



# A Taphonomic Perspective on Neolithic Beginnings: Theory, Interpretation, and Empirical Data in the Western Mediterranean

Joan Bernabeu Auban

*Departament de Prehistòria i Arqueologia, Universitat de València, Blasco Ibáñez, 28, 46010—València, Spain*

C. Michael Barton

*Department of Anthropology, Arizona State University, PO Box 872402, Tempe, AZ 85287-2402, U.S.A.*

Manuel Pérez Ripoll

*Departament de Prehistòria i Arqueologia, Universitat de València, Blasco Ibáñez, 28, 46010—València, Spain*

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The fills of caves and rockshelters generally comprise complex depositional palimpsests, making fine scale chronological resolution extremely difficult. Nevertheless, these settings remain very important in archaeology because they often preserve long records of cultural change. This is true for the initial appearance of food producing economies in the western Mediterranean. The chronologically ambiguous nature of cave and shelter deposits is one of the reasons for the continued debate over the processes responsible for the beginning of the Neolithic in this region. We employ taphonomic studies of the archeofaunal record from Mesolithic and early Neolithic cave and shelter sites in Mediterranean Spain to disentangle some of the formation processes affecting relevant deposits in order to better understand the processes of cultural change that led to the spread of agricultural communities. © 2001 Academic Press

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## Introduction

**B**ecause they are sediment traps in which artifact-bearing deposits can accumulate over long periods of time, caves and rockshelters have been the focus of archaeological investigation since the inception of the discipline (Barton & Clark, 1993; Straus, 1990). This characteristic has made them invaluable for recording long-term patterns of prehistoric social change. Nonetheless, as geoarchaeological and taphonomic studies have accumulated for cave and shelter deposits, and the artifacts they incorporate, it has become increasingly apparent that the interpretation of assemblages from these contexts is often problematic.

Although artifact assemblages from discrete stratigraphic units have long been interpreted as accumulating during the occupation of a locale by a discrete social group for a single season or for a short sequence of closely spaced occupations, there is a growing

recognition that this is the case rarely if at all (Barton & Clark, 1993; Barton & Neeley, 1996; Colcutt, 1979; Dibble *et al.*, 1997; Jelinek, 1976). Rather, assemblages are likely palimpsests of repeated occupations of diverse length, separated by varying time spans, and representing intervals of varying but often multi-generational length—even in carefully controlled excavations. “Living floors” in such contexts are more a product of archaeological practice than prehistoric behaviour patterns.

Given the frequent inability of cave and rockshelter deposits to provide archaeologists with a series of superimposed snapshots of past society, they are of less use for detailing the process of social change than they are for preserving a record of the long-term results of change. In spite of these potential uncertainties about the depositional integrity of cave and shelter deposits, they still commonly serve as the basis for inferences about the processes of social change. In many areas of the world, these locales remain by far the best known

type of site for most of the prehistoric past. Even where more open-air localities are known, difficulties in the application and interpretation of numerical dating techniques for contexts older than the last few millennia often make it impossible to develop reliable chronological frameworks with sufficiently fine resolution to address the processes of social change. Such is the case for the western Mediterranean in the Early Holocene. This period marks a series of profound and far-reaching socioeconomic changes that transformed specialized, mobile hunter-gather societies of the terminal Pleistocene into sedentary agropastoral villagers. In spite of recent research focusing on regional organization and open-air contexts (Barton *et al.*, 1999; Barton *et al.*, 2002; Bernabeu *et al.*, 1999), the relevant data for this period is still overwhelmingly derived from caves and rockshelters.

In the light of the concerns outlined above, what is needed to make better use of these data for modelling social dynamics are ways to evaluate the depositional integrity of these cave and shelter sites and, in turn, the reliability of the archaeological record they contain. More careful sedimentological studies can certainly be helpful, but often do not reveal the short-term and small scale formation processes that can have major impacts on the character of archaeological assemblages (Barton & Clark, 1993; Butzer, 1982: 77–87; Colcutt, 1979). An alternative and promising approach is to model taphonomic processes responsible for the accumulation of cultural materials from the formal and distributional properties of the materials themselves (e.g., Dibble *et al.*, 1997; Villa, 1982) (see also Barton *et al.*, 2002; Paddayya & Petraglia, 1993, for examples of this approach on landscapes). This taphonomic approach is the one we take here.

## Background

We focus especially on the period of *c.* 8000–5000 BP, when foraging economies were largely replaced by ones dependent on domestic plants and animals across the western Mediterranean. In this region there has been a longstanding debate over the relative importance of population movement, information movement, and indigenous development in this economic transition (e.g., Ammerman, 1989; Ammerman & Cavalli-Sforza, 1984; Barker, 1985; Bernabeu, 1996; Bernabeu, 1997; Bernabeu, Aura & Badal, 1993; Lewthwaite, 1986; Renfrew, 1987; Vicent, 1997; Zilhao, 1993; Zvelebil, 1986; Zvelebil & Zvelebil, 1988). The more extreme positions of this debate have sometimes been termed “migrationist” and “indigenist” (Lewthwaite, 1986; Vicent, 1997; Zvelebil, Green & Machlin, 1992).

Recently, the migrationist–indigenist debate has come to focus more on the nature of the empirical databases on which each model has been developed—almost exclusively derived from cave and shelter

deposits. In terms of the archaeological record, both migrationist and indigenist models postulate that material evidence of the transition to food producing economies is distributed time-transgressively at regional scales. That is, Neolithic material culture should appear in an east–west chronological gradient as farming peoples (for migrationists) or information about the agropastoral way of life (for indigenists) spread across the western Mediterranean. These models differ, however, in their expectations about the archaeological record at the scale of individual sites.

Because migrationist models postulate that groups of immigrant farmers were responsible for the spread of agropastoral systems, Neolithic technoeconomic elements (e.g., Cardial ware ceramics, marginally retouched bladelets, bones of domestic ovicaprids, domestic cereals and pulses, etc.) are expected to appear abruptly in archaeological sequences and to co-occur as a coherent package in assemblages at individual sites (Bernabeu, 1996; Zilhao, 1993; see also Bernabeu, 1997). A hallmark of the earliest of these immigrant farming populations, between *c.* 6800 and 5800 BP, is the widespread occurrence of Cardial ware ceramics, which migrationists assert should be associated with the initial appearance of a complete Neolithic “package” of material culture. This is followed by Epicardial ceramics throughout western Mediterranean, and subsequently by the development regional ceramic styles (dominated by plainwares) in the Late Neolithic.

Indigenist models, on the other hand, postulate that information responsible for production and ultimate deposition of these same Neolithic elements diffused independently for each element, meaning that they may not consistently co-occur in the archaeological record (Lewthwaite, 1986; Vicent, 1997). The complete Neolithic “package” of material culture, then, should appear time-transgressively within individual sites as indigenous foragers adopted different aspects of an agropastoral way of life over the course of a transition period.

Given these expectations, it has been argued recently (e.g., Guilaine *et al.*, 1993; Pallarés, Bordas & Mora, 1997) that indigenist, rather than migrationist, expectations about Neolithic material culture are more closely matched by assemblages from a series cave and shelter sites in the Mediterranean regions of France and Spain. Specifically, it has been suggested that ceramics, domestic animals, and agriculture do not consistently co-occur in the archaeological record at these sites. Also, the radiocarbon dates and stylistic sequence for the initial occurrence of ceramics are not consistent with the migrationist model. The initial ceramic horizons in a majority of these caves are dominated by Epicardial wares. These ceramics occur earlier, both stratigraphically and in terms of radiocarbon dates, than expected by migrationist models that situate Epicardial styles after the initial appearance of ceramics (i.e., Cardial wares).

**Table 1** summarizes the stratigraphy,  $^{14}\text{C}$  dates, archaeological contexts, and associated domestic resources for assemblages from many of these sites (see also **Figure 1**). The obvious first impression is one of considerable diversity. The Andalucian caves of Nerja and Dehesilla (Acosta & Pellicer, 1990; Pellicer & Acosta, 1986) show an Early Neolithic with non-Cardial ware ceramics and domestic animals. (There is currently no reliable evidence for domestic plants.) The associated radiocarbon chronology is erratic, however. Dates for the Early Neolithic vary from 11,500 to 6200 BP, and Middle Neolithic dates vary from 9900 to 3120 BP. While pre-ceramic deposits have been recognized at Nerja, this is not the case at Dehesilla where all excavated layers contain ceramics (Acosta & Pellicer, 1990). However, the lower deposits at Dehesilla also contain lithic forms such as backed bladelets that are temporally limited to pre-Neolithic contexts elsewhere in the western Mediterranean, suggesting an as yet unrecognized earlier occupation at the site (Zilhao, 1993). Preliminary reports from other cave sites in western Andalucia (Pellicer & Acosta, 1982) seem to indicate depositional circumstances similar to the Dehesilla case.

