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The gastropod fauna of the Epipalaeolithic shell midden in the Vestibulo chamber of Nerja Cave (Málaga, southern Spain)

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ABSTRACT

The sedimentary record of the Vestíbulo, Mina and Torca chambers in the ancient entrance of Nerja Cave (Málaga, southern Spain) developed between around 30 and 3.6 ka cal BP. The long record of human occupation shows a dominance of terrestrial snails associated with the Gravettian, with a continuation of these types in the Solutrean when marine shells begin to be introduced. During the Magdalenian, marine bivalves are dominant. Marine molluscs reach a maximum during the Epipalaeolithic, giving rise to a shell midden formed primarily by *Mytilus edulis* and diverse species of *Patella*. The Epipalaeolithic shell midden occurs in Unit 4 and can be dated to the Pleistocene–Holocene boundary. This paper focuses on the terrestrial, marine and freshwater gastropods present in the Epipalaeolithic. Among these remains were specimens carried in by humans for both food and ornamental purposes. Others were introduced accidentally by humans, and finally, other specimens entered the cave by natural processes.

1. Introduction

Nerja Cave is located at the southern end of the Iberian Peninsula in Málaga province (Fig. 1). The external chambers of the cave (Torca, Mina and Vestíbulo) contain an archaeological record dated between 30 and 3.6 ka cal BP. The molluscs recovered during the archaeological excavations directed by Francisco Jordá Cerdá were studied between 1979 and 1986. They came from the Mina chamber (campaigns of 1979, 1980 and 1981) and the Vestíbulo chamber where only a 1 m square test unit (C-4) was excavated (campaigns of 1982, 1983 and 1984) (Jordá Pardo, 1981, 1982, 1983, 1984–85, 1986; González-Tablas et al., 1984; Jordá Cerdá et al., 1987, Aura et al., 1993; Jordá Pardo et al., 2003). Later, other researchers studied the molluscs from the excavations of Manuel Pellicer Catalán (La Mina and La Torca chambers; see Serrano et al., 1995, 1997, 1998) and Ana M. de la Quadra Salcedo (Vestíbulo chamber; see Lozano-Francisco et al., 2003, 2004; Vera et al., 2003), with results similar to ours.

This paper presents the results from the study of gastropods in the Epipalaeolithic Unit (NV.4) recovered during excavations in the Vestíbulo chamber by Francisco Jordá Cerdá between 1983 and 1987 (Fig. 1.3). Not presented here are the previously published materials from the C-4 test unit, which were studied using a different methodology. While this paper places an emphasis on the gastropods at Nerja Cave, shorter analyses including some of the data used here have been published previously in Jordá Pardo and Aura Tortosa (2009), and in Jordá et al. (2010).

2. Geological, stratigraphic and archaeological framework of Nerja Cave

Nerja Cave is located on the Mediterranean coast of southern Spain (Fig. 1.1), 1 km from the current coastline (UTM 30S VF26, $x = 424.695$, $y = 4.069.025$) at 158 m on the SW slope of the Almijara Sierra. The cave is formed in Triassic dolomitic marbles of the upper unit of the Almijara Nappe (Alpujarride Complex, Betic Range) (Sanz de Galdeano, 1993). A few meters south of the cave entrance, the Pleistocene alluvial fan of Maro extends to the sea (Guerra-Merchán and Serrano, 1993; Guerra-Merchán et al., 1999; Jordá Pardo, 2004). The inner area of the cave and its deposits has been intensively studied (Durán et al., 1993, 1998).

The galleries near the palaeo-entrance of Nerja Cave (Torca, Mina and Vestíbulo chambers) contain an important archaeological sequence of deposits dating from end of the Pleistocene and the greater part of the Holocene (Fig. 2). Different aspects of this

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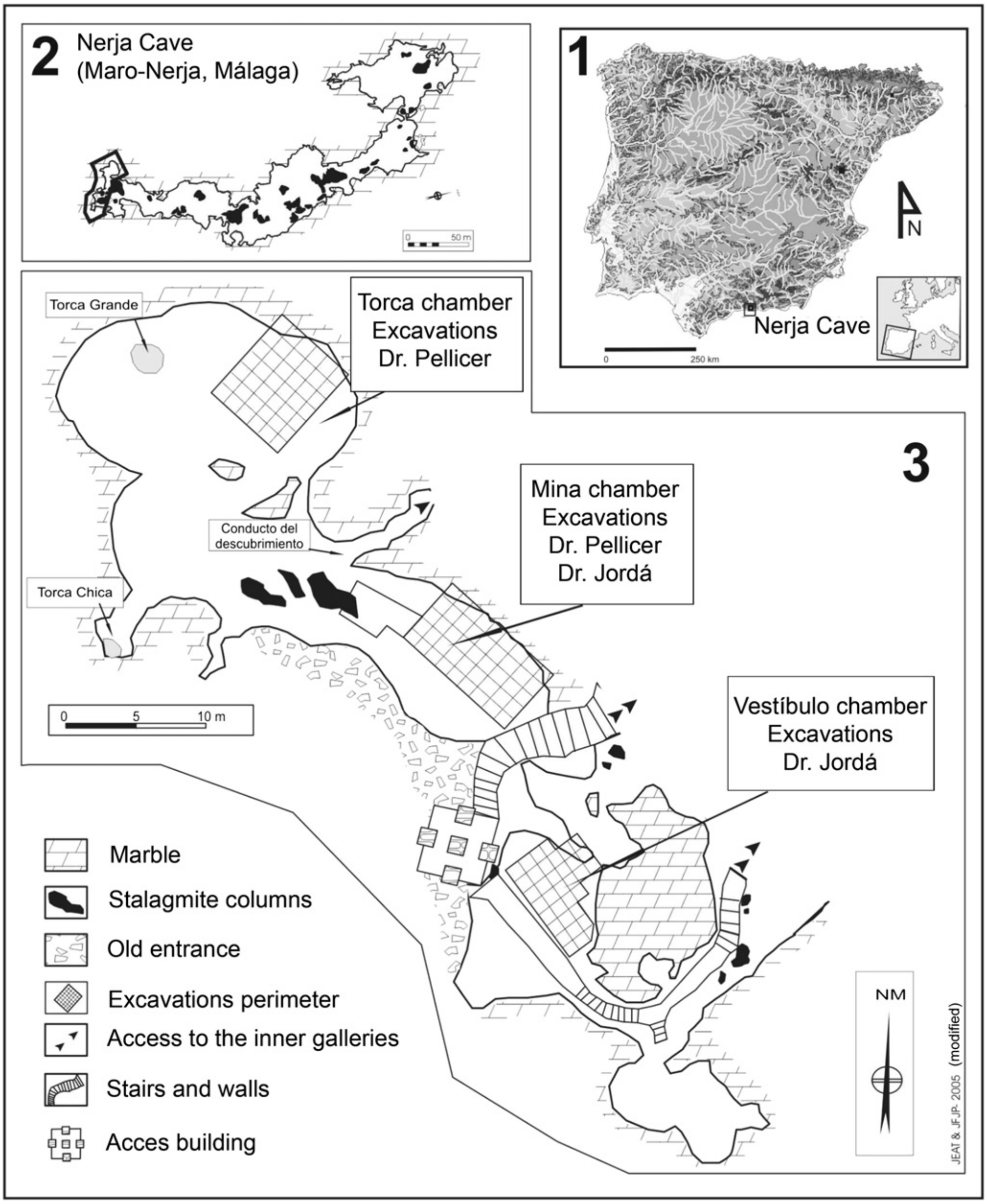

