



Identifying fossil rabbit warrens: Insights from a taphonomical analysis of a modern warren



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ABSTRACT

The European rabbit is a small burrowing mammal that is particularly abundant in Western Europe since the Pleistocene and introduced around the world over the last few centuries. Rabbit bones are regularly recovered from archaeological and palaeontological sites; however, demonstrating their contemporaneity with associated material is often difficult. Additionally, determining the origin of rabbit remains in fossil sites is equally problematic due to the lack of reference collections for natural accumulations. In order to address these issues, we excavated a modern rabbit warren in southwestern France using modern archaeological field methods and techniques. The bone accumulation was analysed using a taphonomic approach in order to determine the most relevant criteria for identifying fossil warrens. The assemblage is heavily fragmented and dominated by individuals less than three months old and, unlike what could be expected, no preserved anatomical connections were documented. Bone concentration is low and connected to occupation duration. Taken together, the criteria we identify aid in better identifying fossil warrens in fossil sites as well as evaluate the integrity of the deposits. Finally, our results also add precision to environmental, biostratigraphic and palaeoethnographic interpretations.

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1. Introduction

Elucidating the taphonomic context of archaeological material recovered from a given site is fundamental for establishing the integrity of palaeo-ethnographic and palaeo-environmental interpretations (Wood and Johnson, 1978). Post-depositional disturbances by burrowing animals (i.e. bioturbation; e.g., Araujo and Marcelino, 2003; Mallye, 2007), who create underground galleries for shelter, reproduction, or caching food (Butler, 1995), may substantially alter stratified deposits (Eldridge and Myers, 2001; Hole, 1981; Rutin, 1992; Voslamber and Veen, 1985) and mix archaeological material (Dalland and Carter, 1998; Frankel, 1986; Mallye, 2007, 2011; Vergès et al., 2002; Zilhão et al., 2010). The presence of burrowing animal bones in archaeological or paleontological assemblages therefore poses questions for their role in site formation, including the contemporaneity of these remains with other assemblage components and therefore the reliability of the studied material (Balek, 2002; Bocek, 1986; Mallye, 2007, 2011).

Amongst burrowing mammals (e.g. bears, badgers, foxes, marmots, moles), the European rabbit (*Oryctolagus cuniculus*) plays a particular role in Old World Archaeology. After a complex evolutionary history since the Pleistocene, this species is currently found across a large area of the Mediterranean Basin, particularly in southern Europe and the Maghreb (De Marfà, 2009; Donard, 1982; López-Martínez, 1989; Pelletier et al., 2015a). Following its introduction or the creation of favourable conditions for survival by human activity since the 4th century (Callou, 1995), the common rabbit is now present on all six continents as well as >800 islands (Callou, 2003; Flux, 1994; Flux and Fullagar, 1992). The remains of this leporid are frequently found on archaeological and paleontological sites and can be the most abundant species in certain cases (Bourguignon et al., 2016; Brugal et al., 2012; Cochard et al., 2012; Jones, 2006; Lloveras et al., 2011; Rodríguez-Hidalgo et al., 2013a; Rosell et al., 2010; Sanchis Serra and Fernández Peris, 2008).

The European rabbit, as well as its ancestors who likely shared the same behavioural patterns, generally burrow into loose, well-drained soils on flat or sloped terrain at altitudes of up to 1000 m (Biadi and Le Gall, 1993). The architecture of the interconnected burrows, known as a warren, is directly related to the nature of the sediment. For example, in loose sediments (e.g. sands) they are relatively simple, comprising a limited number of entrances and galleries whereas in more compact substrates (e.g. silts and clays) they can be deeper and much more complex (Kolb, 1985). Additionally, given its size and weight (1 to 2 kg), the rabbit is the preferential prey of more than forty predators (Delibes and Hiraldo, 1981), including humans (Brugal, 2006; Cochard et al., 2012; Hockett and Bicho, 2000; Lloveras et al., 2016; Pérez Ripoll, 2004; Sanchis Serra, 2012).

