Journal of Archaeological Science: Reports 22 (2018) 237–247

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Settlement patterns during the Magdalenian in the south-eastern Pyrenees, Iberian Peninsula. A territorial study based on GIS

Bàrbara Mas[a,b,*], Ethel Allué[a,b], Marta Sánchez de la Torre[c,d], Óscar Parque[a,b,d], José Miguel Tejero[d,e], Xavier Mangado[d], Josep Maria Fullola[d]

[a] Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain
[b] IPHES, Institut Català de Paleoecologia Humana i Evolució Social, Zona Educacional 4, Campus Sescelades URV (Edifici W3), 43007 Tarragona, Spain
[c] PPVE, Universidad de Zaragoza, 12 Pedro Cerbuna, 50009 Zaragoza, Spain
[d] SERP (Seminari d'Estudis i Recerques Prehistòriques), Universitat de Barcelona, Montalegre 6-8, E-08001 Barcelona, Spain
[e] CNRS, UMR 7041, ArScAn Équipe Ethnologie Préhistorique, 92023 Nanterre, France

ARTICLE INFO

Keywords:
GIS
Settlement patterns
Site location
Macrospatial analysis
Late Palaeolithic
South-eastern Pyrenees

ABSTRACT

The territorial characteristics and environmental factors involved in the selection of a specific site for establishing a settlement are key features in the analysis of hunter-gatherers' knowledge of (and dominance over) their surroundings and in the attempts to understand the survival strategies that they deployed. This paper presents a macrospatial analysis using GIS tools, which provides an objective comparison of territorial variables at several Magdalenian archaeological sites located in the south-eastern Pyrenees (NE Iberia). To establish the settlement patterns, we analyse territorial values: orientation, elevation, slope, sites aspect (caves, rock shelters or open air) and distance from rivers. With the data obtained, we create solar radiation models, construct groups of sites according to visibility, and calculate the displacement costs of mobility. The results suggest a series of different settlement patterns during the Magdalenian. The visibility of rivers from the archaeological sites and potential sunlight are characteristic features throughout the period, but the distance between rivers and settlements decreases diachronically. Comparison of the climate models indicates that settlements in the vicinity of the river were more frequent at times with evidence of low rainfall. Likewise, the costs of displacement from the surrounding territory to the archaeological sites increase; access to the Lower Magdalenian sites is easier, and access to the Upper Magdalenian sites much more difficult.

1. Introduction

The Magdalenian is one of the most documented and well-known Palaeolithic chrono-cultural phases in western Europe, characterized by the diversity of symbolic art, fauna and lithic remains in the archaeological record (Fullola et al., 2012; Vega et al., 2013). These records have allowed the study of changes in strategies for procuring biotic and abiotic resources and in social and symbolic behaviour, and reflect the variability and development of technical systems of lithic knapping and production of bone tools (Benito-Calvo et al., 2009; Calvo et al., 2009, 2008; Esteve, 2009; Fullola, 2001; Fullola et al., 2006; García-Diez and Vaquero, 2015; Langlais, 2010; Maluquer de Motes, 1983–1984; Mangado et al., 2014, 2013, 2010, 2009; Martínez-Moreno et al., 2007; Mithen, 1988; Montes, 2005; Mora et al., 2011; Morales and Verges, 2014; Peña and Cruz, 2014; Roman, 2016; Sánchez de la Torre, 2015; Sánchez de la Torre and Mangado, 2013; Tejero, 2009; Tejero et al., 2013; Utrilla et al., 2013, 2010; Utrilla and Mazo, 2014; Utrilla and Montes, 2009). These studies have used a variety of approaches, but spatial analyses have not been applied to date in the Magdalenian sites of north-eastern Iberia. The spatial analysis of prehistoric sites provides interesting insights into the study of settlement dynamics and mobility strategies. Moreover, the conservation and excavation of the Magdalenian sites in north-eastern Iberia has allowed paleoenvironmental reconstructions of the southern Pyrenees at the end of the Last Glacial period, coinciding with the deglaciation of the Pyrenees around 20 kyr BP (Alcolea, 2017; Allué, 2009; Allué et al., 2012a, 2012b, 2018; Aura et al., 2011; Bergadà, 1991; Burjachs, 2009; Fullola et al., 2012; Fumanal and Ferrer, 2014; Soler et al., 2009). During the Magdalenian, the climatic sequence underwent a transition between the colder episode GS-2a and the GI-1 interstadial. The interstadial GI-1 began with a