Fig. 1. Geographical location of Nerja Cave and position of the Vestíbulo chamber into the cave.

sequence have been discussed in numerous publications (for a full list see Aura et al., 2010). The synthetic stratigraphic sequence was constructed by correlating the lithostratigraphic and archaeological sequences of the Mina and Vestíbulo chambers (Fig. 2). Twelve stages of sedimentation and erosion (Nerja 1 to 12) belong to seven lithostratigraphic units, separated by five discontinuities (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009).

The stratigraphic sequence starts with the lower levels of the Vestíbulo chamber (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009), which constitute Unit 1 (Nerja 1) which rests on a thick speleothem. Three ^{14}C dates for this unit (Jordá Pardo and Aura Tortosa, 2009), place it between 30,180 and 28,580 years cal BP (Fig. 3). This is a stage of cold character that is correlated with the end of MIS 3a, coincident with the end of Heinrich Event 3 (H3), and including stadial GS 5 and interstadial GI 4. During Nerja 1, the sea surface temperatures (SST) in the adjacent waters of the Alborán Sea (AS) ranged from 10° to 14 °C (Cacho et al., 2001), with a decrease of 10 °C – the minimum for the entire sequence of Nerja Cave – during the last cold episode of MIS 3a (Fig. 3). Unit 1 contains evidence for Gravettian occupations, which becomes more abundant higher up. In the basal section (NV13), coprolites are attributed to *Crocuta crocuta spelaea* which indicate the absence of humans at the beginning of the sedimentary record in the Vestíbulo chamber (Arribas Herrera et al., 2004). The sequence continues in this chamber with a stratigraphic hiatus (Nerja 2), estimated between 1000 and 2700 years in length, and generated by an erosive process (Jordá Pardo et al., 1990). This hiatus separates Unit 1 from Unit 2, and can be related to interstadial GI 3 and the beginning of stadial GS 3 (Aura Tortosa et al., 2006).

After this hiatus, a new sedimentary episode occurs in the Vestíbulo chamber. This is Unit 2 (Jordá Pardo et al., 1990) (Fig. 2), which was deposited during Nerja 3. Unit 2 dates between 25,810 and 18,930 cal BP, a period of cold but not extreme temperatures, with AS SST of 12/13 °C (Cacho et al., 2001) (Fig. 3). According to Aura Tortosa et al., (2006), the sediments of the two lower levels of this unit (NV10 and NV9), would be situated in the cold stadial GS 3.

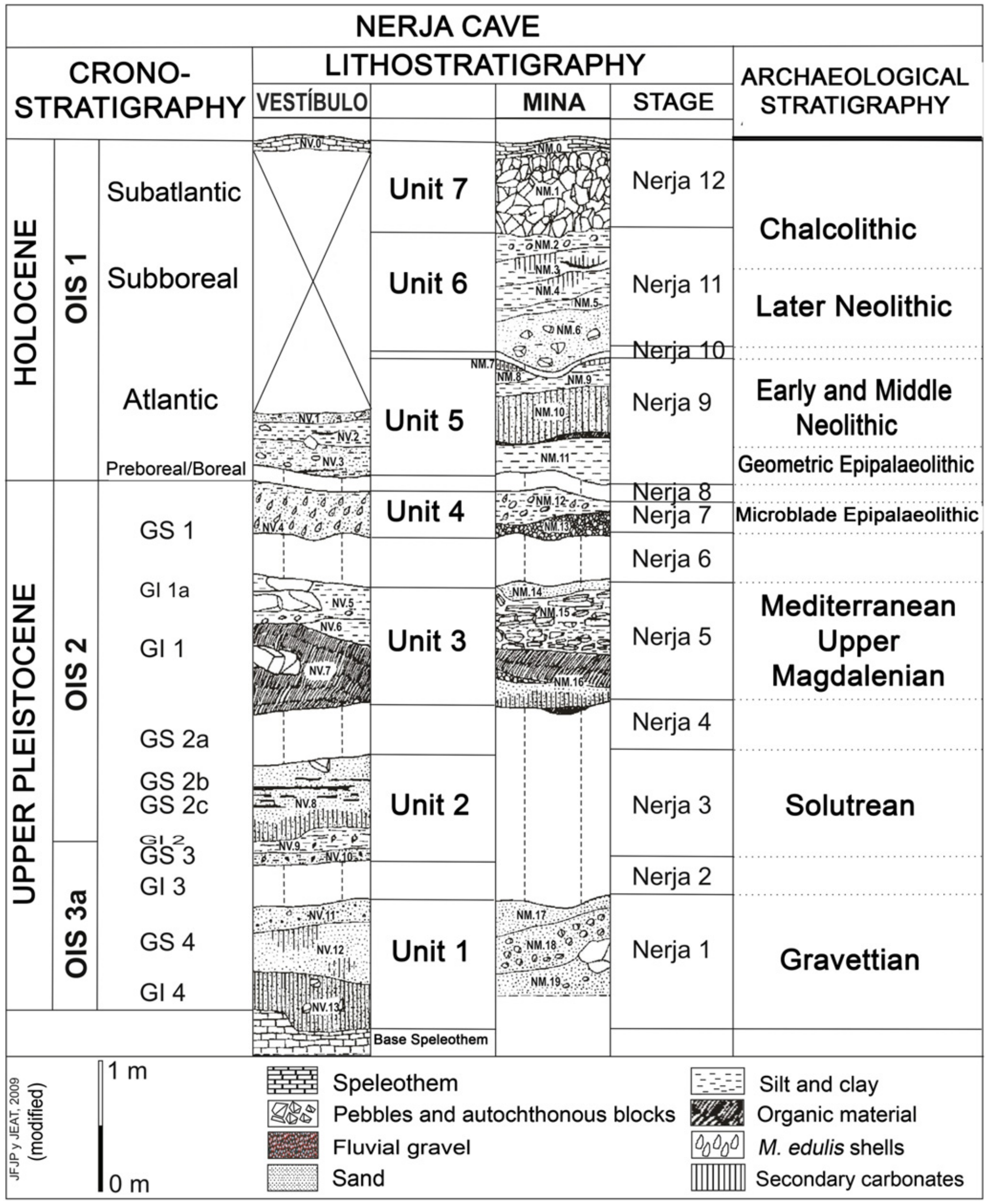

Fig. 2. Nerja Cave: lithostratography, archaeological stratigraphy and chronostratigraphy of the sedimentary sequences of Vestíbulo and Mina chambers.

