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A STUDY OF THE POST-GLACIAL VEGETATION IN "MONTES DO BUIO" (NW SPAIN)

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Summary. Although recent works have utilized longer sequences and contain a number of absolute dates, there is still insufficient information to provide a full account of the vegetation history in the northwest of the Iberian Peninsula. This work presents palynological analysis of three peat-bogs and a coastal organic-sediment deposit that were carried out the goal to complete the data of the vegetation change after the transition Younger Dryas/Holocene in the NW of the Iberian Peninsula. This work presents four pollen sequences from Montes do Buio covering the last ca. 10000 yrs. The most important results are: 1.-The taxa that best reflect the climatic changes and main stages of vegetation dynamics, since the last phases of the Lateglacial until the present are oak, hazelnut, birch, scot-pine, gramineae, heather and certain other more specific elements. 2.-To confirm the early retreat of scot-pine as a main component of the regional vegetation (9000 years ago), which did not occur in the higher mountains situated in the north of the Iberian Peninsula. 3.-To confirm the early expansion of oak, almost synchronously with the presence of the hazelnut (9800 years ago). To confirm the early development of hazelnut (8770 years ago), the presence of elm, so the early appearance of alder (9800 years ago) and its expansion after 6000 yr BP.

Resumen. Aunque recientes trabajos han utilizado secuencias largas y contienen un buen número de dataciones absolutas, resulta todavía insuficiente información para permitir una completa composición de la historia de la vegetación en el noroeste de la Península Ibérica. Este trabajo presenta el análisis polínico de tres turberas y un sedimento orgánico costero que se recogieron con el propósito de completar datos sobre el cambio de la vegetación tras la transición Dryas Reciente/Holoceno en el NO de la Península Ibérica. Este trabajo presenta cuatro secuencias polínicas de los Montes do Buio que cubren en torno a los últimos 10000 años. Los resultados más destacables son: 1.-Los táxones que mejor evidenciaron los cambios climáticos y dinámica de las principales etapas de vegetación, desde las últimas fases del Tardiglaciar hasta el presente en esta área son el roble, avellano, abedul, pino silvestre, gramíneas, brezos y algún otro elemento de carácter más puntual. 2.-Confirmar el retroceso precoz del pino silvestre como componente mayoritario de la vegetación regional (9000 años antes del presente), lo cual se indicó que no ocurría en las altas montañas situadas en el norte de la Península Ibérica. 3.-Confirmar la temprana expansión del roble, casi sincrónicamente con la presencia del avellano (9800 años antes del presente). Confirmar el desarrollo temprano del avellano (8770 años antes del presente), la presencia del olmo, así como, la temprana aparición del aliso (9800 años antes del presente) y su expansión a partir de los 6000 años BP.

INTRODUCTION

This study is aimed at reconstructing past conditions on the basis of the palynological record of the Montes do Buio in northwestern Iberian Peninsula.

The four sequences from Montes do Buio (NW Spain), which are supported by six radiocarbon dates, cover approximately the last 10000 yr. Although numerous palynological studies exist in this area (MENÉNDEZ-AMOR & FLORSCHÜTZ, 1961, 1963; MARY & al., 1973, 1975; AIRA, 1986; VAN MOURIK, 1986; SAA & DÍAZ-FIERROS, 1986, 1988; SAA & AIRA, 1988, RAMIL, 1992; RAMIL & al., 1994; GONZÁLEZ, 1996; GONZÁLEZ & SAA, 2000; SANTOS & al., 2000), situated in the Cantabrian-Atlantic province of the Eurosiberian geographic region (RIVAS & *al.*, 1987), it has not been possible to establish definitive conclusions on the vegetation dynamics of the Lateglacial-Holocene transition and Holocene period. As a result, the individual importance that each of the arboreal taxa *Quercus, Corylus* and *Betula* has in the development of the Post-Würm period vegetation is subject to some disagreement. It is also intended that the present study will contribute to the knowledge of the different stages of development of vegetation in the northernmost sector of SW Europe, as the climatic conditions imposed by the last glacial period were modified.

This study is a contribution to the understanding of the Holocene vegetation dynamics of the northwestern Iberian Peninsula, using the pollen analysis of a series of sequences, located in the Montes do Buio (Lugo, Spain). The Montes do Buio is located in the north of Lugo province, in the NW of the Iberian Peninsula at altitudes between 110 m and 700 m above sea level (Fig. 1). The sites are in geographic and topographic situations indicated in Table 1. The Lobeiras and Chao de Lagozas peat-bogs are located in the top of the mountain; in the south-east slope is Cuadramón peat-bog, whereas Xove is an organic sediment at near littoral.

Mean annual precipitation is around 1700 mm (between 1200-1400 mm in littoral), and mean annual temperature oscillates between 12°C and 14°C in the northern most and 11°C in the central territories along upper slopes. Thus, the climate is temperate maritime to cool maritime, with oceanic influence in upper slopes (PAPADAKIS, 1966; CASTROVIEJO, 1988). The north-west winds dominate in this region, though the north-east winds are, in certain times of the year, of some importance.

This site is located in the Eurosiberian biogeographic region (RIVAS & al., 1987; IZCO, 1987). It is possible to identify Eurosiberian-type deciduous forest belonging to the phytosociological *Blechno spicanti-Quercetum roboris* (TUXEN & OBERDORFER, 1958), whereas the sites swamped belonging to the *Carpinion-Polysticho-Fraxinetum excelsioris* or *Carpinion-Alno-Ulmion*. In the summit and upper slopes the present-day vegetation is basically scrubland.