* Corresponding author at: Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain.
E-mail addresses: barbara.mas86@gmail.com (B. Mas), eallue@iphes.cat (E. Allué), sanchezdelatorre@unizar.es (M. Sánchez de la Torre), jose-miguel.tejero@mae.cnrs.fr (J.M. Tejero), mangado@ub.edu (X. Mangado), fullola@ub.edu (J.M. Fullola).

https://doi.org/10.1016/j.jasrep.2018.10.002
Received 11 June 2018; Received in revised form 1 October 2018; Accepted 2 October 2018

rapid increase in temperatures, similar to current temperatures. Favourable temperatures were interrupted by two colder oscillations, the sub-stadials GI-1d and GI-1b (sensu Walker et al., 1999). The warm pulsation after GI-1a oscillation gradually decreased until the beginning of stadial GS-1, with very cold temperatures in a large part of Europe until the beginning of the Holocene.

Models of the differences in the forms of territorial occupation and exploitation can help to define the adaptation and survival strategies used by palaeolithic human groups (Binford, 1980, 1982; Brück and Goodman, 1999; Cleland, 1966; Gamble, 1986; Kelly, 1983). Interpreting the possible interactions between these groups and their immediate environment is essential to an explanation of the influence of the different strategies used for land management and natural resource catchment (Allen et al., 1990; Butzer, 1989; Chatters, 1987; Clark, 1972; Clarke, 1977; Eriksen, 1997). The choice of the site for a settlement depends on the season in which it is to be occupied, the pattern of territorial mobility and the procedures involved in the decisions made by human groups (Binford, 1980; Clark, 1972; Kelly, 1983; Saaty, 1972: 1061). A variety of factors of the landscape must be taken into consideration when deciding on its exploitation, for example its topography (location, riverbeds, vegetation), resource availability (proximity and accessibility), and conditions of liveability (dimensions, visibility and thermal comfort).

Quantitative and qualitative information on the territorial and environmental characteristics of archaeological sites allows the description of settlement patterns and mobility strategies of hunter-gatherer groups (Grove, 2009; Jochim, 1976). Using Geographical Information Systems (GIS) it is possible to obtain, quantify, and analyse the territorial factors that are observed qualitatively in the immediate environment of an archaeological site (Allen et al., 1990; Conolly and Lake, 2006; Eriksen, 1997; Hodder and Orton, 1990).

Site location preferences play a role in social organization. There are a range of landscape factors, such as proximity to specifics resources (like rivers or forests), terrain conditions (like slope or accessibility) or habitability conditions that could affect these preferences. Subsistence in the southern Pyrenees during the Magdalenian is not determined exclusively by the climatic conditions, cultural behaviour or by technological adaptations (Fullola et al., 2012). There are certain territorial variables that define different landscapes, like latitude, altitude and topography. In many cases, these preferences have been intuitively related, but they have been seldom analysed in a systematic way. The objective of this study is to define the settlement patterns and territorial characteristics in the Magdalenian sites located in the southern Pyrenees. Studies of the spatial characteristics around the Magdalenian sites have never been analysed jointly in the south-eastern Pyrenees. However, the settlement patterns of Magdalenian sites in the adjoining area of Cantabrian region have been carried out (see García, 2013; García-Moreno, 2013, 2015). In order to evaluate how the changes in settlement patterns could have been related the landscape conditions, the territorial characteristics are analysed. Using GIS, sites orientation, solar radiation, visibility and energy mobility cost from a set of Magdalenian sites are analysed and evolution in preferences are defined. The spatial analysis performed should broaden our understanding of the changes in the territorial management strategies and site location preference by human groups, during the Lower Magdalenian to the Upper Magdalenian in south-eastern Pyrenees.

