brachyura vinogradovi*, from the Cova del Gegant, with *Hystrix refossa* (n = 5), *Hystrix vinogradovi* (n = 4), *Hystrix brachyura* (n = 5; van Weers, 2005), *Hystrix cristata* (n = 2; Montoya, 1993), and *Hystrix vinogradovi* from the middle Pleistocene of Atapuerca-Galeria (n = 2; Cuenca-Bescós et al., 1999). Measures are taken in mm. d: Right (1–2) and left (3) first lower molar (M_1) of *Iberomys cabrerae* from the Cova del Gegant. Pictures are taken at ×35 magnifications.

coastal plain in front of the entrance to the cave, with a richer terrestrial ecosystem than presently available.

Taphonomy might have influenced the components of the small-vertebrate assemblage. Following the analytic methods in taphonomy provided by Andrews (1990), owls in particular may have been responsible for the accumulation of the microvertebrate remains. Being that this type of predator is often considered opportunistic, their prey should be representative of fauna in the immediate environment (Pokines, 1998). In support of this, it seems likely based on taphonomic bias that is not visible (mainly digestion evidence), that the owl species responsible for the assemblage was a category 1 nocturnal bird of prey (sensu Andrews, 1990). Such birds which are known to be opportunistic predators. From another standpoint, the fossil remains of bats and porcupines, known to frequent caves, should accumulate from an in-situ mortality rather than predator activity.

The small-vertebrate assemblage of Cova del Gegant is dominated by taxa linked to woodland edges (Mediterranean forest), such as *Apodemus sylvaticus*, *Eliomys quercinus*, and *Hystrix (A)* cf. *brachyura vinogradovi*. Nevertheless, *Terricola duodecimcostatus*, *Microtus arvalis*, *Erinaceus europaeus*, *Crocidura russula*, *Pelobates cultripes*, and the squamates in general, prefer open environments. The association of *Iberomys cabrerae*, *Microtus agrestis*, *Sorex coronatus-araneus*, and *Talpa europaea* (not currently present in the Garraf), indicates wetter conditions than today, although *Pelobates cultripes* and *Rhinechis scalaris* are indicators of dry Mediterranean environments. The intersection of the present distribution of all the fossil species that occur at a locality may point to ancient climatic conditions (Blain, 2005).

In order to evaluate palaeoclimatic parameters, we use the principle of mutual climatic range that consists of defining the climatic conditions of the area currently inhabited by the extant fauna from the site. The porcupine, which has no extant representatives in the Iberian Peninsula, has been excluded, although it is considered in the final interpretation. In the Cova del Gegant, this method gives a total of three 10×10 km UTM squares situated in the external Sierras of the Pyrenees in Huesca. Such an intersection for the Cova del Gegant suggests mean annual temperatures (recent data are from Font Tullot, 2000) lower than at present ($MAT_{Gegant} = 10 \pm 2.6$ °C, minimum = 6 °C, maximum = 10.5 °C; at present MAT = 15.3 °C at the meteorological station of Barcelona airport, located along the sea nearly 30 km to the north of the cave) and mean annual precipitation higher than at present ($MAP_{Gegant} = 850 \pm 150$ mm, min. = 700 mm, max. = 1000 mm; at present MAP = 659 mm at Barcelona airport). The mean temperature of the coldest month (MTC) for the Cova del Gegant is equal to 2.6 ± 0.7 °C (max. = 3.5 °C, min. = 2 °C; at present 8.8 °C at Barcelona airport), and for the warmest month (MTW) it is equal to 20.1 ± 1 °C (max. = 21 °C, min. = 19 °C; at present 23.0 °C at Barcelona airport). This suggests that when Neanderthals lived in the cave the temperatures were lower (−2.7 °C) than at present in the Catalan coastal area, with temperate summers (−1.7 °C) and harsher winters (−5.3 °C), maintaining the Mediterranean character of the climate. Taking into account the presence of the porcupine, the climate should be slightly wetter than today, probably the rainfall was slightly higher than at present in the studied area.