Above this, the stratigraphic analysis shows an erosional contact between NV9 and NV8, whereas sedimentological analysis indicates that the formation of NV8 took place in a slightly cold and wet climate with a tendency towards aridity in the upper levels (Aura Tortosa et al., 2006). This hiatus within Unit 2 can be correlated with GI 2, while the upper section of Unit 2 can be correlated with GS 2c. The archaeological materials in this unit belong to the Solutrean. The sequence continues with a new stratigraphic hiatus (Nerja 4) produced by erosional processes and a possible absence of sedimentation (Jordá Pardo et al., 1990), for a maximum of 4000 years. This hiatus belongs to a cold pulse at the beginning of stadial GS 2a when AS SST were around 10 °C (Cacho et al., 2001) (Fig. 3).

The next sedimentary stage (Unit 3, Nerja 5) (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009), present in the Vestíbulo, Mina and Torca chambers, dates between 14,860 and 13,570 cal BP (Fig. 2). This stage coincides with interstadial GI 1, which precedes the climatic downturn in stadial GS 1 (Younger Dryas). Level NM15, which is characterized by cryoclastic debris of marble detritus, is one of the coldest moments of the Nerja sequence and can be correlated with the cold episode GI 1b or Intra-Alleröd Cold Period (IACP). This short period coincides with AS SST of around 12/14 °C (Cacho et al., 2001) (Fig. 3). These colder characteristics are verified by the existence of open herbal vegetation (Badal, 2001) and the presence of avian species adapted to cold environments (Eastham, 1986). Nerja 5 ends with the deposition of levels NM14 and NV5 (Jordá Pardo et al., 1990), of temperate characteristics, during episode GI 1a. Nerja 5 contains a human occupation of Mediterranean Upper Magdalenian.

A fluvial erosional stage (Nerja 6) removed about 600 years of the sedimentary record in the Vestíbulo and Mina chambers and was followed by a new depositional stage (Unit 4, Nerja 7) characterized by a considerable amount of *Mytilus edulis* shells in the Vestíbulo sequence (Fig. 2). This deposit is a genuine shell midden of anthropic origin (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009). It contains fauna of very cold waters, such as the North-Atlantic bivalve *Pecten maximus*, and fish species of the

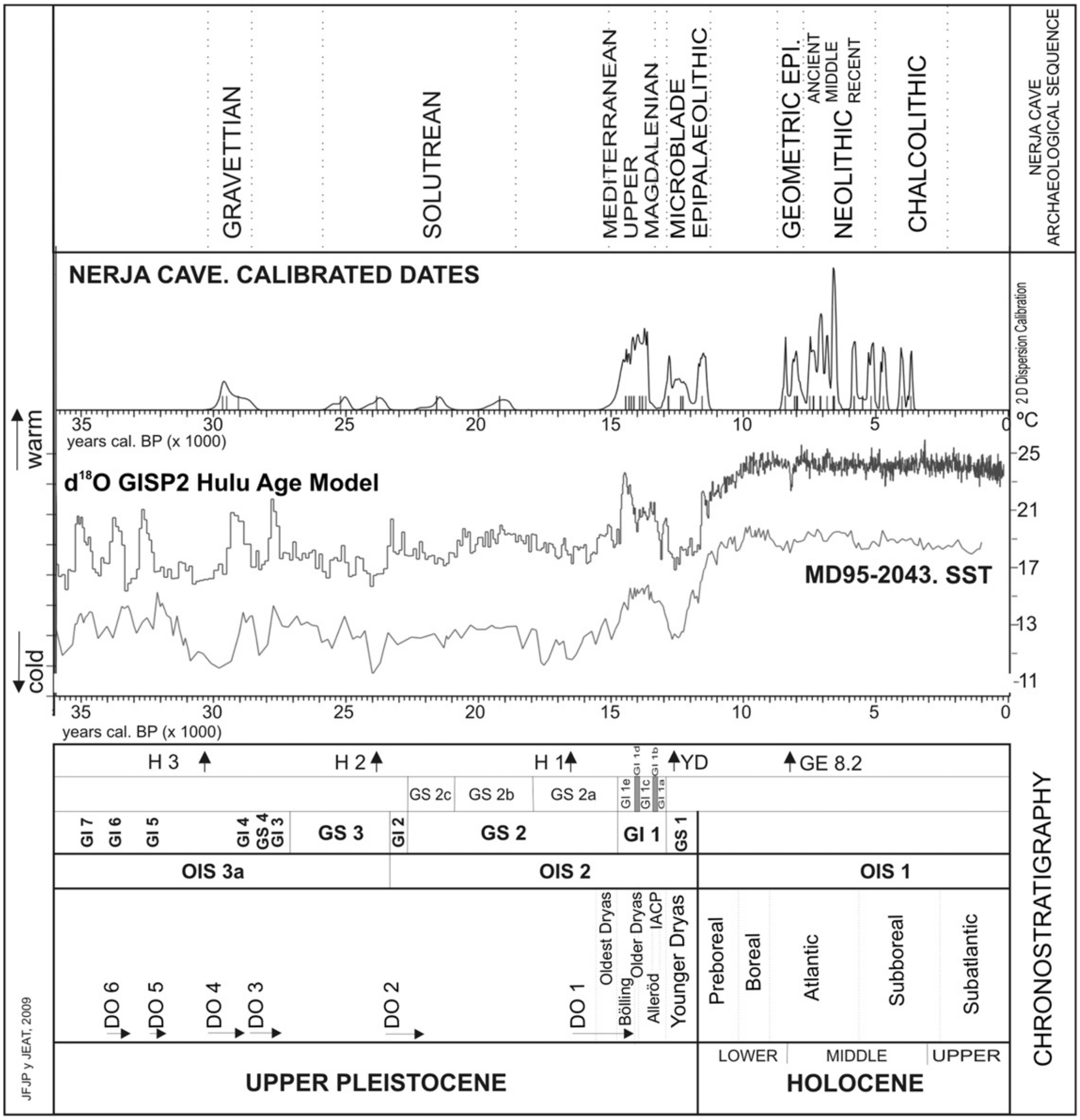

Fig. 3. Chronological and palaeoclimatological interpretation of the Nerja Cave archaeological deposits, using the cumulative probability curve of the valid radiocarbon dates calibrated with CalPal 2007 Hulu curve (CalPal june 2007; Weninger et al., 2010) and the high resolution palaeoclimatological proxies $\delta^{18}O$ GISP2 Hulu Age Model (Grootes et al., 1993; Meese et al., 1994; Wang et al., 2001) and SST MD95-2043 (Cacho et al., 2001).