In the central Mediterranean region of Spain, Fosca (Olaria, 1988) and Verdelpino (Moure & Fernandez Miranda, 1976) offer disparate archaeological assemblages in spite of similar dates. Dated at 7950 BP, the Verdelpino assemblage includes plainware ceramics (normally considered Late Neolithic) but lacks evidence of domesticate plants or animals; the Fosca assemblage, with a date of 7600 BP, includes epicardial ceramics and rare remains of domestic ovicaprids.

In France, Gazel and Dourgne (Geddes, 1980; Geddes & Guilaine, 1985; Guilaine *et al.*, 1993) present yet different situations. Domestic ovicaprids appear in ceramic contexts but separated by a millennium at the two sites—7800 BP at Gazel and 6800 BP at Dourgne. The Dourgne date is comparable to the earliest ceramic using groups in the region. However, the older Gazel date is anomalous, suggesting a much earlier occurrence of domestic ovicaprids at this site than expected by either migrationist or indigenist models, given the dates for their initial appearance elsewhere in the western Mediterranean—as indeed **Guilaine notes** (1993: 457).

Recently, the information derived from this group of sites has been systematically criticized by supporters of the migrationist hypothesis. Zilhao (1993) (see also Fortea & Martí, 1985) has suggested that assemblages from these French and Spanish caves and shelter deposits that have been used as evidence countering the migrationist position, are in reality products of post-depositional processes. This is, they are “spurious” archaeological assemblages that do not represent materials associated in systemic context, but are rather depositional palimpsests derived from the mixing of materials from diverse temporal and depositional origins. This could explain the great range of

$^{14}\text{C}$  dates and varying associations of ceramics and domesticates.

Although Zilhao’s note of caution has received little subsequent attention, we feel, this matter deserves more careful consideration. If, as Zilhao proposes, archaeological contexts with ceramics and/or remains of domesticates that date prior to 6800 BP in the western Mediterranean are primarily spurious assemblages resulting from post-depositional mixing, there is less support for indigenist expectations about the archaeological record. A key question in evaluating such evidence is the reliability of the associations found in relevant archaeological contexts, especially those from sites with complex stratigraphies where Neolithic (i.e., with ceramics) assemblages are found superimposed over Mesolithic (i.e., aceramic) assemblages. Such sites may well record the transition to agricultural societies in this region. However, this same stratigraphic complexity makes the reliability of inferences derived from relevant archaeological assemblages open to question due the potential lack of depositional integrity discussed above.

## Taphonomy of Mesolithic and Neolithic Faunal Assemblages

We employ a taphonomic approach to evaluate the integrity of a series archaeological deposits ascribed to the beginning of the Neolithic in Mediterranean Spain. In a recent study dedicated to the analysis of butchering marks, fractures, and tooth marks in prehistoric bones of Mediterranean Spain, Pérez Ripoll (1992) has noted that the frequency of anthropogenic fractures and tooth marks in human-accumulated faunal assemblages varies according to the age of the collections. Fractures resulting from marrow extraction are frequently associated with pre-ceramic contexts—both Late Upper Paleolithic and Mesolithic—but are comparatively rare in Neolithic assemblages. On the other hand, carnivore tooth marks are considerably more frequent in Neolithic faunal assemblages than in pre-ceramic ones where there is other evidence (e.g., butchering marks) that humans were the primary accumulating agents. Although carnivore marks (including those of non-canids) occur in pre-ceramic contexts, their frequency is generally inversely related to other signs of human occupations. In the regional sequence (Villaverde & Martínez Valle, 1995), butchering marks indicate that the majority of small and medium prey taxa found in terminal Paleolithic and Mesolithic sites were introduced as a result of human activity. This suggests that human occupation of these sites was sufficiently intensive to discourage the regular and long-term occupation of the same locales by bone accumulating carnivores (see also Villaverde, Aura & Barton, 1998). In such contexts, tooth marks are extremely rare.

Table 1. Radiocarbon dates for western Mediterranean Mesolithic and Early Neolithic sites discussed in the text

Site	Level	Phase	Ceramics	Domestic mammals	Cereals	<sup>14</sup> C bp	Lab ID	Material
Nerja	Torca,3	Late Neolithic	Epicardial	Yes	Yes	4810 ± 210	GAK-8960	Charcoal
	Torca,4	Early Neolithic	Epicardial	Yes	No	7160 ± 150	GAK-8963	Charcoal
						7960 ± 200	GAK-8962	Charcoal
						11,570 ± 320	GAK-8961	Charcoal
	Torca,7	Mesolithic	None	No	No	10,580 ± 350	GAK-8964	Charcoal
	Torca,8	U. Paleolithic	None	No	No	8260 ± 360	GAK-8967	Charcoal
	Mina,2	Late Neolithic	Epicardial	Yes	Yes	5790 ± 140	GAK-8969	Charcoal
						7390 ± 120	GAK-8968	Cereals
						8770 ± 140	GAK-8970	Cereals
	Mina,3	M. Neolithic	Epicardial	Yes	?	7170 ± 150	GAK-8971	Charcoal
						9900 ± 180	GAK-8972	Charcoal
	Mina,4	Early Neolithic	Epicardial	Yes	?	7130 ± 150	GAK-8974	Charcoal
						7160 ± 180	GAK-8975	Nuts
	Mina,5	Meso/Neoli.	None	No	No	7890 ± 170	GAK-8974	Charcoal
	Mina,8	U. Paleolithic	None	No	No	16,520 ± 540	GAK-8965	Charcoal
	Mina,9	U. Paleolithic	None	No	No	13350 ± 270	GAK-8976	Charcoal
	NV2	Early Neolithic	Epicardial	Yes		6420 ± 60	Ly-5218	Charcoal
	NV3	Late Mesolithic	Epicardial	Yes		7240 ± 80	Ly-2517	Charcoal
	NV8*	Early Mesolithic	None	No	No	10,860 ± 160	Ly-5216	Charcoal
Falguera	F1	Late Mesolithic	None	No	No	7410 ± 70	AA-2295	Olive seed
Or	J III	Early Neolithic		Yes	Yes	5890 ± 280	Ganop-C11	Charcoal
	JII					6630 ± 290	Ganop-C12	Charcoal
						6720 ± 380	Ganop-C13	Charcoal
Niuet		Late Neolithic		Yes	Yes	4260 ± 60	Beta-75216	Charcoal
						4600 ± 80	UBAR-175	Charcoal
Tossal de la Roca	TR2	Late Mesolithic	None	No	No	7560 ± 80	Gif-6897	Bone
	TR1	Early Mesolithic	None	No	No	7660 ± 80	Gif-6898	Bone
						8050 ± 120	Gif-7061	?
						9150 ± 100	Gif-7064	?
Cendres	CC7/H15	Early Neolithic	Epicardial	Yes		6010 ± 80	Beta-75216	Charcoal, S.
	CC6/H15a	Early Neolithic	Epicardial	Yes	Yes	6150 ± 80	Beta-75217	Charcoal, S.
	CC4/H17,hearth	Early Neolithic	Cardial	Yes	Yes	6260 ± 80	Beta-75218	Charcoal, NS.
	CC3/H18	Early Neolithic	Cardial	Yes	Yes	6420 ± 80	Beta-75219	Charcoal, S.
	CC3/VIe	Early Neolithic	Cardial	Yes	Yes	7540 ± 140	Ly-4302	Charcoal, NS.
	CC2/VII	Early Neolithic	Cardial	Yes	Yes	6730 ± 80	Beta-75220	Charcoal, S.
	CC2/H19	Early Neolithic	Cardial	Yes	Yes	20,430 ± 170	Beta-116625*	Charcoal, <i>Pinus nigra</i>
	CC1/VIIa	Early Neolithic	Cardial	Yes	Yes	6280 ± 80	Beta-107405*	Bone, <i>Ovis aries</i>
	CC1/H19a	Early Neolithic	Cardial	Yes	Yes	8310 ± 80	Beta-116624*	Charcoal, <i>Quercus</i>
Dehesilla	8	Middle Neolithic B	Epicardial	Yes	No	5920 ± 170	GAK-8956	Ch-B;
						8200 ± 160	GAK-8957	Ch-B
						3120 ± 180	GAK-8958	Ch-B;
						7040 ± 170	GAK-8955	Ch.-B
Fosca	10	Middle Neolithic A	Epicardial	Yes	No	7120 ± 200	GAK-8954	Ch-B
	11	Early Neolithic B	Epicardial	Yes	No	7670 ± 400	GAK-8953	Ch-B
	13	Early Neolithic A	Epicardial	Yes	No	6260 ± 100	UGRA-259	Ch-B
Verdelpino	III	Mesolithic	None	No	No	9460 ± 160	I-11313	Charcoal
	II, (1b)	Early Neolithic	Epicardial	Yes	No	8800 ± 200	I-9868	Charcoal
	I (1a)	Early Neolithic	Epicardial	Yes	No	7640 ± 110	CSIC-353	Charcoal
	SUP	Early Neolithic	Epicardial	Yes	No	7210 ± 70	CSIC-357	Charcoal
Dourgne						7100 ± 70	CSIC-356	Charcoal
	c.5	Early Neolithic	Plainware	No	No	5715 ± 180	I-9867	Charcoal
	c.6	Early Neolithic	Epicardial	Yes	No	7950 ± 150	CSIC-153	?
Gazel	c.7	Early Neolithic	Plainware	Yes	No	6170 ± 100	MC-1102	Shell
	II	Mesolithic	None	Yes	No	6470 ± 100	MC-1104	Shell
						6850 ± 100	MC-1107	Shell
F6	I	Early Neolithic	Cardial	Yes	No	6040 ± 65	GrN-6705	Charcoal
		Mesolithic	None	Yes	No	6095 ± 65	GrN-6706	Charcoal
						6305 ± 55	GrN-6707	Charcoal
	F6					6850 ± 90	GrN-6702	Charcoal
						7880 ± 75	GrN-6704	Charcoal?