Assuming the association between the cave micro and macrofauna, we can sketch the Neanderthal occupation as occurring at the beginning of the late Pleistocene, during a period of strong degradation of the climate. The strategic location of the Massis del Garraf may have had a strong attraction for hominins because it provided a large number of caves located near one of the large mammal migration routes between the south (Spanish Levant corridor), the west (Ebro River corridor), and the south of France. The presence and proximity of the sea, acting as a great reservoir of heat during the cold periods, may have ameliorated climatic fluctuations in the area. Moreover, the Cova del Gegant was probably a privileged, raised-observation hide on the plain between the cave and the sea. And so Neanderthals may have had a look at the large variety of food resources provided by this diversified landscape, such as rhinoceroses, aurochs, horses, red deer, and wild boar, while the proximity of mountainous areas was favorable to the presence of Spanish ibex. The southern and eastward location of the cave entrance would have permitted the sun to warm the cave starting at first light.

Conclusions

The Cova del Gegant is considered an important site for our knowledge of the evolution of the Neanderthals during the first half of the Upper Pleistocene in Spain, because at the moment it is the only locality in Catalonia where hominids may be found in association with Middle Palaeolithic stone tools and faunal remains. Based on the micromammals, the age of the locality ranges between the end of MIS 5 and the beginning of MIS 4 (ca. 60–90 ka), which we infer is also the age of the large mammal fauna and the hominin occupation of the site.

The landscape surrounding the cave was favourable to the sustainability of Neanderthal existence, for it appears to have been a Mediterranean forest more humid than today, with open areas of a probably drier condition. The area maintained a Mediterranean character with temperatures (MAT − 2.7 °C) that were probably lower and precipitation that was higher (+ 350 mm) than in the Catalan coastal area today.

Acknowledgments

We want to thank Dr. Julio Gómez Alba, curator of the Museu de Geologia de Barcelona, for permitting the study of the material in his care; Dr. Jordi Agustí (ICREA-IPHES, Tarragona); Dr. Bienvenido Martínez-Navarro (ICREA-IPHES, Tarragona); and M.A. Galindo-Pellicena (UCM-ISCIII, Madrid) for their aid during the elaboration of this paper. We are also grateful to Susan Antón, Peter Andrews, and an anonymous reviewer for their comments that strongly improved this manuscript. Juan Manuel López-García is the beneficiary of a predoctoral research fellowship from the "Generalitat de Catalunya," aid financed by the European Social Fund. This paper is part of the projects PO BOS 2003-8938, DGI CGL 2006-13532-C03-01-02 and CGL2006-4548/BTE.

References

Alférez Delgado, F., 1985. Dos molares humanos procedentes del yacimiento del Pleistoceno Medio de Pinilla del Valle (Madrid). Trabajos de Antropología XIX (4). Resúmenes IV Congreso Español de Antropología Biológica. Barcelona.

Andrews, P., 1990. Owls, Caves and Fossils. Natural History Museum, London.

Arsuaga, J.L., Baquedano, E., Pérez-González, A, in press. Neanderthal and carnivore occupations in Pinilla del Valle sites (Community of Madrid, Spain). In: XV UISPP Proceeding Congress. Lisboa.

Arsuaga, J.L., Bermúdez de Castro, J.M., 1984. Estudio de los restos humanos del yacimiento de la Cova del Fossal de la Font (Villafamés, Castellón). Cuadernos de Prehistoria y Arqueología Castellonenses 10, 19–34.

Arsuaga, J.L., Villaverde, V., Quam, R., Martínez, I., Carretero, J.M., Lorenzo, C., Gracia, A., 2007. New Neanderthal remains from Cova Negra (Valencia, Spain). J. Hum. Evol. 52, 31–58.

Ayarzagüena, J., López Martínez, N., 1976. Estudio filogenético y comparativo de *Microtus cabrerae* y *Microtus brecciensis*. Doñana Acta Vertebrata 3 (2), 181–204.

Blain, H.-A., 2005. Contribution de la paléoherpétofaune (Amphibia and Squamata) à la connaissance de l'évolution du climat et du paysage du Pliocène supérieur au Pléistocène moyen d'Espagne. Ph. D. Dissertation. Muséum National d'Histoire Naturelle de Paris, Institut de Paléontologie Humaine.

Blain, H.-A., Bailon, S., 2006. Catalogue of Spanish Plio-Pleistocene amphibians and squamate reptiles from the Museu de Geologia de Barcelona. Treballs del Museu de Geologia de Barcelona 14, 61–80.

Casanova, S., 2004–2005. Historia del hallazgo de la "mandíbula de Neanderthal" de las cuevas de Sitges. Batalleria 12.