Gadidae family, currently found on the Norwegian coast, such as *Melanogrammus aeglefinus* and *Pollachius pollachius*, and the extinct auk *Pinguinus impennis*. This was a species more usually found in the North Atlantic Ocean during historical epochs (Aura Tortosa et al., 2002). This sedimentary stage dates between 12,980 and 11,360 cal BP, a time period that coincides with GS 1 (Younger Dryas). The end of this stage is followed by the initial cold periods at the beginning of the Holocene. At these times the AS SST decreased to a minimum of 12 °C (Cacho et al., 2001) (Fig. 3). Unit 4 has human occupation of the Mediterranean Microblade Epipalaeolithic and belongs to Pleistocene–Holocene transition, bearing in mind the recent definition of the latter's limit (Walker et al., 2008). A new erosive phase cut these deposits and generated another stratigraphic hiatus (Nerja 8) (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009) of 4430 years that ends with the 8.2 cold event (Weninger et al., 2006).

The sequence continues with the sedimentation of Unit 5 (Nerja 9) (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009) with scarce remains of a Mesolithic occupation dated between 8550 and 7950 cal BP (Fig. 2), during the thermal maximum at the beginning of the Atlantic, when AS SST were around 18/19 °C (Cacho et al., 2001) (Fig. 3). From this period, sedimentation continues in the three chambers with only minimum interruption of deposition. The sequence continues upwards with levels that contain Early and Middle Neolithic finds dated between 8190 and 6940 cal BP, which belong to upper sections of Nerja 9 (Unit 5) (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009) (Fig. 2). These levels correspond to the middle-upper part of the Atlantic chronozone, with AS SST of around 19°/20 °C (Fig. 3). In the Mina sequence there is an erosive break (Nerja 10) followed by the deposition of Unit 6 (Nerja 11), with an occupation of the Recent Neolithic, dating between 6900 and 5060 cal BP, at the start of the Subboreal, when AS SST were around 19.5/18.5 °C (Fig. 3). Above this unit, Chalcolithic levels are found; in the Torca chamber they date to about 4830–3600 cal BP in the Subboreal, with AS SST of around 19°/19,5 °C (Fig. 3). Unit 7 overlies these deposits in the Mina chamber and probably in the Vestíbulo.

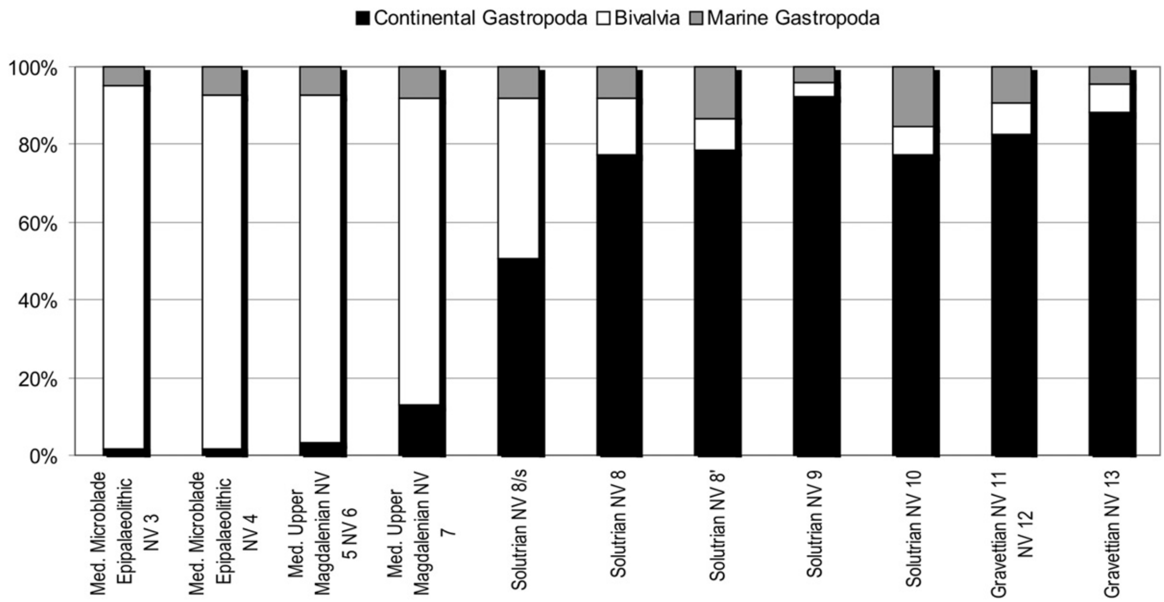

Fig. 4. Distribution of the molluscs of the archaeological levels of Vestíbulo chamber of Nerja Cave expressed in percentage of specimens by m^3 of sediments.

It comprises a breccia overlain by a speleothem (Nerja 12) (Jordá Pardo et al., 1990; Jordá Pardo and Aura Tortosa, 2009) (Fig. 2), developed at the end of the Subboreal or the start of Subatlantic (Upper Holocene), during a new cool pulse, when AS SST were around 18°/19 °C (Fig. 3).

3. Materials and methods

The malacological collection of the Vestíbulo chamber was recovered directly during the excavation; all the deposits were washed and selected by sizes through a triple sieve (10 mm, 5 mm and 2 mm), and later sorted. The invertebrate remains were further sorted in the laboratory, where the molluscs were separated from the rest of the invertebrates. The mollusc assemblage was packed in cardboard trays and every tray was identified with contextual information. The molluscs of the Vestibulo chamber constitute an extraordinary collection, composed of more than 136,000 specimens that weigh over 78 kg. More than 120,000 of these specimens (65 kg) originate from an Epipalaeolithic shell midden. The complete collection stored in the Provincial Museum of Malaga was studied (Jordá et al., 2010).

Specific identification of molluscs, as well as for information on ecology and distribution, used a variety of references on both marine molluscs (Malatesta, 1963, 1974; Nordsieck, 1968, 1969; Cox et al., 1969–1972; Ghisotti and Melone, 1975; Parenzan, 1976; Luque, 1984; Riedl, 1986; D'Angelo and Gargiullo, 1978; Poppe and Goto, 1991, 1993; Lindner, 2000; Mexía Unzurrunzaga, 2000) and continental ones (Macan, 1969; Gasull, 1971; Madurga, 1973; Kerney et al., 1983; Fechter and Falkner, 1993; Ruiz Ruiz et al., 2006). The systematics of Bruschi et al. (1985), Lindner (2000), and online sources such as NatureServe (2008), Hardy's Internet Guide to Marine Gastropods (2005) and Fauna Ibérica (2008) and the Check List of European Marine Mollusca (CLEMAM) were followed.