Key to sample material: B= Bone; C=Charcoal; ?=unknown.

\*Designations NV1-NV8 refer to a set of proveniences combined for analysis in this paper (see text) and do not refer to the original excavation units in the Sala de Vestibulo at Nerja. As used here, NV8 refers to the excavation unit NV4-base in the original excavation report (Aura, 1998: Table 1) and not to the Solutreogratteian unit NV8 in the same report. The latter unit is dated c. 16,000 bp and is clearly not Mesolithic.

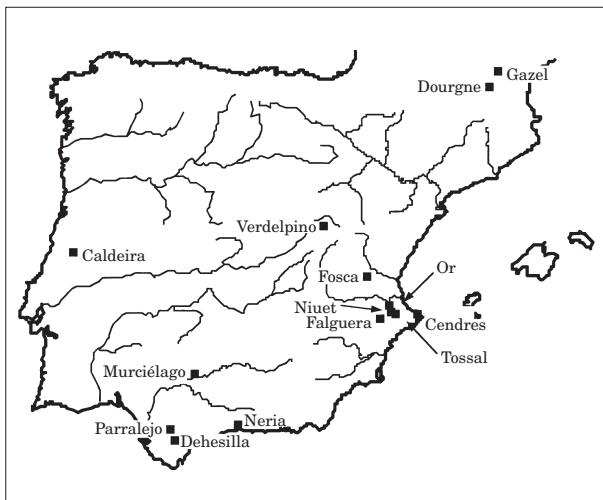


Figure 1. Mesolithic and Early Neolithic sites in the western Mediterranean discussed in the text. ■ indicate sites whose assemblages are analysed in this study.

The tooth marks common in Neolithic faunal assemblages most closely match those of canids. Given that domestic dogs are unknown in the Iberian peninsula prior to the Neolithic, it is not unreasonable to suppose that these marks are from dogs gnawing on the bones that comprise Neolithic faunal assemblages. In other words, for Neolithic groups, the marrow that once comprised an important dietary element for humans became primarily food for dogs.

This pattern has potentially significant implications about changing dietary practices and nutrition from the Mesolithic through the Neolithic, which we only briefly mention here. Marrow extraction is generally viewed as a means to obtain essential dietary fat during times of seasonal scarcity (Speth & Spielmann, 1983). The fact that humans were no longer extracting marrow during the Neolithic suggests that fat was no longer seasonally scarce in diets. While this fat may have been more regularly available in the meat of domestic animals, whose diet and reproductive cycle were managed by humans, an equally intriguing possibility is that fat was now available via secondary dairy products of these domesticates.

Our focus here is on the taphonomic, rather than dietary implications of this pattern. The absence of tooth marks and frequency of anthropogenic fractures in pre-Neolithic contexts and the presence of tooth marks and absence of fractures in Neolithic contexts provides us with a means of examining the depositional integrity of archaeological assemblages of the earliest Neolithic in the region.

## Methods and Sample

We analysed a set of faunal assemblages from seven sites in Mediterranean Spain with deposits that have been assigned chronologically to the Mesolithic

through Neolithic (Figure 1). Assemblages from three sites with only Mesolithic and only Neolithic deposits were analysed as controls. The remaining assemblages are from sites with more complex stratigraphy where post-depositional mixing of materials from Mesolithic and Neolithic temporal contexts is a possibility. These assemblages and their contexts are briefly described below.

### *Tossal de la Roca (TR), Val d'Alcalá, Alicante*

Analysed collections are from the *sector exterior*, with deposits spanning the final Paleolithic through the Geometric (i.e., Late) Mesolithic (Cacho *et al.*, 1996). The excavated layers were grouped into two units for analysis: TR1, which includes the Early Mesolithic and is radiocarbon dated between  $9150 \pm 100$  BP and  $8050 \pm 120$  BP; and TR2, the Late Mesolithic layer with radiocarbon dates of  $7660 \pm 80$  BP and  $7560 \pm 80$  BP.

### *Cova de l'Or (OR), Beniarrés, Alicante*

Analysed material derives from Sector J (Martí *et al.*, 1980). This cave lacks pre-ceramic deposits. The ceramic sequence includes Early Neolithic levels, Cardial and Epicardial phases, with radiocarbon dates of between  $6720 \pm 380$  BP and  $5890 \pm 280$  BP. These Early Neolithic levels are grouped together for analysis here.

### *Niuet (N), Alquería d'Asnar, Alicante*

The deposits and assemblages of this open-air settlement are of Late Neolithic association. Radiocarbon dates range from  $4600 \pm 80$  BP to  $4260 \pm 60$  BP (Bernabeu *et al.*, 1994).

### *Cueva de Nerja, (NV), Nerja, Málaga*

The assemblages excavated by Jordà from the *Sala del Vestíbulo* are used here (see Aura Tortosa *et al.*, 1998). These have been grouped into eight units for analysis. NV1 and NV2 are attributed to the Epicardial phase of the Early Neolithic. NV2 produced a radiocarbon date of  $6420 \pm 60$  BP. NV3 and NV4 are assigned to the Late Mesolithic. However, epicardial ceramics and remains of domestic animals were found in NV3. The lower part of NV3 has been dated at  $7240 \pm 80$  BP. The assemblages NV5 through NV8 are attributed to the Early Mesolithic. The only radiocarbon date from this series is from NV8\*, with an age of  $10,860 \pm 160$  BP.

### *Cova de Cendres (CC) Teulada-Moraira, Alicante*

The assemblages analysed here are from excavations that took place from 1981–1990 (Badal *et al.*, 1991; Bernabeu, 1989) and all fall within the Early Neolithic on the basis of ceramics. A sample of bones (those identifiable as to taxon and comprising from 80–40%

\*See endnote to Table 1.

of the total faunal remains) was analysed from each level. The cardial phase of the Early Neolithic is represented by levels CC1 (units VIIa and H19a), CC2 (units VII and H19), CC3 (units VIId, VIe, and H18), and CC4 (units VIc and H17). The epicardial phase is represented by levels CC5 (VIb and H16), CC6 (VIa and H15a), and CC7 (VI and H15). Reliable radiocarbon dates (see discussion below) for these levels range from  $6730 \pm 80$  to  $6010 \pm 80$  (see also Table 3). New excavations, beginning in 1995, by Villaverde revealed additional Neolithic and Magdalenian layers, although apparently no Mesolithic occupations (Badal *et al.*, 1991; Villaverde & Martínez Valle, 1995). Analysis of faunal remains from this new work is still in process and so could not be used here. However, preliminary analysis suggests a comparatively high frequency of anthropogenic fractures and a complete lack of tooth marks in the pre-ceramic levels (Villaverde & Martínez Valle, 1995: 96).

#### *Cova de La Falguera (F), Alcoi, Alicante*

Although brief references to this rockshelter exist (Barton & Clark, 1993; Barton *et al.*, 1990; Doménech, 1990; Rubio Gomis & Barton, 1992), most data from the site remain unpublished. The collection analysed here derives from cleaning the walls of a looter's pit in the site and represents a rather small sample. The various assemblages have been grouped into three units. F1 comprises all the pre-ceramic material and has a  $^{14}\text{C}$  date of  $7410 \pm 70$  bp. F2 includes the Cardial assemblages and F3 the Epicardial assemblages. Radiocarbon dates are lacking for F2 and F3.

