Quaternary Research 81 (2014) 63–77

Contents lists available at ScienceDirect

Quaternary Research

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

Vegetation and fire history since the last glacial maximum in an inland area of the western Mediterranean Basin (Northern Iberian Plateau, NW Spain)

César Morales-Molino [a,b,*], Mercedes García-Antón [b]

[a] Departamento de Silvopascicultura (U.D. Botánica), E.T.S.I. de Montes, Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain
[b] Departamento de Biología (Botánica), Facultad de Ciencia, Universidad Autónoma de Madrid, c/Darwin 2, Cantoblanco, 28049 Madrid, Spain

ARTICLE INFO

Article history:
Received 28 June 2013
Available online 15 November 2013

Keywords:
Pollen
Microscopic charcoal
Paleoecology
Iberian Peninsula
Late glacial
Holocene
Coprophilous fungi
Climate change
Human impact

ABSTRACT

We reconstructed vegetation responses to climate oscillations, fire and human activities since the last glacial maximum in inland NW Iberia, where previous paleoecological research is scarce. Extremely sparse and open vegetation composed of steppic grasslands and heathlands with scattered pioneer trees suggests very cold and dry conditions during the Oldest Dryas, unsuitable for tree survival in the surroundings of the study site. Slight woodland expansion during the Bølling/Allerød was interrupted by the Younger Dryas cooling. Pinewoods dominated for most of the early Holocene, when a marked increase in fire activity occurred. Deciduous trees expanded later reaching their maximum representation during the mid-Holocene. Enhanced fire activity and the presence of coprophilous fungi around 6400–6000 cal yr BP suggest an early human occupation around the site. However, extensive deforestation only started at 4500 cal yr BP, when fire was used to clear the tree canopy. Final replacement of woodlands with heathlands, grasslands and cereal crops occurred from 2700 cal yr BP onwards due to land-use intensification. Our paleoecological record can help efforts aimed at restoring the natural vegetation by indicating which communities were dominant at the onset of heavy human impact, thus promoting the recovery of currently rare oak and alder stands.

Introduction

The Iberian Peninsula is currently one of the most biodiverse areas in the Mediterranean Basin (Médail and Quézel, 1997), which is in turn one of the main hotspots in the world for biodiversity conservation (Myers et al., 2000). A long history of human disturbance has shaped current floristic and vegetation patterns, often modifying the original ecosystems in a drastic way (Blondel, 2006; Carrión et al., 2007; Colombaroli et al., 2008) and, thus, making it difficult to imagine what the natural landscape would look like. In this sense, the plateaus of inland Iberia represent one of the most extreme cases of natural ecosystem disruption by human activities, as they currently show an almost completely deforested landscape dominated by crops. Deciphering the appearance of the natural vegetation is therefore a formidable task.

Paleoecological study of sedimentary sequences allows for the reconstruction of vegetation history, disturbance regimes and their interactions. Thus, pollen analysis is employed as a proxy for vegetation composition and biome type, anthropogenic pollen indicators (Behre, 1981; Brun, 2011) and dung fungal spores (van Geel et al., 2003; Baker et al., 2013) are related to agriculture and grazing, and microscopic charcoal particles are linked to regional fire activity (Tinner et al., 1998). The Northern Iberian Plateau constitutes a perfect study area for tracking human impacts through the last millennia, as it was strongly disturbed by anthropogenic activities. However, in relatively dry and continental environments such as inland Iberia, suitable sites for paleoecological research (e.g., lakes, mires) are fairly rare. In addition to this, many attempts aiming at paleoenvironmental reconstruction from this region have been unsuccessful due to poor preservation of pollen and other biological indicators in the available sedimentary archives (Carrión et al., 2009). As a consequence, most of the Iberian paleoecological sites are located in mountain and coastal areas (Postigo-Mijarra et al., 2010), and Holocene paleoenvironmental data at mid-altitudes in north-central Iberia are scarce.

Nevertheless, there are several paleoecological sequences from inner lowland areas of northern Iberia that provide valuable information on the past vegetation development over these territories: slope deposits in the Minho Basin (e.g., van Mourik, 1986), saline lakes of the central Ebro Basin (e.g., Valero-Garcés et al., 2000; Davis and Stevenson, 2007; González-Sampériz et al., 2008) and mires and marshlands in the Duero Basin (e.g., Allen et al., 1996; Muñoz Sobrino, 2001; Muñoz Sobrino et al., 2004). Focusing on the Northern Iberian Plateau, most of the existing sequences spanning the Holocene are located in its eastern half (García-Antón et al., 1995; Muñoz Sobrino et al., 1996; Franco-

* Corresponding author at: Dpto. Silvopascicultura (U.D. Botánica), E.T.S.I. Montes, Ciudad Universitaria s/n, 28040, Madrid, Spain.
E-mail addresses: cesarmoralesdelmolino@gmail.com (C. Morales-Molino), mercedes.garcia@uam.es (M. García-Antón).