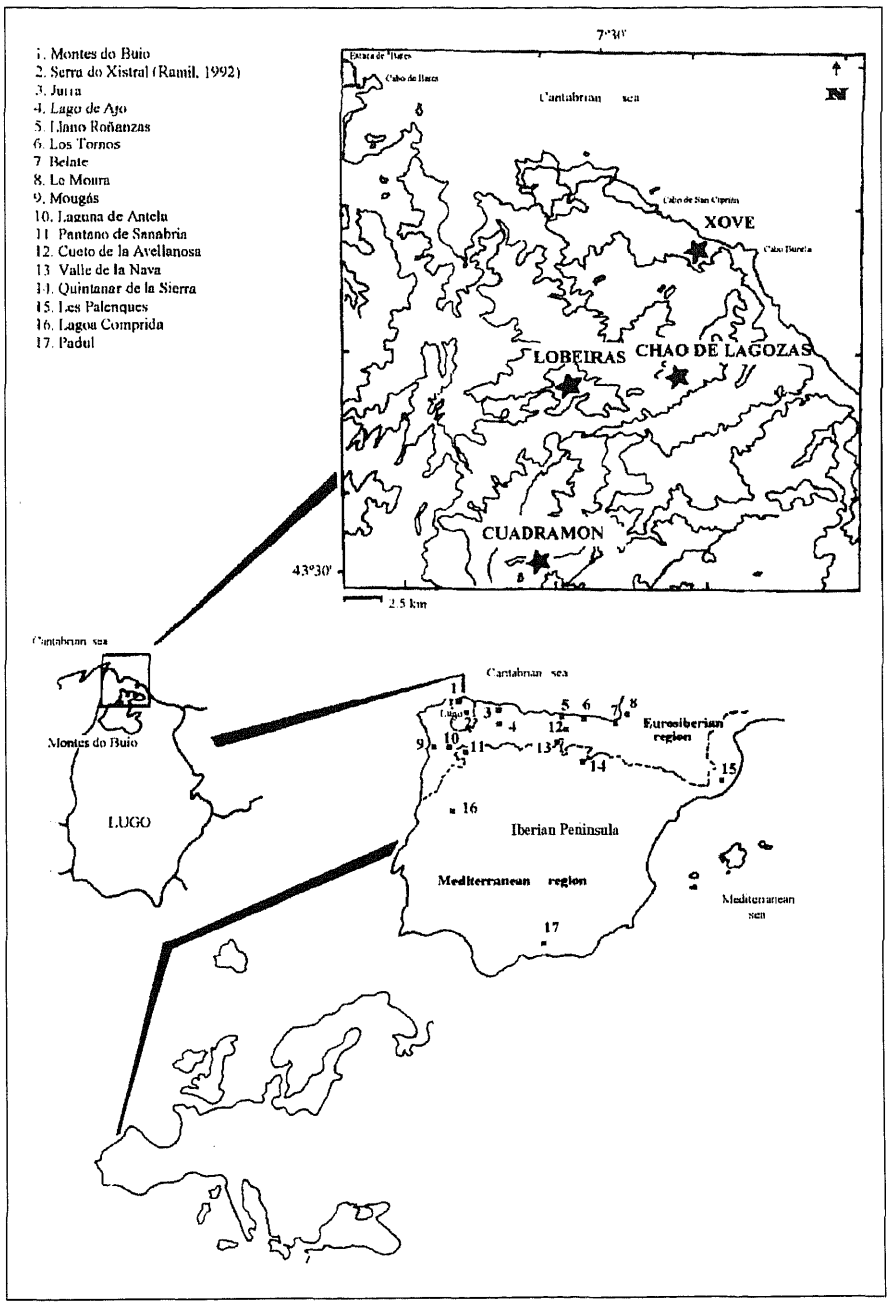

Fig. 1. Geographical and topographical situation. Location of other available interest data.

Site	Latitude	Longitude	Altitude	National map reference	Present vegetation
Lobeiras	43°35'20"	7°30'40"	660 m	29PJ2027	The present surrounding vegetation (Lobeiras, Cuadramón and Chao de Lagozas), markedly deforested at the present time, is formed by an acidophil heathland of *Erica cinerea* L., *Erica vagans* L., *Daboecia cantabrica* (Hudson) C. Koch, *Vaccinium myrtillus* L., *Calluna vulgaris* (L.) Hull, *Ulex gallii* sensu Samp. non Planchon, *Ulex europaeus* L. Vegetation in the peat-bogs is a hydromorphic peat heath composed of abundant *Erica mackaiana* Bab., *Erica ciliaris* L., *Calluna vulgaris* (L.) Hull, *Eriophorum angustifolium* Hockeney, *Narthecium ossifragum* (L.) Hudsom, *Cirsium filipendulum* Lange, *Molinia caerulea* (L.) Moench
Cuadramón	43°27'	7°31'50"	700 m	29PJ1913	
	43°36'	7°24'30"		29PJ2727	
Chao de Lagozas	43°35'20"	7°25'50"	520 m	29PJ2828	
Xove	43°40'10"	7°30'40"	110 m	29PJ2037	Due to reforestation the surrounding vegetation is *Pinus pinaster* Aiton and *Eucalyptus globulus* Labill. The thicket is fundamentally *Pteridium aquilinum* (L.) Kuhn

Table 1. Topographic and geographic location of the sites, and description of the present vegetation.

MATERIAL AND METHODS

Palynological analyses were performed on cores from several peat-bogs. Sampling has been carried out directly on the profile whenever possible (Cuadramón II, Lobeiras I, Lobeiras II and Xove) and using a Dachnowski corer (Lagozas III) when not.

Two sections have been sampled in Lobeiras, Lobeiras I & Lobeiras II. The latter one, is located a few centimetres from the former, and is embedded between two sandy beds at a depth of 130 cm

The most suitable traditional methods have been used for pollen extraction, according to the nature of the sediments. The method of extraction of pollen from mineral sediment consists of differential floating using a dense solution of BrZn (SAA, 1985). Sediments from peat bogs are treated with acids, acetolysis and filtration (BEAULIEU, 1977). Spores and indeterminate pollen have been excluded from the total pollen sum. Tilia software (GRIM, 1992) was used to compute the pollen concentration (APF) according to COUR (1974).

Local pollen assemblage zones were determined from the results of CONISS analysis using a square-root transformation (EDWARDS & CAVALLI-SFORZA's chord-distance) (GRIM, 1992).

RESULTS

The data obtained from palynological analysis are presented in the form of relative pollen percentage diagrams (Figs. 2, 3, 4, 5, 6).

Chronology

This data contribute a sufficiently solid basis for an approximation of the dynamics of development of the Galician Eurosiberian vegetation from the Lateglacial-Holocene transition to the present time. The pollen stratigraphic succession is supported by six radiocarbon ^{14}C dates obtained from bulk sediment samples. The diagram of Lobeiras, from the two sections, covers a wide palynological record and has three ^{14}C dates. Cuadramón, Chao de Lagozas, and Xove also have carbon dates (Table 2).