#### *Cueva de la Cocina (Co), Dos Aguas, Valencia*

The faunal collection analysed here derives from recent excavations by Fortea (Fortea *et al.*, 1987). The cultural sequence spans the Late Mesolithic through the Late Neolithic. However, quantitative data on anthropogenic fractures and tooth marks are only available for the Middle–Late Neolithic levels (here grouped as Co1) and the upper Early Neolithic levels (Co2) where domestic animals first appear. No radiocarbon dates are available for these assemblages.

#### *Variables measured*

In order to evaluate the depositional integrity of the assemblages from these sites, we calculated the frequencies of anthropogenic fractures and carnivore tooth marks for the bones of domestic and wild taxa in each of the assemblages analysed. The faunal remains were analysed by Manuel Pérez Ripoll (Or, Niuet, Nerja, Falguera, and Cocina) and Rafael Martínez Valle (Cendres) at the Universitat de Valencia. Except for Tossal de la Roca (Pérez Ripoll & Martínez Valle, 1995), all are previously unpublished. We focus here on four variables:

$\text{TM}_{\text{dom}}$ =the relative frequency of canid tooth marks among bones of domestic taxa

$\text{AF}_{\text{dom}}$ =the relative frequency of anthropogenic fractures among bones of domestic taxa

$\text{TM}_{\text{wild}}$ =the relative frequency of canid tooth marks among bones of wild taxa

$\text{AF}_{\text{wild}}$ =the relative frequency of anthropogenic fractures among bones of wild taxa

**Table 2** and **Figure 2** summarize the frequency of anthropogenic fractures and tooth marks for the collections analysed and also shows the absolute frequency of domestic, wild taxa for each assemblage. Domestic taxa include *Ovis aries*, *Capra hircus*, *Bos taurus* and *Sus domesticus*; wild taxa considered are *Capra pyrenaica*, *Cervus elaphus* y *Oryctolagus cuniculus*. In spite of temporal differences in damage patterns mentioned above, it is of course possible that the bones of domestic and wild fauna were treated differently when both were consumed by the same people. For this reason, we selected variables that independently monitor damage patterns on wild and domestic taxa. However, as discussed below, apparent differences in treatment are better explained by post-depositional processes affecting deposits.

The inclusion of rabbit along with the larger ibex and deer also merits additional comments. The remains of rabbit are consistently an important component of archeofaunas in Mediterranean Spain from the Magdalenian through the Mesolithic (Villaverde, Aura & Barton, 1998), comprising primary taxon in many assemblages (Figure 3). Although present in lower frequencies subsequently, they remain important through the Neolithic where they often outnumber other wild taxa in numbers of remains in archaeological contexts. The common occurrence of butchering marks and anthropogenic fractures on these rabbit bones indicate the primary role of human activities in their accumulation at archaeological sites (Aura & Pérez-Ripoll, 1995; Villaverde & Martínez Valle, 1995).

Although their economic use may have differed from larger ungulates—wild and domestic—the patterns of fractures and tooth marks on rabbit bones parallels those seen in the other taxa (Figure 4). In fact, the frequencies of anthropogenic fractures on rabbit bones and wild ungulates are significantly correlated in the Mesolithic assemblages examined (Spearman's  $r=0.61$ ,  $P=0.1$ ) and the frequencies of canid tooth marks on rabbit bones and domestic ungulates are significantly correlated for the Neolithic assemblages studied here (Spearman's  $r=0.66$ ,  $P=0.006$ ). The primary difference seems to be a systematically higher rate of fracture for rabbit bones than for bones of wild ungulates in pre-ceramic contexts (Figure 4a, F1-TR2). These taphonomic differences are most likely due to rabbits more commonly being returned whole to sites for preparation and consumption while larger animals were more often partly processed in the field (Villaverde & Martínez Valle, 1995: 101). However, this difference

Table 2. Faunal assemblage data used in this study

Assemblage	Group	N	Domestic Taxa		N	Wild taxa	
			% with tooth marks (TM <sub>dom</sub> )	% with anthropogenic fractures (AF <sub>dom</sub> )		% with tooth marks (TM <sub>wild</sub> )	% with anthropogenic fractures (AF <sub>wild</sub> )
F1	1	0	0	0	127	0.008	0.024
NV4	1	0	0	0	506	0	0.174
NV5	1	0	0	0	507	0	0.122
NV6	1	0	0	0	532	0	0.124
NV7	1	0	0	0	704	0	0.141
NV8	1	0	0	0	533	0	0.143
TR1	1	0	0	0	545	0	0.042
TR2	1	0	0	0	950	0	0.083
CC4	2	192	0.192	0.005	138	0.087	0.036
CC5	2	110	0.39	0.008	35	0.143	0
CC6	2	126	0.317	0.008	108	0.083	0
CC7	2	318	0.195	0.012	145	0.083	0.007
F2	2	46	0.37	0	137	0.197	0.015
F3	2	35	0.57	0	134	0.142	0
Niuet	2	1446	0.18	0.006	122	0.189	0
Or	2	2008	0.434	0.002	368	0.340	0.011
CC1	3	33	0.12	0	274	0.007	0.095
CC2	3	187	0.16	0.005	538	0.011	0.069
CC3	3	204	0.19	0	102	0.020	0.108
Co1	3	104	0.201	0	108	0.019	0.120
Co2	3	26	0.384	0	232	0.013	0.237
NV1	3	93	0.172	0	53	0	0.151
NV2	3	392	0.145	0	129	0.031	0.062
NV3	3	155	0.174	0	272	0	0.132

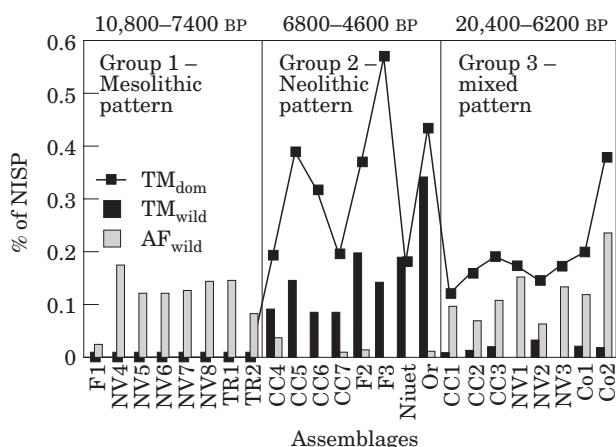


Figure 2. Variability in anthropogenic fractures and carnivore tooth marks by group.

does not alter the observation that wild animal bones (both rabbits and ungulates) were systematically fractured by hunter-gatherers in the terminal Paleolithic and Mesolithic, and that such fracturing becomes rare during the Neolithic. Similarly, carnivore tooth marks are generally absent or very rare on rabbit bones as well as bones of larger ungulates in pre-Neolithic contexts but become much more frequent on all bones during the Neolithic.

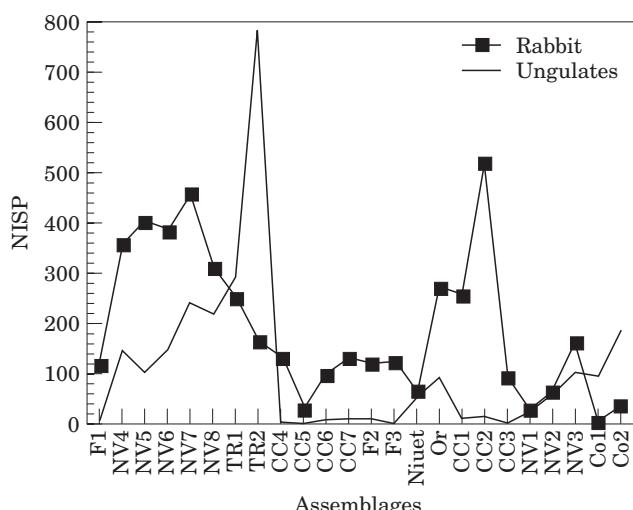


Figure 3. NISP for lagomorphs and ungulates in sites analysed here.