0033-5894/$ – see front matter © 2013 University of Washington. Published by Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.yqres.2013.10.010

Múgica et al., 2001; Iriarte et al., 2001; Iriarte-Chiapusso et al., 2003; Franco-Múgica et al., 2005; García-Antón et al., 2011), while almost no paleoecological information is available from the western sector (López Sáez, 2012; Morales-Molino et al., 2013). Furthermore, some of these sites record only part of the Holocene or lack an accurate chronology, reinforcing the importance of obtaining new paleoecological data with a well-established chronological framework.

The late glacial period is a crucial period for understanding the subsequent ecosystem dynamics during the Holocene, and it has been studied profusely in the Northwestern Iberian Mountains (summarized in Muñoz Sobrino et al., 2007) and other mountainous areas of Iberia (e.g., Pons and Reille, 1988; Peñalba et al., 1997; van der Knaap and van Leeuwen, 1997; González-Sampériz et al., 2006). However, studies dealing with late glacial vegetation dynamics in inland Iberia are quite rare (Carrión et al., 2010), with no data from the Northern Iberian Plateau. Consequently, the response of vegetation to the abrupt climatic oscillations reconstructed for this period (Moreno et al., 2012; Muñoz Sobrino et al., 2013) remains unknown over vast areas of inland Iberia. It is important to determine whether there were rapid biotic responses to these climatic changes in inland Spain, similar to those recorded in central and northern Europe (Birks and Ammann, 2000; Ammann et al., 2000, 2012). Finally, fire history remains poorly studied in the westernmost sector of the Mediterranean Basin (e.g., Morales-Molino et al., 2011, 2013; Vannière et al., 2011; Connor et al., 2012), despite the enormous importance that fire has in the functioning of Mediterranean ecosystems (Pausas et al., 2008; Colombaroli et al., 2009; Gil-Romera et al., 2010).

In this paper we present a new paleoecological sequence (pollen, microscopic charcoal, dung fungal spores) from a mire located in the northwestern sector of the Northern Iberian Plateau. Our main aims were: i) reconstructing late glacial and Holocene vegetation history in the surroundings of the study site; ii) identifying the responses of inland Iberian ecosystems to the climatic oscillations occurred since the last glacial maximum (LGM); iii) reconstructing the fire history around the study site since the LGM and its relationship to vegetation dynamics; and iv) assessing human impact on the natural vegetation and determining which activities have led the landscape to be in its current state.

Study area

The Ayoó de Vidriales site (called Ayoó onwards) is a small mire (≈2 ha) situated on the northwestern fringe of the Northern Iberian Plateau (42°7.57′N, 6°4.22′W, 780 m asl; Fig. 1). It occupies a small hollow that lies on Pleistocene sediments, approximately 400 m from the town of Ayoó de Vidriales (Zamora province). Wet grassland dominated by *Molinia caerulea*, *Nardus stricta* and *Carex* spp., with some sparse shrubs (*Genista anglica*, *Calluna vulgaris*, *Erica tetralix*), covers most of the studied mire. The landscape surrounding the site is hilly and defined by the broad valleys of the River Esla tributaries, all of which are included in the River Duero Basin.

The regional climate is Mediterranean with some continental features. The mean annual temperature is approximately 10°C and annual precipitation averages approximately 500 mm, with a summer drought period that is approximately three months long (SIGA; sig.marm.es/siga). At a nearby weather station at Castrocontrigo (920 m asl), the mean temperature of the coldest month is 3.8°C and the mean temperature of the hottest month is 19°C. With regards to lithology, siliceous rocks are dominant and consist mainly of Ordovician phyllites, schists and