Description of pollen Zones

Pollen assemblage zones have been defined on the basis of variations in the pollen percentages of the most abundant. In Table 3 we describe the regional pollen assemblage zones. Despite the hiatus in sedimentation existing in some diagrams, an effort has been made to interpret the different vegetation stages by establishing a correlation with other nearby records. These records show similar chronologies on the basis of radiocarbon-dating published in bibliographic references of the area (MENÉNDEZ AMOR & FLORSCHÜTZ, 1961; SAA & DÍAZ-FIERROS, 1987; TURNER & HANNON, 1988; PEÑALBA, 1989; PEÑALBA & al., 1997; RAMIL, 1992, 1993; AIRA & al., 1994; SANTOS, 1996). These correlations are based on pollen percentage changes of the most important deciduous trees, such as *Corylus*, *Quercus* and *Betula*, and the non-arboreal, Poaceae, *Calluna* and other Ericaceae. In "other Ericaceae" we include pollen of *E. mackaiana*, *E. tetralix*, *E. ciliaris*, *E. arborea*, *Daboecia cantabrica*, *Vaccinium myrtillus*.

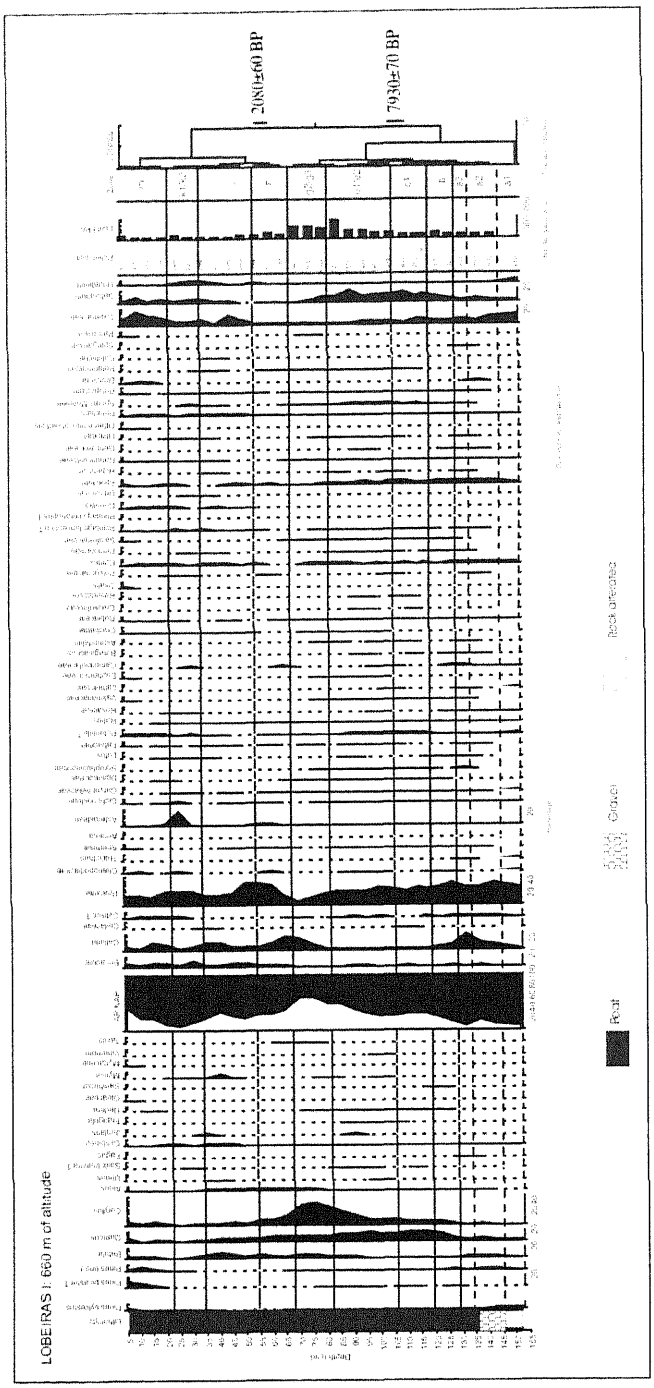

Fig. 2. Pollen diagram of relatives frequencies and absolute total frequency of Lobeiras peat-bog (Lobeiras I).

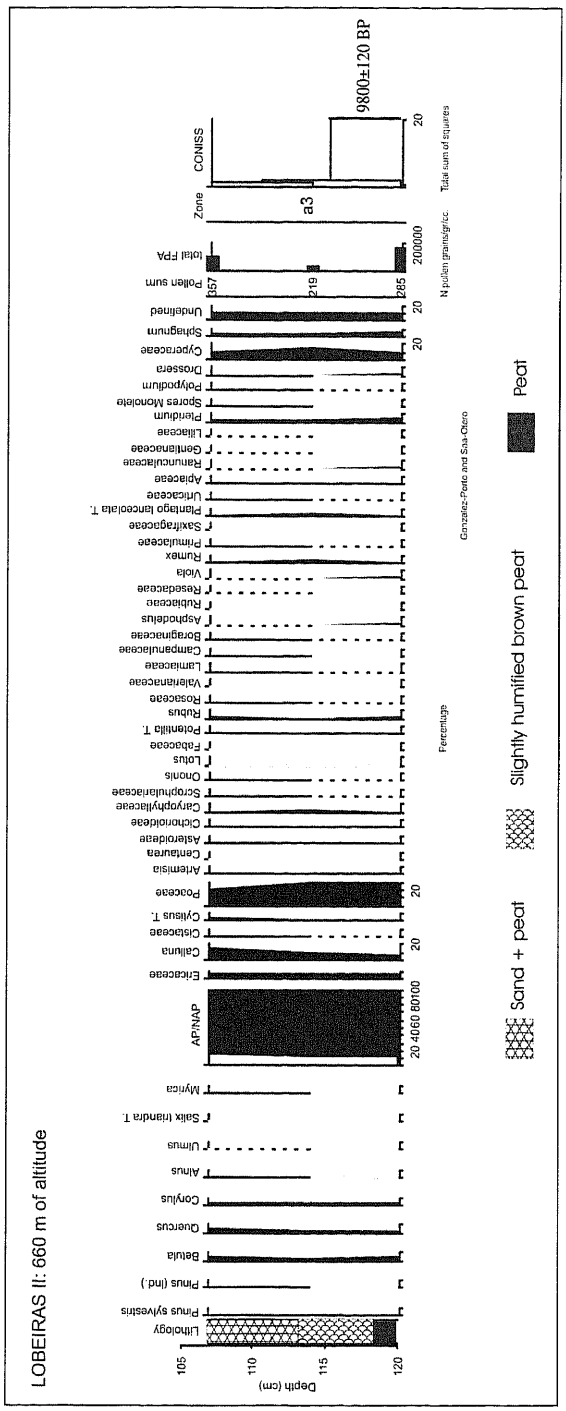

Fig. 3. Pollen diagram of relatives frequencies and absolute total frequency of Lobeiras peat-bog (Lobeiras II).