## Analysis and Results

### Assemblage groups

It is apparent in Table 2 and Figure 2 that variability in TM<sub>dom</sub>, TM<sub>wild</sub>, AF<sub>dom</sub>, and AF<sub>wild</sub> differentiates three groups of assemblages. In one group (Group 1) only human induced fractures are present and canid tooth marks are absent. A second group (Group 2), is

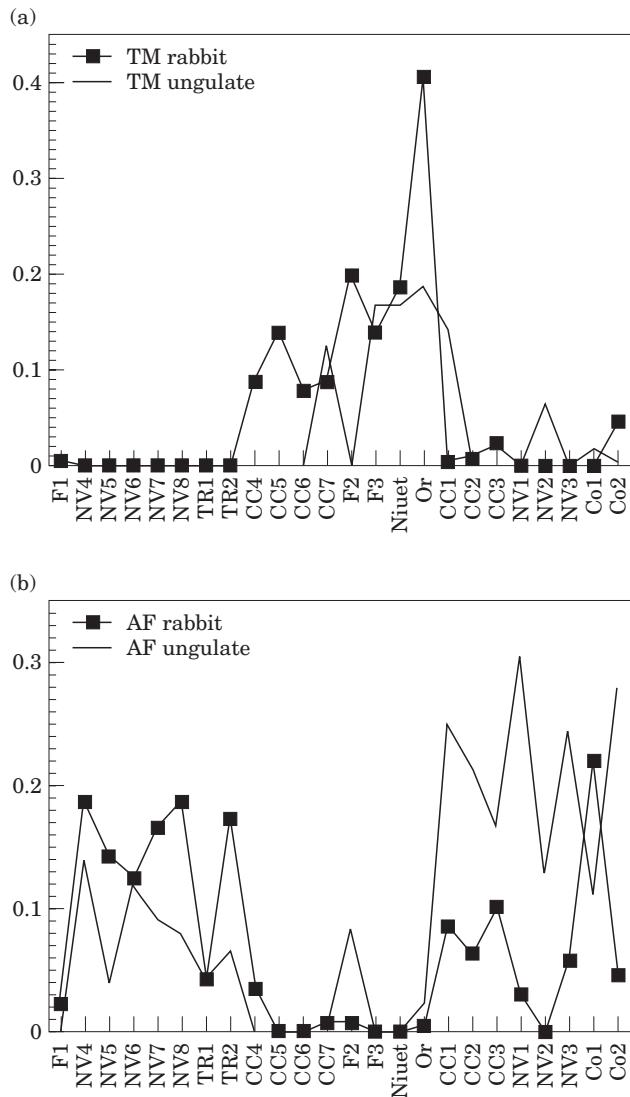


Figure 4. Carnivore tooth marks (A) and anthropogenic fractures (B) for lagomorph and ungulate bones. The overall patterns of variation in these taphonomic features are very similar for both groups of taxa, though generally more frequent on lagomorph remains. The sites with the greatest differences between rabbits and ungulates are those with the smallest samples.

generally characterized by high incidences of canid tooth marks, while anthropogenic fracturing is rare or absent. The last group of assemblages (Group 3) canid tooth marks are much more frequent on remains of domestic animals ( $TM_{dom}$ ) than on wild taxa ( $TM_{wild}$ ), and anthropogenic fractures on wild animal bones ( $AF_{wild}$ ) are found in frequencies comparable to Group 1 assemblages.

Correspondence analysis is a method to quantitatively evaluate the similarities and differences between rows and/or columns in such tabular data. We have employed it here to examine how sites group with respect to taphonomic damage to animal bones. The first dimension accounts for the greatest amount of

variability (84% of inertia) which is heavily weighted towards  $TM_{wild}$ . The second dimension, to which  $AF_{wild}$  makes the strongest contribution, accounts for most of the remaining variation (13% of inertia).

It is clear in Figure 5 that the sites fall into the three groups suggested in Table 2. Group 1 is very tightly defined and includes all clearly Mesolithic assemblages except Falguera F1 (i.e., those from Tossal de la Roca, TR1 and TR2, and Nerja units NV4–NV8). Group 1 faunal assemblages evidence anthropogenic fractures but lack carnivore tooth marks. Radiocarbon dates for these assemblages fall between 10,800 BP and 7400 BP (with F1 being the most recent). Falguera F1 seems to be an outlier to this group and will be discussed more below.

Group 2 is tightly clustered along the first dimension, but shows diversity in the second dimension. It is strongly differentiated from Group 1. This group comprises all of the clearly Neolithic assemblages (Or, Niuet, Cendres units CC4–CC7, and Falguera units F2 and F3). Faunal assemblages generally show high incidences of canid tooth marks, with anthropogenic fractures rare or absent. Radiocarbon dates for Group 2 also are well separated from Group 1 dates, ranging from 6720 to 4260.

The last group (Group 3) varies in both the first and second dimensions and lies intermediate between Groups 1 and 2, but distinct from both, on the first dimension. This group includes a variety of assemblages which have mixtures of Neolithic and Mesolithic elements (Cendres units CC1–CC3, Nerja units NV1–NV3, and both Cocina units). Anthropogenic tooth marks are much more frequent on remains of domestic animals than for wild taxa, as characteristic of the Neolithic Group 2, while anthropogenic fractures occur in frequencies comparable to the Mesolithic Group 1 assemblages. These assemblages derive from the intervals of Mesolithic–Neolithic transition at their respective sites, and the characters that put them in Group 3 tend to diminish in proportion to their stratigraphic separation from the pre-ceramic levels in each site. Radiocarbon dates for Group 3 assemblages are much more variable than either of the other two groups (at 20,400 to 6260 BP) and overlap the dates of both Group 1 and 2 assemblages.

#### Taphonomic evidence for mixing

The discrete nature of Group 3 assemblages and their intermediate position between clearly Neolithic and clearly Mesolithic assemblages suggests that they may indeed be mixed accumulations of artifacts from discrete Mesolithic and Neolithic occupations. This group shows the greatest amount of variation along the primary axis of variability for the assemblages (dimension 1 in Figure 5) as well as the greatest variation in radiocarbon dates. Nevertheless, it is also possible that variation in the presence of canids is being

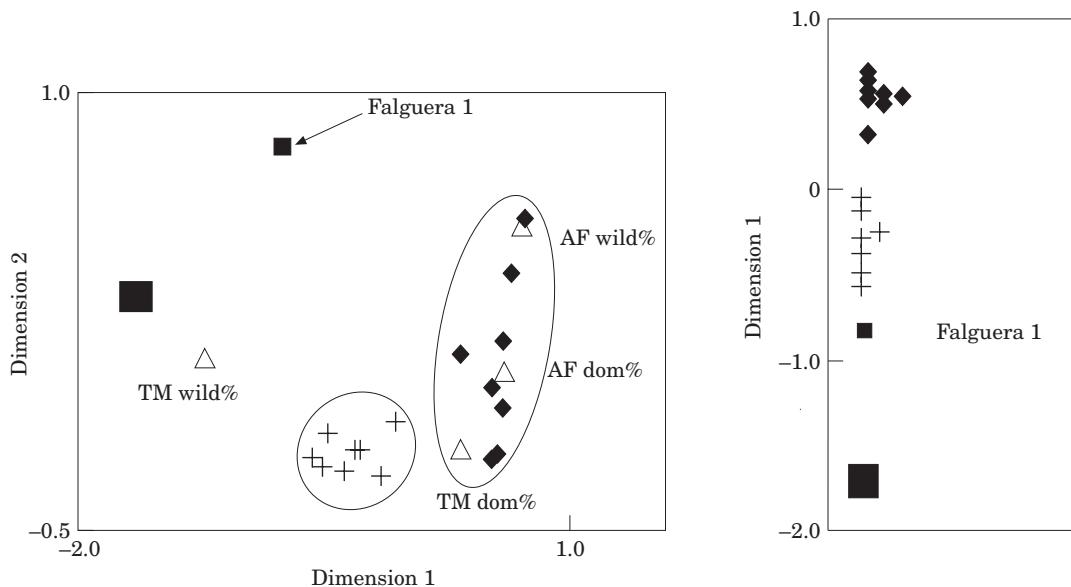


Figure 5. Results of correspondence analysis for percent of anthropogenic fractures and carnivore tooth marks in wild and domestic fauna from Mesolithic and Neolithic assemblages. First 2 dimensions plotted. ■, Mesolithic (group 1); ♦, Neolithic (group 2); +, Neolithic/Mixed (group 3); Δ, locations of original variables in new dimensions.

measured here rather than variation in the amount of post-depositional mixing. That is, human association with dogs could have been a behaviour that was adopted with varying frequency and independent of other Neolithic "elements" during the Mesolithic–Neolithic transition rather than as part of a complete Neolithic "package". If so, canid gnawing should be found equally on bones of domestic and wild fauna in Group 3 assemblages; it should be dependent of the prehistoric presence of dogs during an occupation and not be related to other evidence for a Neolithic way of life, such as the frequency of domestic fauna in an assemblage.

We tested this using Spearman rank order correlation analysis, which provides a robust measure of association. In fact, the frequency of canid tooth marks on domestic and wild fauna vary independently in Group 3 assemblages (Spearman's  $r=0.16$ ). However, the overall frequency of tooth marks (among wild and domestic fauna combined) is strongly correlated with the frequency of domestic fauna in an assemblage (Spearman's  $r=0.90$ ). The frequency of domestic fauna is even more strongly negatively correlated with the overall representation of anthropogenic fractures (Spearman's  $r=-0.93$ ). Since dogs are not likely to differentiate between domestic and wild fauna in their masticatory habits, this strongly supports our contention that Group 3 assemblages are depositional palimpsests that mix debris from distinct Neolithic (with dogs and domestic animals) and pre-Neolithic (lacking dogs and domestic animals) occupations.