All the data were recorded in a database containing the following fields: location data, list of taxa recognized in every excavation unit, recognized elements and ecological characteristics of every taxon. The location data contains the information of the archaeological context: site (Nerja Cave), chamber (Vestíbulo), year of excavation (1983, 1984, 1985, 1986, 1987), excavation grid (of one square meter) or sets of portions of several grids, stratigraphic level (NV1 an NV13, except NV11) and operative levels (from a to z). The complete list of taxa is composed of 12 continental snails, 34 marine snails, 36 marine bivalves, three scaphopods and one cephalopod. The recognized elements of every taxon include complete specimens, complete specimens with perforation, complete valve, identified fragments, unidentified fragments and others. This information was used to calculate the total number of remains (RN) and the minimum number of individuals (MNI), for both the snails and the bivalves, expressed in number and in weight. The MNI of the snails was obtained by the addition of the entire specimens with the major numeric value of the different identified fragments (apical extremes, aperture fragments, columela and siphon channel). The MNI of the bivalves was obtained by the addition of complete valves and articular extremes of valves divided by two. The MNI of the scaphopods was obtained by the addition of the entire specimens and the different fragments. The MNI of cephalopods is difficult to calculate as fragments are not identifiable as unique parts of the shell; in addition, usually, there was only one fragment in the excavation unit, and so for every set of remains in a unit of excavation, and therefore the MNI is one.

During the excavations by Jordá Cerdá in the Vestíbulo chamber, a series of tests from the excavations by Quadra Salcedo were reopened. As a result, the excavated areas of each unit have different surfaces. This differential excavation suggests that the volume of excavated sediment changes very much from one level to another: 1.83 m^3 of the Gravettian levels, 3.94 m^3 of the Solutrean levels, 1.22 m^3 of the Magdalenian levels and 2.45 m^3 of the Epipalaeolithic ones. Due to the difference of excavated volume in each level and in order to compare the content of molluscs from the different levels, this content was calculated for unit of volume (m^3), and obtained comparable values. The excavated surface of the Epipalaeolithic level includes 5 m^2 (grids C-3, D-3, D-4, D-5 and D-6) and a small test of the earlier excavations.

In relation to the archaeological levels, study included all those excavated in the Vestíbulo chamber by Jordá Cerdá: from NV13 to NV 1. The vertical distribution of the molluscs in the Vestíbulo archaeological record shows that during the Gravettian period, terrestrial snails are dominant and continue to dominate in the Solutrean levels but that marine snails begin to be introduced. During the Magdalenian marine bivalves are dominant. Marine molluscs reach

Table 1
Molluscs of the Epipalaeolithic shell midden of the Vestíbulo chamber of Nerja Cave (RM, remains number; MNI, minimum number of individuals).

	RN	% RN	MNI	% MNI	WEIGHT (g)	% WEIGHT
Continental gastropods	1932	1.6046	1925	3.1357	1802.6	2.7894
Marine gastropods	2865	2.3795	1906	3.1048	3770.5	5.8346
Bivalves	115,605	96.0143	57,556	93.7562	59,049.25	91.3753
Cephalopods	2	0.0017	2	0.0033	0.40	0.0006
Total	120,404		61,389		64,622.75	

a maximum during the Epipalaeolithic, giving rise to a shell midden formed primarily by *M. edulis* and several species of *Patella*. The variation of the percentage of specimens by m^3 is shown in Fig. 4. This paper considers only the archaeomalacological collection of Unit 4 (level NV.4, Epipalaeolithic) with special emphasis on the gastropods.

4. Gastropods of the unit 4 shell midden

4.1. Quantitative and qualitative analysis

The Epipalaeolithic shell midden that constitutes Unit 4 (level NV.4) in the Vestíbulo chamber has a maximum thickness of 1 m and tabular geometry. It lies on an erosive surface, so its lower boundary is irregular; its upper boundary has been eroded. The top of this sedimentary unit was disturbed by a series of pits, excavated from the overlying Neolithic levels, which are filled by sediments with a mixture of Epipalaeolithic and Neolithic material. The archaeological materials of Unit 4 have been assigned to the Epi-Magdalenian (Aura Tortosa, 1995: 176–178), an epipalaeolithic techno-complex that retains the Magdalenian tool-kit traditions, but without bone harpoons. In this occupation, features of the lithic technology shared with others from more northern regions of Iberia can be recognized, such as triangles, double-backed points and pieces with a curved back. Another artefact type found in Malaga coastal Epipalaeolithic sites are the group of macrolithic industries with worked and shaped pebbles which are associated with fine bone points, considered to be fishing gorges (Aura Tortosa and Jardón Giner, 2006).

The 2.45 m^3 excavated in the shell midden has provided 120,404 remains of molluscs whose weight is 64.6 kg (Table 1). Marine bivalves are the main constituents with 115,605 shell remains weighing 59 kg and giving an MNI of 57,556. The bivalves represent the 96% of the shell midden remains equivalent to 91% of its weight. The gastropods are represented by 4797 remains, equivalent to 5.6 kg. There are 2865 marine gastropods (3.8 kg) and 1932 terrestrial and fresh water snails (1.8 kg). The gastropods are a small part of the shell midden: 4% of total remains and 8.6% of total weight. The MNI is 1906 for the marine gastropods and 1925 for the terrestrial and fresh water snails. Cephalopods are rare, with two remains (0.4 gr) of inner shells. In addition, there were 168 remains (radioles, plates and plate fragments) of the echinoid *Paracentrotus lividus* (Villalba Currás et al., 2007) and some remains of crustaceans including *Balanus balanoides*, *Thamalus* sp., *Cancer pagurus*, *Eriphia spinifrons*, and *Pachygrapsus* sp., which are currently under study by Álvarez-Fernández (Álvarez-Fernández, personal communication).

From a qualitative point of view, the bivalves are represented by 21 taxa: 10 have been identified to species, six to genus, four to family and one to class. The marine gastropods are represented by 24 taxa: 17 identified to species, four to genus, two to family and one to class. There are eight identified taxa of continental snails, with seven species and one genus. The cephalopods are represented only by a genus (*Sepia* sp.).

Table 2
Marine gastropods of the Epipalaeolithic shell midden of the Vestíbulo chamber of Nerja Cave (RM, remains number; MNI, minimum number of individuals).