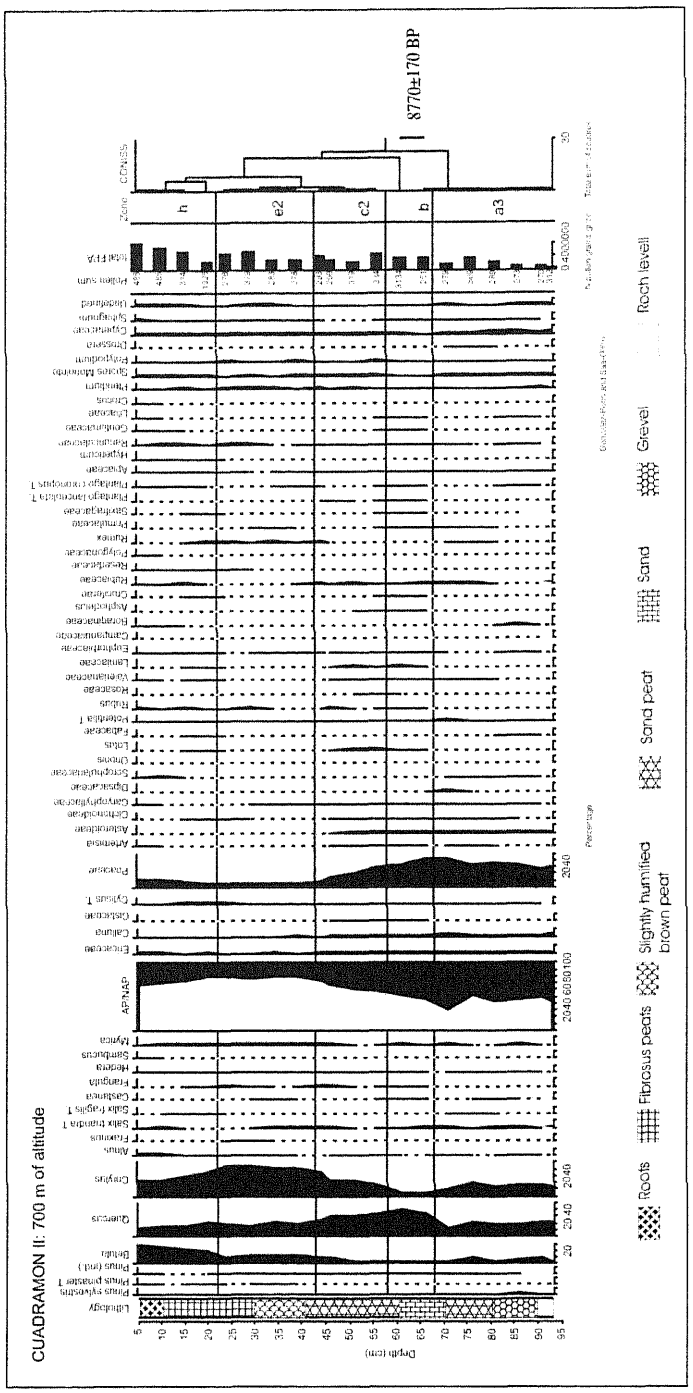

Fig. 4. Pollen diagram of relatives frequencies and absolute total frequency of Cuadramón peat-bog.