#### Radiocarbon dates for archaeological palimpsests

Given the taphonomic evidence that many assemblages from Mediterranean Spain that appear to be tran-

sitional from the Mesolithic to Neolithic are actually comprised of a mixture of distinct Mesolithic and Neolithic occupational debris, how are the radiocarbon dates from these assemblages to be interpreted? Often carbonized organic materials are rare and dispersed throughout archaeological levels; it is necessary to collect a group of these fragments to have a sample sufficiently large for conventional radiocarbon dating. If these deposits are palimpsests, it is very possible that dates obtained from samples collected in this way are averages of temporally distinct fragments and do not provide an accurate estimate of the age of the deposit. Repeated dates from samples in the same level, might show considerable variation because they derive from averages of different random samples of temporally diverse charcoal fragments.

We tested this possibility with data from Cova de Cendres, the source of several Group 3 assemblages (CC1–CC3) in the analysis above. The original date returned for Cendres was  $7540 \pm 140$  BP from assemblage CC3 (Ly-4302, from unit VIe). Although this is a little older than expected for the associated Cardial Neolithic ceramics, there was no evidence for depositional mixing in the material culture recovered. The taphonomic analyses described above suggest otherwise, however. Two procedures were used to check for the possibility that the original date is also a palimpsest. Charcoal fragments of known ecological associations were dated by conventional techniques, and individual fragments of known taxonomic association were dated by the AMS method.

Recent excavations at Cendres and associated paleoecological studies have shown that charcoal of Mediterranean woodland taxa such as *Olea* spp. and *Quercus* spp. are common in ceramic-bearing deposits,

Table 3. Radiocarbon dates from Cendres Cave, Alicante. Charcoal samples are composed of fragments dispersed across approximately 1 sq. m. of sediment except for the sample from H17, which is from hearth fill and the single fragments dated by AMS method.

Bone sample	Level	Laboratory reference	Material	Method	$^{14}\text{C}$ BP	Bone cluster
CC7	H15	Beta-75216	Charcoal (selected)	Standard	$6010 \pm 80$	2
CC6	H15a	Beta-75217	Charcoal (selected)	Standard	$6150 \pm 80$	2
CC4	H17,fireplace	Beta-75218	Charcoal (not selected)	Standard	$6260 \pm 80$	2
CC3	H18	Beta-75219	Charcoal (selected)	Standard	$6420 \pm 80$	3
CC3	VIe	Ly-4302	Charcoal (not selected)	Standard	$7540 \pm 140$	3
CC2	VII	Beta-75220	Charcoal (selected)	Standard	$6730 \pm 80$	3
CC2	H19	Beta-116625	Charcoal <i>Pinus nigra</i>	AMS	$20,430 \pm 170$	3
CC1	VIIa	Beta-107405	Bone, <i>Ovis aries</i>	AMS	$6280 \pm 80$	3
CC1	H19a	Beta-116624	Charcoal, <i>Quercus</i>	AMS	$8310 \pm 80$	3

while conifers such as *Pinus nigra* and *Juniperus* spp. are rare. The latter are much more common in Pleistocene-age deposits (and Mediterranean woodland taxa correspondingly rare) when lower temperatures favoured conifer forest near the site (Badal, Bernabeu & Vernet, 1994). On the basis of these findings, a series of charcoal samples was collected from assemblages CC2–CC7 and the fragments identified as to taxon. Only oak and olive charcoal fragments were retained and submitted for dating. The result is a coherent series of dates (Beta-75216 to Beta-75220) that more closely matches ages of Cardial Neolithic contexts elsewhere in the peninsula (Table 3). This suggests that the occasional fragments of *Pinus nigra* and *Juniperus* sp. charcoal found in Neolithic deposits are likely derived from earlier, pre-ceramic use of the site.

Additionally, four samples were collected from assemblage CC1 context, identified according to taxon, and submitted for AMS dating (Table 3)—the AMS technique permitting individual small fragments to be analysed. The four samples were selected to represent a range of ecological associations that probably derived from distinct temporal contexts. They were a fragment of oak charcoal (from Holocene Mediterranean woodland), a fragment of pine charcoal (*Pinus nigra*, probably from late Pleistocene conifer forest), a fragment of red deer bone (*Cervus elaphus*, possibly hunted by pre-Neolithic occupants of the cave), and a fragment of domestic sheep bone (*Ovis aries*) deposited by Neolithic occupants. The radiocarbon results are very informative. The sheep bone is younger than the taxonomically selected charcoal from assemblages CC2 and CC3. The oak charcoal is early Holocene in age. The pine charcoal dates to the last glacial maximum. The deer bone had insufficient surviving collagen for reliable radiocarbon dating. This suggests that it is considerably older than the sheep bone from the same depositional context.

This radiocarbon analysis of Early Neolithic contexts at Cova de Cendres strongly supports the taphonomic evidence for depositional mixing discussed

above. The original date for Cendres CC3 (Ly-4302) probably derives from a mix of charcoal from ceramic and pre-ceramic depositional contexts. On the other hand, the AMS dates for individual samples of pine charcoal, oak charcoal, and sheep bone are more likely give age estimates close to their time of death rather than to their inclusion in the mixed archaeological deposit in which they were found. Similar processes may well be responsible for many other apparently anomalous dates in Table 1—especially if radiocarbon dates are based on collections of dispersed charcoal fragments unselected as to taxa. For example, the radiocarbon dates from NV2 and NV3 derive from charcoal of unknown taxa, dispersed throughout the archaeological deposit. It is quite possible that they provide a spurious date analogous to the Ly-4302 date from Cendres.

## Discussion and Conclusions

### Depositional palimpsests and taphonomic processes

It seems clear from the convergent evidence presented above that mixing of temporally discrete materials has occurred in series of assemblages from caves and shelters in Mediterranean Spain. While these assemblages appear to document a gradual transition from the Mesolithic to the Neolithic, they are in fact depositional palimpsests and their transitional appearance is an artifact of taphonomic processes. Of the four sites with complex stratigraphy discussed above, depositional palimpsests appear to characterize the initial Neolithic archaeological assemblages of three—Nerja, Cendres, and Cocina. Two of these, Nerja and Cendres, also produced evidence of domestication economies.

At Falguera, on the other hand, the earliest assemblage (F1) does not group with other mixed assemblages, but also differs from the rest of the Mesolithic assemblages examined; the Neolithic assemblages (F2 and F3) group with other clearly Neolithic assemblages. Also, outside of the presence of ceramics, the

initial Neolithic deposits differ little in character or archaeological contents from the underlying pre-Neolithic units. Finally, the date for the F1 Falguera assemblage is an AMS date on a single olive seed (Barton *et al.*, 1990); it is not a spurious average date from dispersed charcoal fragments. F1 may indeed be a late Mesolithic assemblage. However, the lack of dates from F2 and F3 assemblages and the small sample of material recovered and analysed to date leave the interpretation of this site open to question. Hopefully, new excavations now underway at Falguera will help to clarify the nature of its deposits and their contents.

Similar processes may also affect later Neolithic and earlier pre-Neolithic assemblages in these same sites, but we currently lack the means to recognize it. However, the creation of taphonomic palimpsests may be a more severe problem at the beginning of the Neolithic in this region than slightly earlier or later for several reasons.

Sedimentological studies in a series of Valencian caves and rockshelters (Fumanal, 1995: 121) suggest an interval of marked slope denudation in the early Holocene (between c. 7500 and 6000 BP) due to a combination of human disturbance of vegetation (e.g., Neolithic forest clearance) and the onset of a climatic regime characterized by more intensive rainfalls. Resulting slope wash and mass movement clastics were periodically trapped in caves and rockshelters, becoming incorporated into their fills. These comparatively energetic depositional episodes were accompanied by erosion and redeposition of the upper parts of existing cave and rockshelter fills, forming secondary deposits composed of materials from diverse primary contexts. Such processes are not always easy to identify during even careful excavation (see also Barton & Clark, 1993; Colcutt, 1979).

Additionally, Neolithic caves and rock shelters of this region were often used for food storage during the Neolithic. Pits have been documented at both Cendres and Nerja, excavated by Neolithic occupants down into pre-ceramic deposits. At both sites, these pits were excavated in loose sediments and subsequently suffered partial wall collapse that mixed diverse earlier materials with later pit fill. This makes it difficult to delineate the boundaries of these features and to differentiate temporally diverse materials redeposited since their initial excavation. Under these conditions, there may well be other such features at these and other Early Neolithic sites that have gone unrecognized.