Fossil rabbit bone assemblages can be connected to three different accumulation agents. Non-human predators (terrestrial carnivores, nocturnal or diurnal birds of prey) identifiable based on numerous experimental reference collections (Álvarez et al., 2012; Armstrong, 2016; Cochard, 2004b, 2004c; Cohen and Kibii, 2015; Cruz-Uribe and Klein, 1998; Hockett, 1989, 1991, 1995, 1996; Lloveras et al., 2008a, 2008b, 2009a, 2012a, 2014a, 2014b; Mallye et al., 2008; Rodríguez-Hidalgo et al., 2013b, 2015; Sanchis Serra, 2000; Sanchis Serra et al., 2014; Schmitt, 1995; Schmitt and Juell, 1994) and characteristic tooth marks or traces of digestion (e.g., Cochard, 2004a; Lloveras, 2011; Sanchis Serra, 2012). On the other hand, the repetition of specifically located cut-marks, traces of burning (Lloveras et al., 2009b; Pérez Ripoll, 1993; Vigne and Marinval-Vigne, 1983; Vigne et al., 1981) and or a significant proportion of shaft cylinders (Hockett, 1991) are typically associated with human predation. Finally, natural bone accumulations without any direct evidence for a predator input reflect either accidental deaths, for example in natural traps (Cochard, 2004a; Pelletier et al., 2015b) or attritional deaths in burrows.

These attritional death profiles have important implications for fossil bone assemblages and associated bioturbation processes affecting

sediments and fossil deposits, as 'intrusive' bones are not contemporaneous with other remains found on a site. This phenomenon, while often evoked to explain the presence of rabbits in archaeological sites (e.g., Cochard, 2007; Pelletier et al., 2015b) it is rarely demonstrated by zooarchaeological analysis. Therefore, reliably distinguishing the origin of bone accumulations is fundamental not only in terms of biostratigraphy and paleoenvironmental reconstructions but also for better documenting subsistence practices of prehistoric groups. However, the identification of an attritional assemblage and the previous existence of a warren in a site are commonly based on theoretical models predicting the following (see Cochard, 2007 for a synthesis):

- 1) Spatial distribution and concentration: bone assemblages dispersed primarily in galleries with numerous anatomical connections preserved. The concentration of bones is relatively low compared to the overall volume of the warren;
- 2) Age and sex profiles: higher proportions of both immature individuals (0–8 months) compared to adults (> 8 months) and females to males;
- 3) Differential conservation: Very low bone breakage or uniquely dry bone breaks in relation to bone density;
- 4) Bone surface modification: non-predator accumulation with no traces of digestion, perforation, cut marks or burning as well as limited traces of weathering;
- 5) Bone preservation: Bone patinas (coloration and or mineralisation) differing from associated faunal remains.

Here we present the results from the excavation of a modern rabbit warren and a taphonomic analysis of the faunal material in order to evaluate these criteria and test which are most diagnostic for identifying rabbit warrens and hence the bioturbation of archaeological sites by this burrowing mammal.

2. Material and methods

2.1. The "Six Chemins" warren

The "Six Chemins" (LSC) warren (45°39'13"N, 0°18'9"W) is located in the Charente department of southwestern France on the commune of Gensac-la-Pallue. The area consists of sparsely wooded limestone plains used for cereal crops and vineyards planted in a calcareous brown soil no thicker than a few dozen centimetres. The warren is spread over approximately 55 m² at the edge of a small wood, taking advantage of a soil heap at its edge. Twenty-six entrances were identified in the north-south oriented warren (Fig. 1), an orientation that is generally the case with rabbits as it permits the longest exposure to light and warmth during the day (Biadi and Le Gall, 1993).

Local inhabitants have noted the abundance of rabbits at the site for at least 60 years. While surveys carried out in the winter of 2014 documented fresh rabbit droppings at the burrow entrances, suggesting a recent occupation, cobwebs and dead leaves seen to be obstructing the entrances during the summer of 2015 indicate the warren to be abandoned seasonally (Biadi and Le Gall, 1993). Our excavations were carried out during this period of abandon.

Our surveys also noted the warren to lay approximately 100 m from a fox den (*Vulpes vulpes*), where we collected the remains of 15 rabbits, seven of which bore traces of predation (tooth marks), in loose anatomical connection from a 40 m radius around the den. While this association of warrens and fox dens is relatively common (Biadi and Le Gall, 1993; Mulder and Wallage-Drees, 1979), no visible evidence for the presence of foxes or other predators was noted in the excavated area.

The warren was excavated using common archaeological methods and a one square metre grid system aligned along the principal axis of the warren. The southern section of the site is covered with relatively recent household waste (e.g. glass fragments and metal objects), with two-thirds of the northern zone covered by earth. We focused primarily on the northern section, between lines D to G and bands 5 to 10, for a

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