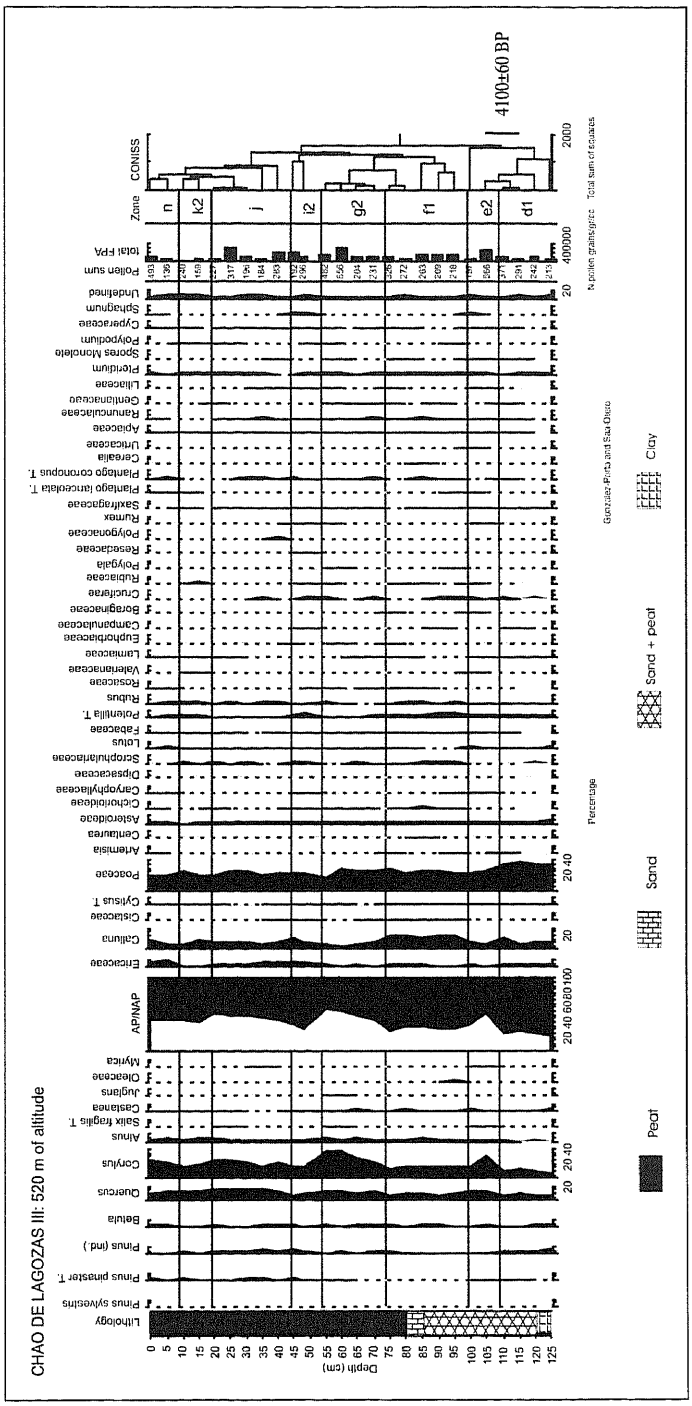

Fig. 5. Pollen diagram of relatives frequencies and absolute total frequency of Chao de Lagozas peat-bog.

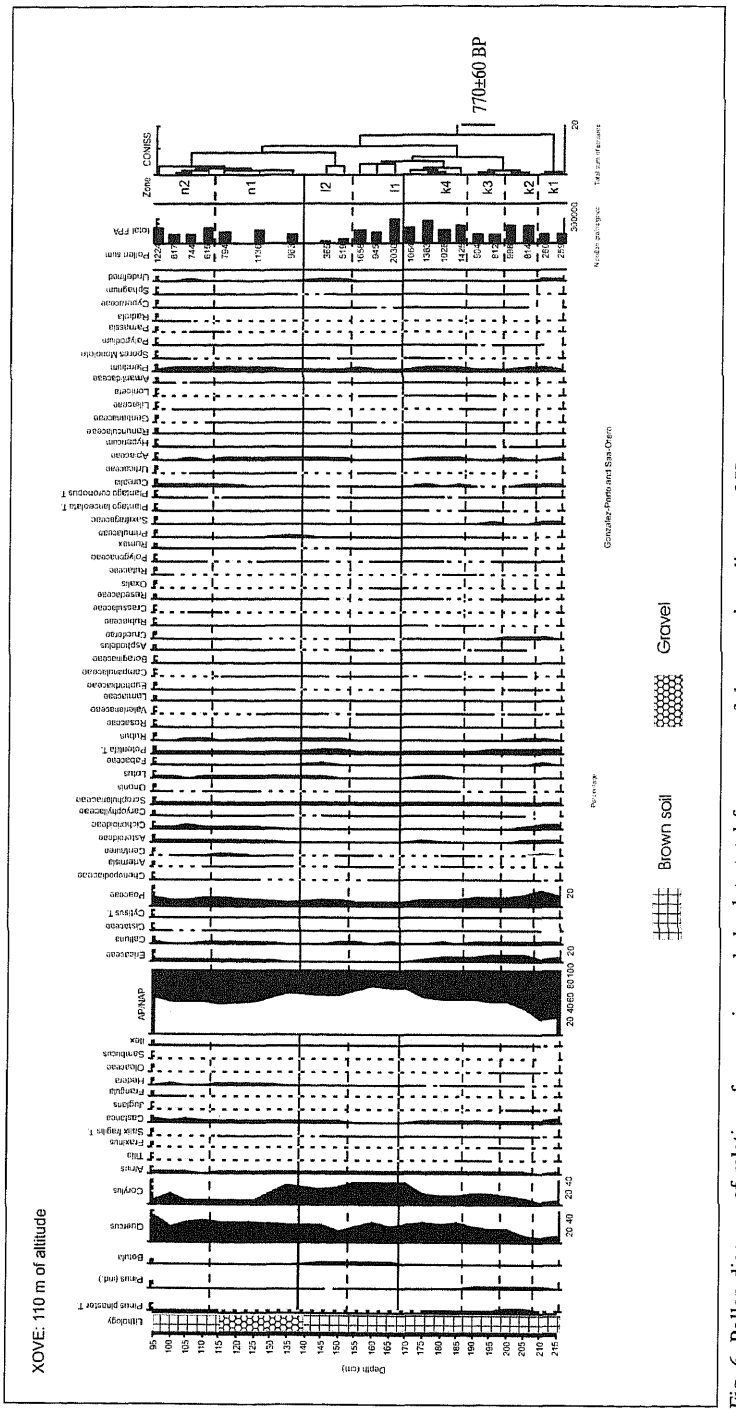

Fig. 6. Pollen diagram of relatives frequencies and absolute total frequency of the organic sediment of Xove.

Site	Pollen zone	Depth (cm)	Age (^{14}C yr BP)	Ref. lab.	Calibrated age (yr BC)
Lobeiras II	a3	114-120	9800±120	UGRA-348	9750-8750
Lobeiras I	c1	105-110	7930±70	ICEN-554	7050-6640
Lobeiras I	h	55-60	2080±60	UGRA-347	240-60
Cuadramón II	b	61-66	8770±170	UGRA-491	8300-7500
Chao de Lagozas III	e2/d1	105-115	4100±60	UBAR-515	2880-2550
Xove	k3	185-195	770±60	UBAR-517	1150-1310

Table 2. Radiocarbon dating (UGRA=Laboratorio de Datación C14 de la Universidad de Granada; ICEN=Laboratório Nacional de Engenharia e Tecnologia Industrial del Instituto de Ciências e Engenharia Nucleares de Portugal; UBAR=Laboratori de Datació per Radiocarboni de la Facultat de Química de la Universitat de Barcelona. Radiocarbon Calibration age OxCal Program v3.9 (c) Copyright Crristopher Bronk Ramsey. 2003. University of Oxford.