Overall, these taphonomic processes likely had a greater impact in the context of societies dependent on food production than for hunting and gathering societies. In the western Mediterranean, food producers appear to have had a significantly greater impact on their environment—both domestic space and the landscape—than hunter-gatherers. Longer stays or more regularly recurrent occupations at settlement loci (see Barton *et al.*, 1999; Bernabeu *et al.*, 1999) tended

to be associated with greater modification of living space and the creation of food storage features (including pits). At larger geographic scales, this impact is manifest in the effects of tillage, pastoralism, and village construction on vegetation and soils. These combine to produce geomorphically more active landscapes at various scales, in which there is a greater chance of depositional mixing in the caves and rockshelters that serve both as sediment traps and foci of human settlement. Such large-scale patterns in taphonomic processes need to be further evaluated with larger samples than employed here.

#### *Unmixing palimpsests*

In addition to indicating that depositional mixing has occurred, taphonomic data also can help to unmix such palimpsests. At Cendres, the degree of mixing for each assemblage can be modelled on the basis of the taphonomic analysis presented above. We parsimoniously assume that the domestic taxa in each assemblage from the site derive from Neolithic occupation refuse. Then we can use the ratio of anthropogenic fractures to canid tooth marks to estimate the proportion of wild fauna that accumulated during Mesolithic and Neolithic occupations.\*

We present the results of this modelling in Table 4 and Figure 6. The original data from the cave show a gradual increase in the proportion of domestic to wild taxa in the faunal assemblage over time. However, the modelling presented here indicates a somewhat different picture. As can be seen in Figure 6a, assemblage CC1 primarily consists of pre-Neolithic occupation debris with intrusive Neolithic material. A reasonable age for most of this material is given by the AMS date on oak of  $8310 \pm 80$  BP. The intrusive Neolithic material is of considerably later age, as indicated by the  $6280 \pm 80$  BP date on sheep bone. Assemblage CC2 is about an equal mix of pre-Neolithic (probably Mesolithic) and Neolithic material. The single taxon  $^{14}\text{C}$  date of  $6730 \pm 80$  BP is more likely representative of the Neolithic component than the Mesolithic one. The remaining assemblages are primarily Early Neolithic, with declining amounts of mixed Mesolithic and Paleolithic (given the 20,430 BP date for pine charcoal) material—probably including dispersed charcoal fragments that increased the age of  $^{14}\text{C}$  sample Ly-4302 to  $7540 \pm 140$  BP.

As seen in Figure 6b, the proportion of wild ungulates in the fauna is consistently low (well under 10%) in all Neolithic assemblages, including the earliest, and shows no clear trend. This further suggests that the apparent economic transition—in which domestic

\*While more complex functions—such as fuzzy discriminant or bayesian functions—could be used to estimate the Neolithic and pre-Neolithic contribution to the wild faunal, we have no way to evaluate whether these would provide more accurate representations of actual mixing than the simple linear function we use here.

Table 4. Unmixing palimpsests from Cova de Cendres. Ratios of wild and domestic fauna for the Early Neolithic layers of Cendres Cave. Original ratios are compared with ratios adjusted according to evidence of depositional mixing

Assemblage	AF Index <sup>1</sup>	All domestic	NISP All wild herbivores <sup>2</sup>	Wild ungulates	Estimated NISP for all herbivores Mesolithic component	Estimated NISP for wild ungulates Mesolithic component	Estimated NISP for wild ungulates Neolithic component	Wild herbivores Mesolithic: Neolithic	Neolithic component % of ungulates that are wild	
CC7	0.06	318	145	12	9	136	1	11	0.07	0.04
CC6	0.02	126	108	8	2	106	0	8	0.02	0.06
CC5	0.02	110	35	0	1	34	0	0	0.02	0.00
CC4	0.11	192	138	3	15	123	0	3	0.12	0.01
CC3	0.21	204	102	6	21	81	1	5	0.26	0.02
CC2	0.50	187	538	14	269	269	7	7	1.00	0.04
CC1	0.81	33	274	12	223	51	10	2	4.33	0.07

<sup>1</sup>Relative frequency of anthropogenic fractures among all bone marks.

<sup>2</sup>Wild ungulates + lagomorphs.

fauna gradually replace wild taxa in the diet—is an artifact of taphonomic processes.

#### Other Early Neolithic sites

The taphonomic analyses presented here lend support for Zilhão's (1993) caution about the potential contamination of deposits with radiocarbon dates prior to 7000–6800 BP and associated with domestic ovicaprides and/or ceramics. Detailed taphonomic data are unavailable for most such sites. However, a review of the radiocarbon dating for some of these assemblages is suggestive. The context and composition of the samples dated at Dehesilla are not described beyond indicating that they are charcoal or bone. However, the variation in age and lack of concordance with the site stratigraphy resembles the pattern seen in the Cendres dates.

With the exception of samples from Sala de la Mina, Stratum III (GAK-8968 and GAK-8970), the other anomalous dates from Nerja are also based on samples of dispersed charcoal. According to Pellicer and Acosta (1986: 382) these Stratum III dates were on samples of domestic cereals although there have not been any published analyses of the archaeological or botanical materials recovered from this deposit. Given that the ages of these samples—7390 BP and 8770 BP respectively—seem old for their supposed association with a Late Neolithic context and that they appear out of sequence stratigraphically it is possible that the samples may include fragments of wild seeds of pre-ceramic association along with the domestic cereal grains.

With fewer dated samples, Fosca and Verdelpino do not display the wide variance in dates seen in Cendres, Nerja, and Dehesilla. However, the dates from these sites discussed here were obtained from dispersed charcoal that was not selected by plant taxon. Hence, these dates could well derive from averaging chronologically

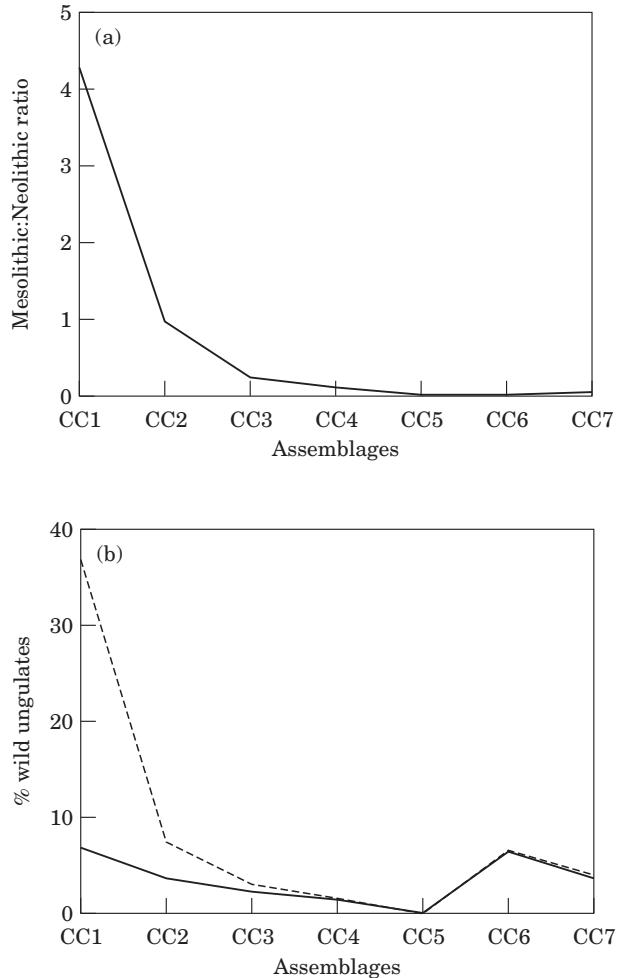


Figure 6. Unmixing palimpsests from Cendres Cave. (a): estimated ratio of Mesolithic and Neolithic contribution to the faunal assemblages of each level. (b): estimated percent of wild fauna in Neolithic component of each level (percent of wild fauna for mixed Mesolithic and Neolithic components shown for comparison). —, Mixed Mesolithic; +, Neolithic; —, Neolithic component only.

Table 5. Radiocarbon dates from Murciélagos Cave, Córdoba. Dates with CSIC and GrN laboratory designations are from earlier excavations in the late 1960s

Site	Layer	Context	$^{14}\text{C}$ -BP
Murciélagos Cave Zuheros, Córdoba	Neolithic C	Late Epicardial	5080 ± 120 (I-17761) 5380 ± 110 (I-17762)
		Middle Epicardial	5570 ± 110 (I-17764) 5660 ± 120 (I-17763)
	Neolithic A	Early Epicardial	5800 ± 120 (I-17770) 5170 ± 130 (CSIC-55)
			5900 ± 120 (I-17775) 5930 ± 130 (CSIC-59)
			5960 ± 130 (CSIC-56) 5980 ± 130 (CSIC-57)
			6100 ± 130 (CSIC-58) 6150 ± 45 (GrN-6169)
			6190 ± 120 (I-17771) 6190 ± 130 (CSIC-53)
			6190 ± 130 (CSIC-54) 6260 ± 120 (I-17773)
			6270 ± 120 (I-17774) 6310 ± 120 (I-17776)
			6430 ± 130 (I-17772)

diverse charcoal samples. The apparent temporal spread (over 1000 years) between the latest pre-ceramic and earliest ceramic levels at Fosca could simply be an artifact of the taphonomy of dated organic materials.