TAXA	RN	% RN	MNI	% MNI	WEIGHT (g)	% WEIGHT
Fissurellidae indet.	1	0.03	1	0.05	0.40	0.01
Patella nigra	1	0.03	1	0.05	8.60	0.23
P. caerulea	440	15.37	425	22.32	740.80	19.67
P. intermedia	459	16.03	449	23.58	1311.60	34.82
P. ulyssisponensis	3	0.10	3	0.16	5.00	0.13
P. vulgata	1	0.03	1	0.05	5.60	0.15
P. rustica	5	0.17	5	0.26	28.00	0.74
Patella sp.	867	30.28	506	26.58	771.80	20.49
Monodonta turbinata	24	0.84	9	0.47	26.40	0.70
Monodonta articulada	1	0.03		0.00	0.40	0.01
Monodonta sp.	13	0.45		0.00	6.00	0.16
Gibbula richardi	15	0.52	8	0.42	9.40	0.25
Gibbula sp.	1	0.03		0.00	0.20	0.01
Trochidae *indet.*	6	0.21	2	0.11	4.80	0.13
Trivia arctica	6	0.21	5	0.26	1.20	0.03
Trivia pulex	1	0.03	1	0.05	0.20	0.01
Trivia sp.	1	0.03		0.00	0.20	0.01
Nucella lapillus	785	27.42	271	14.23	769.80	20.44
Stramonita haemastoma	15	0.52	2	0.11	29.00	0.77
Columbella rustica	3	0.10	3	0.16	3.00	0.08
Cyclope neritea	31	1.08	29	1.52	5.80	0.15
Conus mediterraneus	2	0.07	2	0.10	4.00	0.11
Nassarius reticulatus	1	0.03	1	0.05	1.00	0.03
Gastropoda indet.	182	6.36	181	9.51	35.70	0.95
Total	**2864**		**1905**		**3768.90**	

Limpets dominate the marine gastropods (Table 2). They are represented by six species which all belong to the genus *Patella*. Limpets are represented by 1776 remains or 62% of whole marine gastropods, equivalent to 76% of weight, and 1390 individuals, equivalent to 73% of the gastropod MNI. The predominant species are *Patella caerulea* and *Patella intermedia*, with 25% of remains of all the limpets; their MNI is around 30/32% of all limpets, with 425 and 449 individuals respectively. The other limpets are less frequent with around 1%, both in RN and MNI and in weight. Finally, the identified remains of *Patella* sp. are 49% of RN and 36% of MNI, equivalent to 27% in weight.

Another species of marine snail well represented at the shell midden is *Nucella lapillus*, with 785 RN (27.42% of gastropods and 20.44% in weight) and 271 MNI (14.23% of MNI). The remaining taxa (Fissurellidae indet., *Monodonta turbinata*, *M. articulata*, *Monodonta* sp., *Gibbula richardi*, *Gibbula* sp., Trochidae indet., *Trivia arctica*, *Trivia pulex*, *Trivia* sp., *Stramonita haemastoma*, *Columbella rustica* and *Nassarius reticulatus*) have frequencies lower than 1% in RN, MNI and weight, with the exception of *Cyclope neritea* which is present at around 1% both in RN and MNI (Table 2). There is also a small group of unidentified gastropods (currently under study) which account for 6.36% of the number of remains and 9.51% of the MNI.

Among continental gastropods (Table 3), *Iberus alonensis* dominates with 1805 for both RN and MNI, or about 93.77% in each

Table 3
Continental gastropods of the Epipalaeolithic shell midden of the Vestíbulo chamber of Nerja Cave (RM, remains number; MNI, minimum number of individuals).

TAXA	RN	% RN	MNI	% MNI	WEIGHT (g)	% WEIGHT
Melanopsis laevigata	76	3.93	71	3.688	7.30	0.40
Melanopsis sp.	3	0.16	3	0.156	0.60	0.03
Theodoxus fluviatilis	17	0.88	17	0.883	3.40	0.19
Rumina decollata	8	0.41	7	0.364	1.50	0.08
Sphinterochilla cariosula hispanica	2	0.10	2	0.104	0.80	0.04
Iberus alonensis	1805	93.43	1805	93.77	1783.60	98.95
I. marmoratus	9	0.47	8	0.416	3.60	0.20
Helicella unifasciata	12	0.62	12	0.623	1.80	0.10
Total	**1932**		**1925**		**1802.60**	

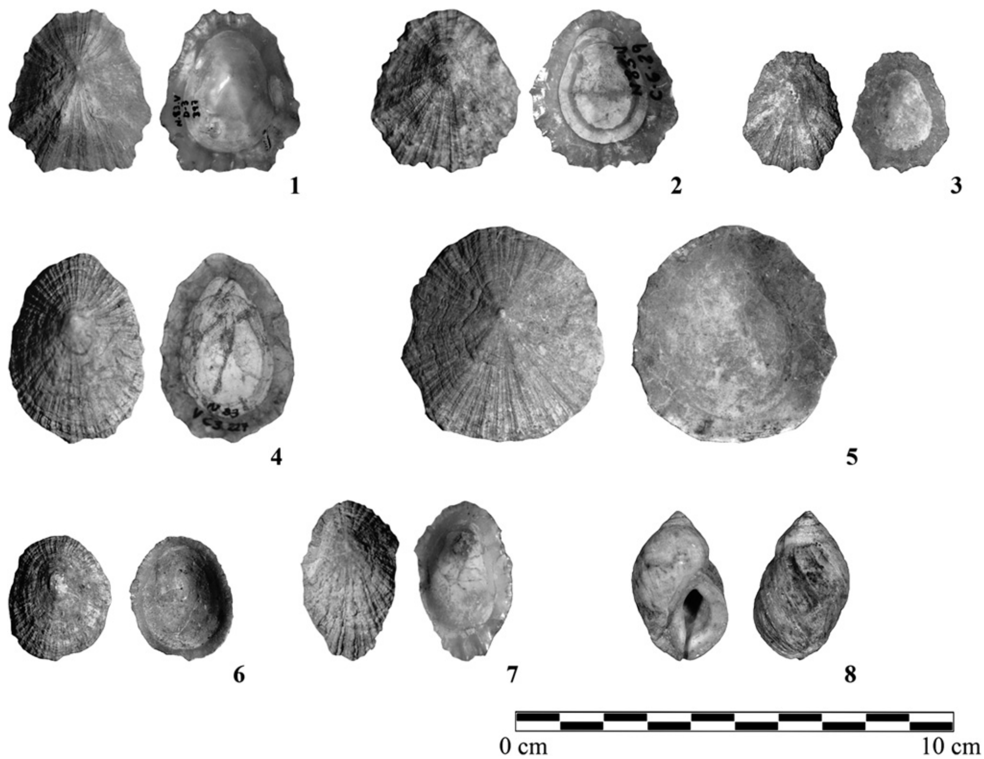

Fig. 5. Marine gastropods of Vestíbulo chamber of Nerja Cave: 1–3, *Patella caerulea*; 4, *P. intermedia*; 5, *P. nigra*; 6, *P. rustica*; 7, *P. ulyssiponensis*, 8, *Nucella lapillus*.

instance, and its weight is almost 98.95% of the continental gastropods. Another snail of this family, *Iberus marmoratus*, is scarcely represented – 9 RN and 8 MNI. *Melanopsis laevigata* and *Melanopsis* sp. are represented by 79 RN, which corresponds to 74 MNI, with a percentage close to 4%. The rest of the continental snails (*Theodoxus fluviatilis*, *Rumina decollata*, *Sphinterochilla cariosula hispanica* and *Helicella unifasciata*) are present in the shell midden with percentages less than 1%, in RN, MNI and weight.