DISCUSSION

The Lateglacial-Holocene transition

The most ancient palynological record presented date, in part, from before 9800 ± 120 ^{14}C yr BP. Three different sub-zones can be distinguished in Lobeiras (I), which could indicate sedimentation stages under different climatic conditions widely separated in time. These palynological zones correspond to the end of the Lateglacial in Galicia. The characteristics observed in zone **a2**, such as the presence of the deciduous taxa, *Quercus* and *Corylus*, the low values of steppic taxa (*Artemisia*, Cichorioideae and Asteroideae), and the greater abundance of *Calluna*, are characteristic of the Lateglacial interstadial (RAMIL, 1992, PEÑALBA, 1989). The increase of *Betula* and of the taxa representative of greater humidity (*Calluna* or Cyperaceae) at the same time that temperate taxa became established, such as *Quercus* and *Corylus*, would indicate an increase of the precipitation and temperatures. In zone **a3**, the percentags of Poaceae and, in this case, *Calluna* (with higher frequencies than the other Ericaceae in this area, due to the orientation, vicinity to the sea, and low altitude of these mountains), associated with the low pollen percentages of trees, to the occurences of steppic taxa, to the lower pollen concentration and to the characteristics of the silt with elevating content in sands, on a channel of gravels, all this characteristics allow to frame this zone in the Lateglacial-Holocene transition. The non-arboreal taxa at the beginning of the Holocene period and the end of Lateglacial is characterised by the presence of *Thalictrum* and *Armeria*, also *Artemisia*). The evidence of the Younger Dryas cold spell cooling has been

Zone	Age (yr BP) (Age dated ^{14}C)	Description
a	>9800 (9800±120)	The palynological results show that in Lobeiras the vegetation contains an abundance of Poaceae and a few trees: *Pinus sylvestris* and *Quercus*. In Cuadramón, *Quercus* and *Corylus* are more abundant. In **a1** and **a3** the palynological data could indicate characteristics of Late-glacial steppe vegetation, consisting mainly of Poaceae, with few trees (*Pinus sylvestris*, *Quercus* and *Betula*) and the presence of plants found in cold, dry, habitats (*Armeria*, *Artemisia*, Asteroideae). In **a2** found in Lobeiras and Cuadramón (II), Holocene vegetation conditions could be reflected, indicated by a reduction of Poaceae, the greater importance of *Quercus*, *Betula* and *Corylus*. The zone **a3** could represent the early manifestation of *Corylus* which is few abundant in Lobeiras and more important in Cuadramón. The presence of *Ulmus* and a greater importance of the *Calluna* formations were observed.
b	>8770-8000 (8770±170)	Present in both peat-bogs (Cuadramón & Lobeiras), records an increase in *Quercus* pollen and also, in Cuadramón, a reduction of *Corylus* and *Betula*. Poaceae show a tendency to decrease. Beginning from this moment on represent the early expansion of the *Corylus*, which is few abundant in Cuadramón and more important in Lobeiras. Pollen concentration is higher.
c	8000-6000 (7930±70)	Is defined in Lobeiras (I) and Cuadramón. Characterised by a relative abundance of arboreal vegetation pollen: *Quercus* and *Corylus* are found to be in expansion. This fact, together with the low abundance of Poaceae, in addition to the low frequencies of *Calluna*, could indicate an optimum arboreal episode. The minimal presence of *Ulmus* in Lobeiras should be noted which could answer than regional contributions.
d	6000-5000	Defined in the diagram of Chao de Lagozas, indicates a retreat of the arboreal vegetation, *Corylus*, *Quercus* and *Betula* being the most representative taxa. The presence of cereal pollen and other taxa that evidence of human intervention is reduced.
e	5000-4000 (4100±60)	Has been defined in Cuadramón, Lobeiras (I) and Chao de Lagozas. It is characterised by the increase in arboreal vegetation due, above all, to the increase of *Corylus*. The curve of *Alnus* begins to be constant. The presence of *Fraxinus* in Cuadramón and *Juglans* in Lobeiras, that which because their low dispersion should define the local establishment of these taxa, should be noted. The presence of the latter taxa is clear proof of human presence. The increase in the pollen frequencies of *Corylus* and *Alnus* is often found in diagrams with a similar chronology, in some cases due to climatic factors, in others due to anthropic causes. The pollen concentration is higher than the previous levels.

Table 3. Description of the regional pollen assemblage zones.

Zone	Age (yr BP) (Age dated ^{14}C)	Description
f	4000->2500	Is defined for Chao de Lagozas, reflects a minimum arboreal content, an increase of *Calluna* and other Ericaceae, as well as Asteroideae. Despite the net decrease of the arboreal pollen: *Quercus* and *Corylus* should be noted. The presence of cereal pollen is a manifestation of human activity and thereby the chronology close to the zone
g	>2500	Has been defined in Lobeiras (I) and Chao de Lagozas. It shows a maximum arboreal-shrub content, related to the recuperation of *Corylus* and *Quercus* in Chao de Lagozas, the increase of *Betula*, of *Alnus* to a lesser extent. A decline in *Calluna* and other Ericaceae in Chao de Lagozas is recorded.
h	(2080±60)	Is recorded in Cuadramón and Lobeiras (I), is characterised by abundant arboreal vegetation which decline, due, above all, to the decrease of *Corylus*. The decrease of *Quercus* is also recorded.
i		Defined in Chao de Lagozas describes a new minimum arboreal-shrub content, where an increase of Ericaceae and *Calluna* was obtained, reflecting, an increase of *Pinus pinaster* T. as well. The pollen concentration is lower than the previous levels.
j		Defined in Lobeiras (I) and Chao de Lagozas, records the recuperation of arboreal-shrub, indicated by the increases observed for *Corylus*, *Betula* (Lobeiras) and *Quercus* (Chao de Lagozas). A decrease of Ericaceae, *Calluna* and Poaceae (Lobeiras), is recorded. The presence of cereal pollen is more abundant, whilst *Ulmus* and *Juglans* are presents in Lobeiras
k	(770±60)	Is defined in Lobeiras (I), Chao de Lagozas and Xove. It represents a zone of existing vegetation, characterised by the minor representation of arboreal vegetation. Despite this, predominance at these levels is that of Ericaceae and Poaceae. In this zone the maximal representation of cereal pollen is attained. *Tilia* is recorded at Xove.
l m n	Recent	Characterised by the presence of cereal pollen and Myrtaceae (=*Eucalyptus*), and an increase of *Castanea* and *Pinus pinaster*, are recorded at Lobeiras (I) (**m**). The arboreal recuperation defined in zones l and **m**, can only be seen in the samples from Xove and Lobeiras.