2. Material and methods

The area of study comprises the modern-day regions of Aragon and Catalonia, north-eastern Iberian Peninsula, on the southern slope of the Pre-Pyrenees. This slope is situated between the structure or apex of the Segre river, and between the Mesozoic and Cenozoic outcrops that constitute the eastern boundary from the Mediterranean Sea and, to the west, the Cinca river valley and his tributaries (Vera, 2004) (Fig. 1).

Table 1 presents the reoccupations and the presence/absence of humans at the sites analysed, according to the different chrono-cultural phases of the Magdalenian (Fullola, 2001; Mangado et al., 2010, 2014; Montes, 2005; Mora et al., 2011; Tejero et al., 2013; Utrilla and Mazo, 2014; Utrilla et al., 2010, 2012). For the analysis of the settlement patterns, three chrono-cultural groups have been established according to the spatial characteristics of sites with evidence of occupation, also including archaeological sites with more than one occupation phase: the Lower Magdalenian group, comprising Montlleó, Cova Alonsé, Forcas I and Cova Gran; the Middle Magdalenian group, comprising Cova del Parco, Fuente del Trucho and Cova Gran; and the Upper Magdalenian group, including Cova del Parco, Cueva de Chaves, Bora Gran d'en Carreras, Forcas I, Legunova, Peña 14 and Cova Gran.

2.1. Radiocarbon dating

Human presence or absence was established based on radiocarbon dating reported in other studies, from different Magdalenian archaeological sites (Table 2). We perform the calibration because we believe it is necessary to join the set of Magdalenian sites dates, currently isolated, and put them in a territorial context.

The calibration was carried out using the online tool OxCal v.4.3.2 (Ramsey, 2017), with a deviation range lower than 101. We used IntCal-13 curve (Reimer et al., 2013) and NGRIP ice core (Rasmussen et al., 2014).

2.2. GIS analysis

GIS was used to generate a hypothetical reality model for a specific territory. This allows the interpretation of the relationship between human behaviour and the environment by selecting precise territorial variables. The territorial variables are discussed below.

2.2.1. Vector and raster data: DEM and rivers layers

Data were spatially analysed and referenced from a GIS project through free software program QGIS, and its application GRASS version 10.12.3. Digital cartographic base maps were generated from the topographic maps in raster (Digital Elevation Models), vector and metadata layers (rivers) downloaded for the provinces of Lleida, Huesca, Zaragoza and Girona, obtained from the *Institut Cartogràfic de Catalunya* (ICC) and the *Instituto Geográfico Nacional* (IGN). To undertake the macrospace analysis, we downloaded the Digital Elevation Models (DEM) (mdt25) and rivers layers of the municipalities where the Magdalenian sites are located… The rivers vectors have been necessary for the distances measurements, between the exact location points of the archaeological sites up to the nearest river course.

2.2.2. Analysis of settlement patterns

The term “spatial model” refers to the use of spatial data to simulate a process, to understand a complex relationship, to predict a result, or to analyse a problem (Conolly and Lake, 2006: 73). Spatial models are applied to establish the relationship between the location of archaeological sites and territorial variables such as slope and orientation, classification of archaeological sites according to site type (i.e., cave, open air and rock shelter), visible area and distance from settlements to rivers.

2.2.2.1. The orientation of archaeological sites and site types: solar radiation analysis. Sunlight and sun heating are usually considered desirable factors for good habitability conditions (Fano, 1998; García-Moreno, 2015). In our study, we include the Palaeolithic habitat in the caves, since certain domestic activities were carried out outside the cave or near the entrance (Mangado et al., 2014). The QGIS-GRASS's solar radiation analysis computes direct, diffuse and reflected solar radiation raster maps for a given day, the latitude, the surface and the atmospheric conditions. The latitude used in the calculation of the potential insolation was 42° 30′, since it constitutes the approximate