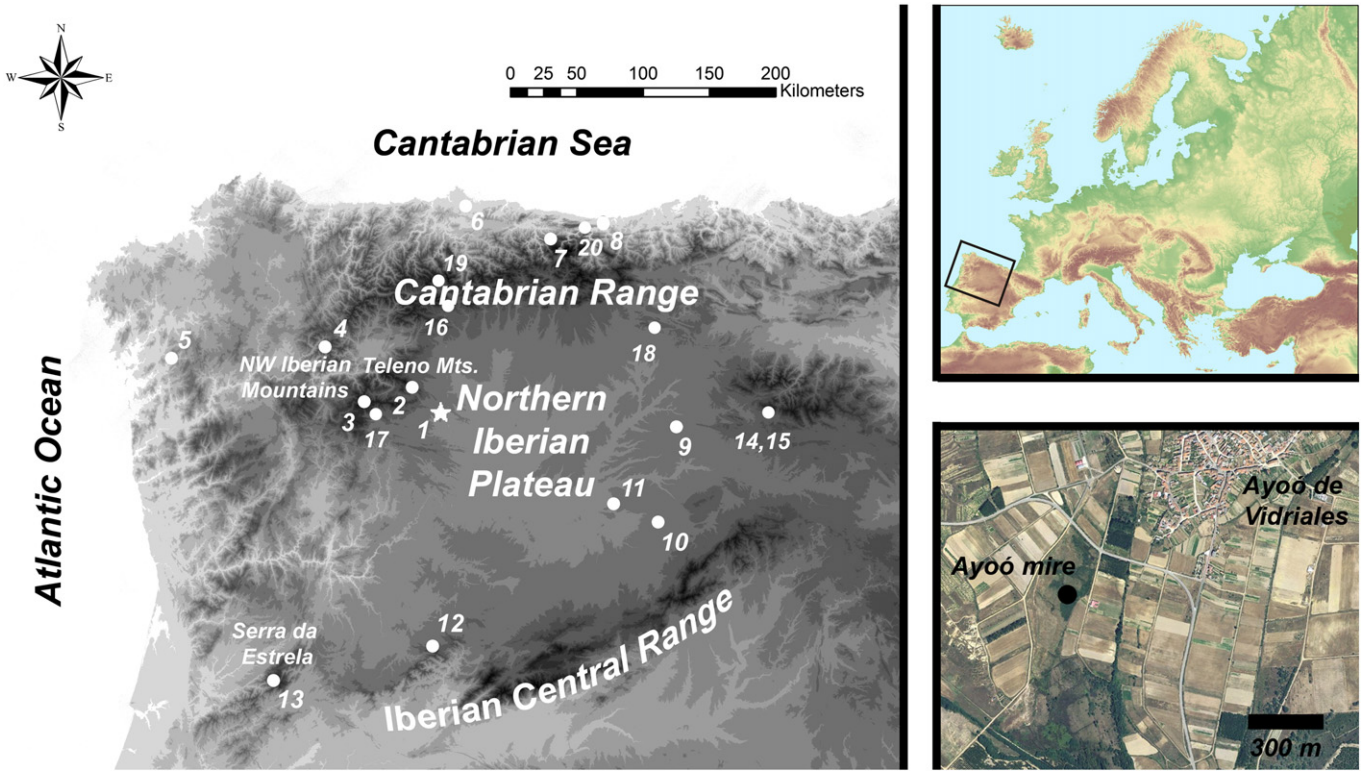

Figure 1. Location of the study site and the main paleoecological and paleoclimatic records discussed in the text. 1. Ayoó (this study), 2. Xan de Llamas (Morales-Molino et al., 2011), 3. La Roya (Allen et al., 1996; Muñoz Sobrino et al., 2013), 4. Lagoa de Lucenza (Muñoz Sobrino et al., 2001), 5. Campo Lameiro (Carrión-Marco et al., 2010; López-Merino et al., 2012), 6. Monte Areo (López-Merino et al., 2010), 7. Lago Enol (Moreno et al., 2011), 8. Pindal Cave (Moreno et al., 2010), 9. Espinosa de Cerrato (Franco-Múgica et al., 2001), 10. El Carrizal (Franco-Múgica et al., 2005), 11. Camporredondo (García-Antón et al., 2011), 12. El Maíllo (Morales-Molino et al., 2013), 13. Charco da Candieira (van der Knaap and van Leeuwen, 1995, 1997; Connor et al., 2012), 14 Quintanar de la Sierra (Peñalba et al., 1997), 15 Laguna Grande (Ruiz Zapata et al., 2002), 16 Laguillín (García-Rovés, 2007), 17 Lleguna, Laguna de las Sanguijuelas (Muñoz Sobrino et al., 2004), 18 La Piedra, San Mamés de Abar (Muñoz Sobrino et al., 1996; Iriarte et al., 2001), 19 La Mata (Jalut et al., 2010), 20 Roñanzas peat bog (Ortiz et al., 2010). At the bottom right is an aerial photograph of the study site, very close to Ayoó de Vidriales town and surrounded predominantly by cereal crops.