Chappell, J., Shackleton, N.J., 1986. Oxygen isotopes and sea level. Nature 324, 137–140.

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, 202–218.

Cuenca-Bescós, G., Canudo, J.I., Laplana, C., 1999. Análisis bioestratigráfico del Pleistoceno medio del yacimiento de Galería (Sierra de Atapuerca, Burgos). In: Carbonell, E., Rosas, A., Díez, J.C. (Eds.), Atapuerca: Ocupaciones humanas y paleoecología del yacimiento de Galería. Junta de Castilla y León, Burgos, pp. 189–210.

Daura, J., Sanz, M., Subirá, M.E., Quam, R., Fullola, J.M., Arsuaga, J.M., 2005. A Neanderthal mandible from the Cova del Gegant (Sitges, Barcelona, Spain). J. Hum. Evol. 49, 56–70.

Font Tullot, I., 2000. Climatología de España y Portugal. Universidad de Salamanca, Salamanca.

Grün, R., Maroto, J., Eggins, S., Stringer, C., Robertson, S., Taylor, L., Mortimer, G., McCulloch, M., 2006. ESR and U-series analysis of enamel and dentine fragments of the Banyoles mandible. J. Hum. Evol. 50, 347–358.

López-García, J.M., Agustí, J., Cuenca-Bescós, G., 2007. Catalogue of the Late Quaternary Iberian micromammals (Rodentia, Eulipothypla, Chiroptera) from the Museu de Geologia de Barcelona. Treballs del Museu de Geologia de Barcelona 15, 5–23.

Martínez, J., Miret, J., Mora, R., Muro, I., 1985. Excavacions a la Cova del Gegant. Butlleti del grup d'estudis sitgetans IX, 32–33.

Masriera González, A., 1975. Observaciones sedimentológicas sobre el depósito cuaternario de la Cova del Gegant (Sitges, Barcelona). Speleon I, 35–38.

Mir, A., 1975. La industria litica de la cova del Gegant. Barcelona. Speleon I, 39–49.

Montes, L., Utrilla, P., Hedges, R., 2000. Le passage Paléolithique Moyen-Paléolithique Supérieur dans la Vallée de l'Ebre (Espagne). Datations radiométriques des grottes de Peña Miel et Gabasa. Les premiers hommes modernes de la Péninsule Ibérique. Actes du Colloque de la Commission VIII de l'UISPP, 87–102.

Montoya, P., 1993. The porcupine *Hystrix suevica* Schlosser, 1884 from the Lower Turolian of Crevillente 2 (Spain). Scripta Geol. 103, 135–149.

Pokines, J.T., 1998. The paleoecology of lower Magdalenian Cantabrian Spain. BAR International Series 713, 1–189.

Quam, R., Arsuaga, J.L., Bermúdez de Castro, J.M., Díez, J.C., Lorenzo, C., Carretero, J.M., García, N., Ortega, A.I., 2001. Human remains from Valdegoba Cave (Huérmeces, Burgos, Spain). J. Hum. Evol. 41, 385–435.

Rosas, A., Martínez-Maza, C., Bastir, M., García-Tabernero, A., Lalueza-Fox, C., Huguet, R., Ortiz, J.E., Julià, R., Soler, V., de Torres, T., Martínez, E., Cañaveras, J.C., Sánchez-Moral, S., Cuezva, S., Lario, J., Santamaría, D., 2006. Paleobiology and comparative morphology of a late Neanderthal sample from El Sidrón, Asturias, Spain. Proc. Natl. Acad. Sci. U.S.A. 103 (51), 19266–19271.

Sánchez-Goñi, M.F., d'Errico, F., 2005. La historia de la vegetación y el clima del último ciclo climático (OIS5-OIS1, 140.000-10.000 años BP) en la Península Ibérica y su posible impacto sobre los grupos paleolíticos. Museo de Altamira Monografías 20, 115–129.

Viñas, R., Villalta, J.F., 1975. El depósito cuaternario de la "Cova del Gegant". Speleon I, 19–33.

VVAA, 2004. Carta nàutica de Catalunya 1:50.000. Vilanova i la Geltrú - Costes del Garraf. Institut Cartogràfic de Catalunya, Barcelona.

van Weers, D.J., 2005. A taxonomic revision of the Pleistocene *Hystrix* (Hystricidae, Rodentia) from Eurasia with notes on the evolution of the family. Contrib. Zool. 74 (3/4), 301–312.