Table 3. Description of the regional pollen assemblage zones. Continued

recorded in some pollen sequences of northwestern Iberia (VAN MOURIK, 1986; WATTS, 1986; TURNER & HANNON, 1988; ALLEN & al., 1996; SANTOS & al., 2000). In this study, low percentages of *Artemisia* and Chenopodiaceae during this phase compared with other peninsular zones indicate that oceanic conditions of greater humidity prevailed in this area during the Younger Dryas (GONZÁLEZ, 1996; SANTOS & al., 2000). RUÍZ & ACASO (1981) describe that in the Sierra de Gredos during the Tardigalaciar there was a very open local landscape, formed by Poaceae, Cichorioideae and Cyperaceae, without *Artemisia*, whereas VÁZQUEZ (1992) describes that in the Sierra de Guadarrama existed a cold and dry steppe with *Artemisia*, like the central European conditions. DORADO & al. (1999), in the Guadiana basin, confirms the expansion of evergreen *Quercus*, *Olea*, etc. and the decrease of *Artemisia* and Quenopodiaceae since 9890± 180 14C yr BP. This zone could represent the early manifestation of *Corylus*, which is little abundant in Lobeiras and more important in Cuadramón. Similar palynological characteristics are obtained by VAN MOURIK (1986) in the Laguna de Antela. This area parallels other nearby peat-bogs, dated 9590 ± 120 ^{14}C yr BP and 9575 ± 55 ^{14}C yr BP in Tremoal de Pena Vella (RAMIL & al., 1994). The presence of *Ulmus* and the higher importance of the *Calluna* formations permit found a analogy between this pollen zone and some of others authors; this zone has been dated by means of carbon dating as such 8785 ± 30 ^{14}C yr BP in Chan do Lamoso (RAMIL, 1992), excepting that, in the present study, pollen from *Abies* has not been detected. However, the presence of pollen from this taxon and *Ulmus* in the NW Peninsular peat-bogs, is scarce in any of the climatic periods recorded and, in particular, the record of *Ulmus* in Galician sediments before the Atlantic Period is subject to controversy (VAN MOURIK, 1986; SAA & DÍAZ-FIERROS, 1986).

The low frequencies of arboreal pollen in Lobeiras could be explained by its topographic position, more influenced by oceanic winds.

Early and mid-Holocene: between 9500 and 5000 yr BP.

In the zone **b**, dated 8770 ± 170 ^{14}C yr BP, the vegetation characteristics correspond to the Boreal Period, represented by the early expansion of *Corylus*, which is not abundant in Cuadramón and more important in Lobeiras. This early expansion occurs more often in areas of more oceanic climatic conditions (SÁNCHEZ GOÑI & HANNON, 1999) such as the Courel Sierra in which the local expansion of *Corylus* begins as early as ca. 8800 yr BP (SANTOS & al., 2000) and at around 8540 ± 100 yr BP (AIRA, 1986); ca. 10000 yr BP (RAMIL & al., 1996). Its expansion to the north of Spain has been dated by other authors at about 8000 yr BP: later than 8785 ^{14}C yr BP (RAMIL, 1992); 7830 ± 90 ^{14}C

yr BP (PEÑALBA, 1989); 7725 ± 50 ^{14}C yr BP (VAN MOURIK, 1986) and 7830 ± 75 ^{14}C yr BP (MENÉNDEZ-AMOR & FLORSCHÜTZ, 1961). TURNER & HANNON (1988) in Sanabria, and recently, SANTOS & al. (2000) in the Courel Sierra, have indicated a strong decrease in the frequencies of *Quercus* at 8300 yr BP that is not shown either in Cuadramón or in Lobeiras. This event that has been interpreted as reflecting climatic deterioration, coinciding with an increase in microcharcoal particles at Courel Sierra where SANTOS & al. (2000), suggests a reduction of *Quercus* caused by a greater frequency of fires. VAN DER KNAAP & VAN LEEUWEN (1994) describe a xerothermic episode for Serra da Estrela in Portugal between 9500 and 8500 yr BP, with an optimum of *Quercus pyrenaica*, which appears to cohere with an increase of *Quercus* in Cuadramón. Vegetation change seems to follow the same pattern as in the high elevation areas where the forest is a dominated by *Quercus,* with *Corylus* as important component of the regional vegetation. This work points to an earlier expansion of *Corylus* in the more northwestern part of the Iberian Peninsula, probably due to the existence of more oceanic conditions, such as stated by SÁNCHEZ GOÑI & HANNON (1999).

During zone **c**, dated at 7930 ± 70 yr BP in the Lobeiras record reflects the expansion of *Quercus* which correspond to the climatic optimum of the Holocene.

In the Amblés valley (Avila), the atlantic forest is formed preponderantly by deciduous *Quercus* and *Betula* dated before 5930±100 14C yr BP (DORADO, 1993). In the Sierra de Gredos also before 5960 yr BP (FRANCO, 1995). In the Guadiana high basin, before 6150 ± 60 14C yr BP is recorded an increase of arboreal vegetation (*Pinus*, deciduous and evergreen *Quercus* and *Olea* (DORADO & al., 1999). In the Castillo de Calatrava is recorded the decrease of *Pinus* and deciduous *Quercus* and the evergreen *Quercus* remain, before 6240 ±190 yr BP (GARCÍA ANTÓN & al. 1986). In Sierra de Bejar (Garganta del Trampal, is recorded the expansion of woodland, with predominance of *Betula*, before to 5270 ±14 C yr BP (ATIENZA, 1993).