4.2. Ecology of the gastropods

All marine gastropods of the Vestíbulo shell midden are common in the littoral zone with benthic habitats (epifaunal). The majority of species live on rocky substratum such as cliffs, marine abrasion platforms and reefs, although some of them live over a muddy and sandy substratum, algal bottom or grasslands of *Posidonia*. All the taxa are mobile except limpets which live fixed to the rocky substratum with a vertical distribution that ranges from the supralittoral zone to the foreshore and some species can reach depths of 50 m. The majority of the taxa prefer turbulent water of normal salinity with temperate and warm temperatures. *Conus mediterraneus* is common in calm and temperate-warm waters of normal salinity and lives on rocky and algal bottoms, in reef areas between 0 and 10 m depth. *C. neritea* and *N. reticulatus* live on sandy and muddy bottoms of estuaries and tidal flats, with calm and temperate-warm waters. *C. neritea* is common in briny waters. The majority of species are common to the Atlantic and the Mediterranean; *P. intermedia*, *P. ulyssisponensis*, *P. vulgata* and *N. lapillus* are exclusive to Atlantic waters, while *G. richardi* and *T. pulex* are exclusive to Mediterranean ones.

The continental gastropods are divided into two groups: freshwater and terrestrial. The freshwater snails are *M. laevigata*, *Melanopsis* sp. and *T. fluviatilis*, found in both fluvial and lacustrine environments. *M. laevigata* lives on rocky and vegetal substrata,-while *T. fluviatilis* is frequent on detritic bottoms. The rest of the

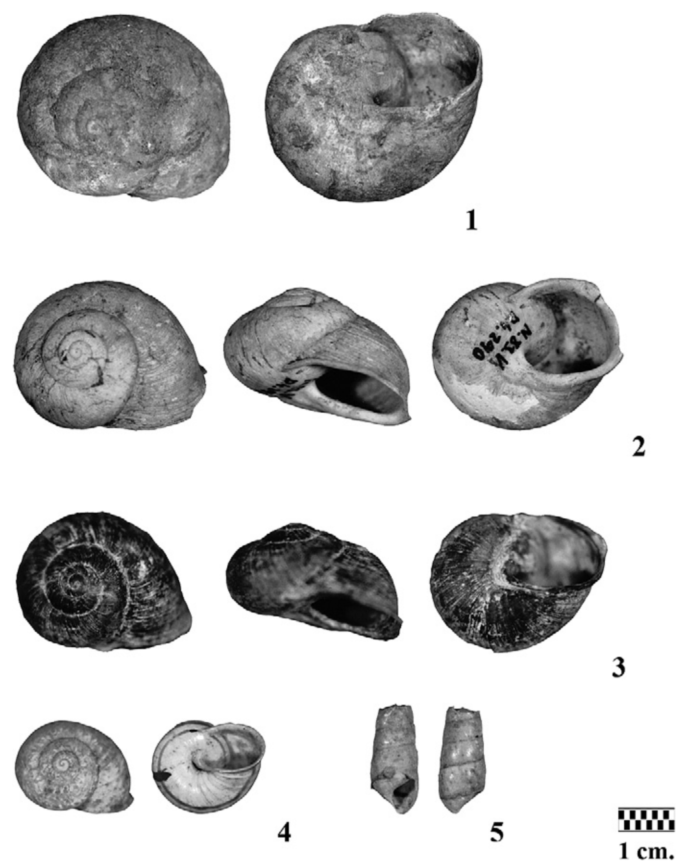

Fig. 6. Continental gastropods of Vestíbulo chamber of Nerja Cave: 1–3, *Iberus alonensis*; 4, *Iberus marmoratus*; 5, *Rumina decollata*.

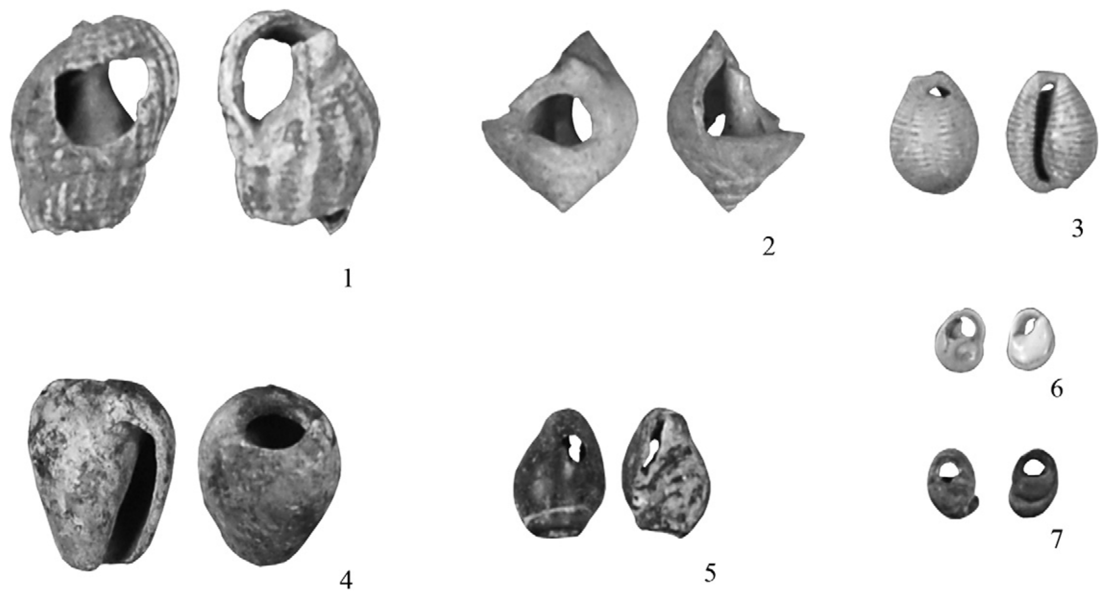

Fig. 7. Epipalaeolithic personal ornaments from Nerja Cave made on gastropods: 1, *Nassarius reticulates*; 2, *Nucella lapillus*; 3, *Trivia arctica*; 4, *Conus mediterraneus*; 5, *Columbella rustica*; 6, *Cyclope pellucida*; 7, *Theodoxus fluviatilis*.

continental snails are terrestrial. *R. decollata* lives on limestone rocky substratum in karst areas; *I. alonensis* and *I. marmoratus* are common on detritic and rocky substrata; finally *Sphinterochilla cariosula hispanica* and *Helicella unifasciata* live in edaphic environments. All the continental gastropods are common in the Mediterranean region.