Given the questionable nature of the radiocarbon evidence at these sites, the archaeological evidence may provide a more reliable indication of the age of the material culture if not the deposits themselves. Only a few, chronologically ambiguous, plainware sherds have been recovered from Verdelpino. However, the other sites have produced Epicardial ceramics which chronologically follow Cardial wares when the two have been found together in stratigraphic context.

Probably the best-dated Epicardial site in the Iberian peninsula is the Cueva de los Murciélagos de Zuheros, Córdoba (Table 5). A total of 16 dates have been obtained from the lower (i.e., Epicardial) stratigraphic units of this site, which lacks either pre-ceramic or Cardial archaeological manifestations. Ten of these dates derive from samples obtained during excavations in the late 1960s (Vicent & Muñoz, A.M., 1973), and the remaining six are from recent work (Gavilán *et al.*, 1996). Some of the early series are on cereal grains and the remainder are from dispersed charcoal not selected as to taxon. All closely agree and produce a stratigraphically consistent series of dates from *c.* 6400–5900 BP. Given this close agreement and the lack of evidence for earlier occupation, the dates on dispersed charcoal at this site seem less problematic than at the others discussed above. This, in turn, gives greater confidence to the associations among the archaeological materials found in these deposits.

Beyond Spain, Zilhao (1992) employed a taphonomic approach to unmix Paleolithic and early Neolithic materials at the Portuguese cave site of Caldeirao, and recent excavations in Chateuneuf rock-

shelter, Provence (Courtin, Evin & Thommeret, 1985), suggest that deposits previously interpreted as containing transitional assemblages have been affected by post-depositional mixing and possibly by the excavation of Neolithic-age pits. In this light it may be worth re-evaluating the reported associations of Neolithic and Mesolithic artifacts and faunal remains reported from other western Mediterranean sites such as at Gazel and Dourgne, also in France, the Grotta dell'Uzzo in Sicily (Tusa, 1994), and Arene Càndide in Liguria (Starnini & Voytek, 1997).

#### Implications for the Neolithic transition

If a series of assemblages thought to represent the Mesolithic–Neolithic transition in Mediterranean Spain are, in fact, depositional palimpsests what can we say about the change from foraging to farming societies in this region? First, these assemblages only appear to match indigenist expectations about the archaeological record—described at the beginning of this paper—because of taphonomic processes, not because of social processes. By the same token, apparently abrupt cultural change can also be due to taphonomic processes (Farrand, 1993). Nevertheless, given the relatively short span between the late Mesolithic—as represented at the few dated sites like Falguera F1, Tossal de la Roca TR2, and potentially Cendres CC1—and the early Neolithic in securely dated contexts, the mixed nature of the apparently transitional assemblages we have examined here suggests that the transition to the agropastoral way of life took place over a few centuries at the most in at least some places.

This would seem to support migrationists expectations about the nature of the archaeological evidence.

However, it likely that the picture is more complex. Ecological instabilities inherent in agropastoral systems encourage dispersals of farmer/herders (Rindos, 1980). Further, as is documented in both recent history and in prehistoric cases such as the LBK expansion across western Europe (Bogucki & Grygiel, 1993; Thorpe, 1996: 29–36) and the Bantu expansion across sub-Saharan Africa (Diamond, 1997: 376–402; Ehret, 1984; Phillipson, 1993: 173–207), it is clear that agropastoralists can rapidly colonize areas even when they are inhabited by hunter-gatherers (but see Vansina, 1995; Whittle, 1996 for discussions of more complex scenarios in both areas). However, the socio-economic behaviours of indigenous foragers can change equally rapidly. Wiessner and Tumu (1998) have recently documented the rapid introduction of sweet potato agriculture among the Enga of highland New Guinea. Here, *in situ* social and economic change transformed communities of hunter-gatherers and garden horticulturalists alike into ranked tribal societies with hereditary leaders in less than three centuries—a shorter time span than the standard deviations of most radiocarbon dates for the assemblages discussed here. The attendant material culture evidenced equally drastic changes. However, virtually all population movements into and within this area were less than 50 km in distance (Wiessner & Tumu, 1998: Tables 4 and 5).

Of course it is quite possible that both expansion and dispersal of agropastoralists, and adoption of Neolithic economy and its social trappings by some foraging groups took place in the mid-Holocene of Mediterranean Spain (see Bernabeu, Aura & Badal, 1993). Our own research on human land use patterns in northern Alicante Province suggest such variation in the processes of socio-economic change (Barton *et al.*, 1999; Bernabeu *et al.*, 1999). In the Polop Alto valley, near Alcoi, there is a long history of human occupation stretching back at least into the Middle Paleolithic. Our study indicates minimal change in human land use patterns during the early Neolithic, suggesting the incorporation of Neolithic domesticates and material culture into an essentially foraging economy and settlement pattern. However, in the Rio Penaguila valley, only 20 km to the east, there is less evidence for earlier occupation, and land use patterns show a dramatic change from the first appearance of Neolithic material culture. This latter pattern is more consistent with the colonization of the Rio Penaguila by agropastoralists. However, even in these cases, it is not currently possible to say with certainty who was responsible for the accumulations of Early Neolithic material culture in either valley on the basis of the rather typical archaeological materials we have collected (i.e., primarily ceramics and lithics). In the end, perhaps, it not who but how and why that are more important questions for understanding the Neolithic revolution. In fact, a better understanding of the processes of social and economic change may provide insight into the people involved.

## Concluding Thoughts

Recent attempts to provide a sounder empirical basis for testing different models about the beginning of food production in the western Mediterranean have focused on cave and rockshelter deposits that contain stratigraphic sequences of material culture that appear to span the Mesolithic to Neolithic transition. Our analysis of taphonomic processes affecting the faunal assemblages in a series of these sites indicates that some of the most relevant assemblages are from depositional palimpsests whose interpretation remains open to question. We echo Zilhão's (1993) caution about the possibility of post-depositional mixing of deposits and their contents in these contexts. If anything, however, the deposits we have evaluated here indicate a more rapid than gradual appearance of Neolithic material culture and domesticates at occupation loci.

We also add a further word of caution over the interpretation of radiocarbon dates on collections of dispersed charcoal fragments. In contexts where depositional palimpsests are likely, these have a high risk of producing spurious and erratic values. Our analysis of Cova de Cendres dates indicates the consequences of mixing charcoal fragments from temporally distinct original contexts. The dates from such samples are averages derived from variable and unknown proportions of temporally distinct organic material. The anomalous dates from other assemblages—such as those mentioned from Nerja, Dehesilla, Fosca, and Verdelpino—could well be the result of similar processes and, hence, should be interpreted with caution.

To the extent possible, of course, dating should focus on organic samples with clear relationships to other archaeological materials. For example, bones and seeds of domestic taxa seem to offer the most reliable dating samples for Early Neolithic assemblages. Similarly, if we can generalize from the taphonomic analyses discussed above, bones with anthropogenic fractures for marrow extraction should provide more reliable dates for pre-ceramic assemblages in Mediterranean Spain. Furthermore, as was shown for Cendres, it is a worthwhile endeavor to identify charcoal fragments according to plant taxa, to the extent possible, before sending a sample to a laboratory for dating. The most reliable (and meaningfully interpretable) dates will come from single fragments or at least from fragments of the same plant taxon.

Finally, as we have argued elsewhere (Barton *et al.*, 2000) taphonomic processes do not need to be viewed as impediments to the interpretation of archaeological data. Rather, better information about the taphonomic processes that invariably affect archaeological assemblages offer the opportunity to better interpret the significance of material culture. As exemplified at Cendres, taphonomic analysis has permitted us to acquire more accurate dates for events represented at the site and more accurately model the transition to domestic economies there. Furthermore, as discussed

above, our analysis has provided better information about the rate of the appearance of Neolithic material culture in the sites studied. While we have focused on the taphonomy of faunal assemblages, it may be possible to employ other aspects of material culture—such as the lithic assemblages—in the same way. Recent work (e.g., Starnini & Voytek, 1997) is promising in this regard. Overall, more comprehensive understanding of the processes responsible for forming the archaeological record are fundamental to interpreting and ultimately explaining that record.

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