4.3. Origin and human use of the gastropods

The accumulation of gastropods in the Unit 4 shell midden is due to a combination of cultural and natural processes. All the marine gastropods and most of the continental snails were introduced by the Epipalaeolithic inhabitants of the cave either intentionally (as food and as raw material for manufacturing personal ornaments), or accidentally, along with other molluscs or with other natural materials (seaweed, algae, branches and grass, etc). In addition, some of the terrestrial snails are characteristic of karst environments and their habitats include the external zones of caves.

Among the gastropods used by humans as food, limpets (Fig. 5) stand out, especially *P. caerulea* with 425 MNI and *P. intermedia* with 449 MNI. Of the specimens represented only 6% of *P. caerulea*, are burned, but the figures are greater for *P. intermedia* (25%) and *Patella* sp. (10%). It is possible that the burned specimens were subjected intentionally to direct heat, but they may also have been thrown into the fire accidentally. The high frequency of limpets in the shell midden indicates that they were collected and eaten intensively by the Epipalaeolitic inhabitants. The bromatological interest of limpets has been observed in other Upper Palaeolithic and Mesolithic sites on the Cantabrian coast of Spain (González and Clark, 2004; Ávarez Fernández, 2005; Gutiérrez Zugasti, 2009). Other species of marine gastropods with potential use as food are the snails of the Trochidae family, among which are *M. turbinata* and *G. richardi*, each with less than 10 individuals, suggesting only occasional consumption. A marine snail well-represented in the shell midden is *N. lapillus* (Fig. 5), some of which appear to have been perforated for use as ornaments. However, the abundance of these snails without drilling and very well preserved (without signs of water and sand erosion) suggests a possible use as food. They may also have been introduced accidentally by humans, given that they live in association with mussels which are present in thousands in the midden.

Another gastropod used as food is the terrestrial snail *I. alonensis* (Fig. 6), represented by 1805 specimens of which 20% are burned. Many of these (80% of MNI), burned and unburned, are only represented by the spire apex. It is possible that the last spire of these snails was removed to facilitate the extraction of the edible flesh. *I. marmoratus* could also be part of the diet, but its MNI is very small.

The gastropods include specimens used as raw material for the production of body ornaments (Fig. 7). Epipalaeolithic shell ornaments total over 60 specimens, and are made almost entirely from nine species of gastropods, all marine except for the freshwater gastropod *T. fluviatilis* that appears throughout the sequence. *C. neritea* also appears throughout the sequence, but it is in the Epipalaeolithic levels where other species such as *T. arctica* and *T. pulex* begin to dominate and species that characterize these deposits have a stronger pattern of Mediterranean origin, especially *C. mediterraneus* and *C. rustica*. *Nucella lapillus, N. reticulatus* and an undetermined marine gastropod are also found in the form of Epipalaeolithic personal ornaments.

Scarce individuals and fragments of *S. haemastoma* in the midden were, without doubt, introduced into the cave by humans, but for the moment the purpose is unknown. Finally, the presence of a single specimen of Fisurellidae indicates that its presence at the cave is accidental; it might have been introduced with the limpets who occupy a similar habitat.

R. decollata is the only karst habitat continental gastropod present in the midden (Fig. 6). Therefore, its presence in the cave is likely to be due to natural processes. Other continental snails were probably introduced accidentally by human activities: for example, *M. laevigata* and *Melanopsis* sp. could have been attached to algae and weeds from the banks of rivers and lakes; *Sphinterochilla cariosula hispanica* and *Helicella unifasciata*, whose presence in the midden is very limited (2 and 12 MNI respectively), could have been brought in with grass or branches of shrubs.

5. Conclusions

Unit 4 of the Vestíbulo chamber at Nerja Cave is formed by an anthropogenic accumulation of mollusc shells, the overwhelming majority of which are *M. edulis*. This accumulation of shells constitutes one of the largest shell middens of this age in the Mediterranean watershed of Iberian Peninsula. Others components are marine and continental gastropods whose study is the subject of this paper.

The majority of the gastropods in this shell midden were introduced by humans, except for a small number of taxa whose presence can be explained by entirely natural processes. Among the marine gastropods, the limpets (especially *P. caerulea* and *P. intermedia*) which were collected by humans as food, stand out. Other marine gastropods were used as raw material for personal ornaments; many of these snails are perforated. The marine gastropods used as personal ornaments are: *C. neritea*, *T. arctica*, *T. pulex*, *C. mediterraneus*, *C. rustica*, *Nucella lapillus, N. reticulatus* and an undetermined species. Among the continental snails, *I. alonensis* is the predominant species used as food and *T. fluviatilis* is the only continental gastropod used as personal ornament. Some terrestrial snails, such as *R. decollata*, are common to karst areas.

The abundance of limpets together with the huge amount of mussels indicates that during the Epipalaeolithic the coast near the cave was characterized by rocky cliffs and marine abrasion platforms. However, there are also species indicative of estuaries and tidal flats. The majority of gastropods are typical of temperate and warm waters and currently live in the Mediterranean, but there are some species that today live in the Atlantic, such as *P. intermedia*, *P. ulyssisponensis*, *P. vulgata* and *N. lapillus*. This is interesting because Unit 4 has other species of bivalves, fish and marine birds characteristic of cold waters, such as *P. maximus*, *M. aeglefinus* and the Great Auk (*Pinguinus impennis)*.

The radiocarbon chronology of the shell midden indicates a date between 12,980 and 11,360 cal BP, so it accumulated during the last cold period of the Upper Pleistocene: GS 1 or the Younger Dryas stadial. At this time, cold waters from the Atlantic entered the Alborán Sea through the Gibraltar Strait, allowing the colonization of the southern coast of Iberia by cold character marine species (Aura Tortosa et al., 2002; Jordá Pardo et al., 2003). In this period, the SST of the Alborán Sea was at a minimum of 12 °C (Cacho et al., 2001).

The shell midden in the Vestíbulo chamber of Nerja Cave is the southernmost deposit with these characteristics on the Iberian Peninsula. The quality and quantity of information that it contains has allowed analysis of one of the most important archaeological records of the Pleistocene–Holocene transition in the Western Mediterranean. Future research will aid in understanding other aspects such as the energy evaluation of molluscs in the diet of the inhabitants of Nerja Cave or the responses of molluscs to the heavy exploitation by humans.

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