Zone **d** is not chronologically precise, as no absolute dating is available. However, its position in the diagram and its similarities with the palynological characteristics at Charca do Chan da Cruz (RAMIL, 1992), which is geographically close and dated 5880 ± 90 ^{14}C yr BP, permits to postulate a chronology in the latter part of the Atlantic period. The evidence of a decrease in woodlands in the area due to agricultural and grazing activity (*Cerealia*, *Plantago*, Urticaceae, *Rumex*, Cruciferae,...) could be included in this zone. This deforestation process is defined for diverse points of the Spanish Cantabrian area, as well as SW France and Portugal. It generally precedes the appearance of cereal pollen and an increase of other taxa indicative of human impact. It is asymmetric over the countryside depending on different anthropogenic pressures, maintai-

ning forestry characteristics in most of the spectra. In this study the zone **d** is present in Chao de Lagozas and absent in Lobeiras where the sedimentation seems even. The beginning of agriculture is estimated, for the NW Peninsula, between 5500 and 4000 yr BP: 5490 ± 90 yr BP in Pena Veira (RAMIL, 1992), before 4740 ± 40 yr BP in Montes do Buio (VAN MOURIK, 1986), before 4340 ± 90 yr BP in Lagoa Comprida, Serra da Estrela (VAN DEN BRINK & JANSSEN, 1985 a, b), indicating a delay with respect to the most meridional locations in the Peninsula, which have dates for this event placed between 6000 and 5000 yr BP (DUPRÉ, 1988). In other locations of the Cantabrian slopes it occurs in a period definitely later than 5500 yr BP. On the other hand, the cooling defined from 6000 yr BP onwards for western European according to the quantitative climatic reconstruction (GUIOT, 1987) would also explain deforestation in this region.

Late Holocene: between 5000 and present

The increases of *Betula* and *Alnus*, defined in the zone **g**, do not indicate a forest recover, but, most likely, should it be interpreted as a consequence of agricultural activity.

The recuperation of the deciduous arboreal taxa (*Betula* at Lobeiras, but *Quercus* and *Corylus* in the others), defined in the zone **j**, is also identified in Braña Rubia, between 1550 and 1200 yr BP (TORNQVIST, 1986; TORNQVIST & JOOSTEN, 1988; TORNQVIST & al., 1989) and in Llano Roñanzas, 1450 ± 90 ^{14}C yr BP (MARY & al., 1973).

This zone is dated at 770 ± 60 ^{14}C yr BP the new arboreal withdrawal began between 1300 and 1200 yr BP in the north Iberian Peninsular (beginning in 1510 ± 60 ^{14}C yr BP, in Montes do Buio, according to VAN MOURIK (1986), previous to the expansion of *Pinus*.

MENÉNDEZ AMOR & FLORSCHÜTZ (1968), in Daimiel II, obtained there was an arboreal vegetation with important predominance of *Quercus* before 3190 ± 70 yr BP. In the Paramera-Serrota (ANDRADE & al., 1990) is recorded the predominance of woodland (*Pinus*) before 2040 yr BP. In the Amblés valley (Avila), also predomined *Pinus Quercus* and *Olea*, both of them before 2953 ± 68 14C yr BP. In the Sierra de Guadarrama and Macizo de Ayllón are recorded an increase of *Betula* y *Corylus* about 2580 yr BP and the development of *Pinus, Quercus* and *Betula* all of them before 1710 yr. BP (GIL, 1992).

Discussion about the spread and establishment of the main taxa during the Holocene in NW of the Iberia

The first fact that stands out in all the diagrams is the diversity of non-arboreal plants, both in the stages with human activity and in the first part of the Holocene and Late-glacial periods. This is due, almost certainly, to the preponderant role played by *Corylus* and *Betula* (taxa which allow the passage of light to the herbaceous stratum of the ecosystem) during the whole Holocene.

Quercus colonisation, when visible is dated between 13200 and 12000 yr BP (Padul: PONS & REILLE, 1988) for the southern Iberian Peninsular and about 12 500 yr BP (Lago de Ajo: WATTS, 1986), or later for the north. The first expansion of *Quercus* has been dated at about 10000 yr BP and before the expansion of *Corylus*, by different authors, in mountainous areas in the north of the Iberian Peninsular (PEÑALBA, 1989, in Los Tornos, TURNER & HANNON, 1988, in Sanabria). In the north Galician mountains this was dated at 9500 yr BP (RAMIL, 1992). The importance de *Quercus* observed in the ancient levels of Cuadramón which we propose previous to 9800 yr BP, could indicate an early expansion episode in the Cantabrian coastal region of Spain (GONZÁLEZ, 1996; GONZÁLEZ & SAA, 2000), due to its privileged situation with relation to the thermal and pluvial regime that marked the Late-glacial period in the North Atlantic region (RUDDIMAN & MAC INTYRE, 1981). The important decrease of *Quercus*, indicated by TURNER & HANNON (1988) in Sanabria, has not been registered in the diagrams studied, nor in Quintanar de la Sierra (PEÑALBA, 1989). During the Holocene period their proportions increased, reaching frequencies of 40% of the total. Their values decrease from 4000 yr BP. This decrease is motivated at first by human activity; later oscillations have been produced by anthropic and climatic factors.

The beginning of the development of *Corylus* is dated, for the north of Spain, about 8000 yr BP: Los Tornos, Quintanar de la Sierra, (PEÑALBA, 1989, 1994); Serra do Xistral (RAMIL, 1992), Montes do Buio (VAN MOURIK, 1986); Piedra Hita (MENÉNDEZ-AMOR & FLORSCHÜTZ, 1961). The results shown here, point to a much earlier date of development, ca. 9800 yr BP. It could be said that it synchronises with that of *Quercus*. This data would seem to be supported by similar results in the South of France Le Moura (OLDFIELD, 1964) and Massif Central (BEAULIEU *& al.*, 1988), where a development date of 10000 yr BP was proposed. The expansion of *Quercus* occurs after 8770 yr BP and, in a more or less degree, its frequencies are important in the NW of Spain during the Holocene period.

The presence of *Alnus*, although sparse, is recorded from 9800 yr BP to in both Lobeiras and Cuadramón; their representation would be regional. This date can be considered as early for the north. In Lagoa Comprida (JANSSEN

& WOLDRINGH, 1981), its first occurrences are dated identically, and more to the south, in Padul (PONS & REILLE, 1988), it is recorded at 10000 yr BP. Its expansion in the Montes do Buio, from the results shown here, takes place after 4000 yr BP. This date, close to that proposed for Los Tornos, 4620 ± 70 ^{14}C yr BP (PEÑALBA, 1989), and Jurra (MARY *& al.*, 1975), 4770 ± 110 ^{14}C yr BP, seems to be late in relation with the data available for enclaves of the same bio-geographic region: 5980 ± 80 ^{14}C yr BP in Belate (PEÑALBA, 1989); 5865 ± 170 ^{14}C yr BP in Le Moura (OLDFIELD, 1964); 5000 yr BP in the western Pyrenees (MARDONES & JALUT, 1983) and more to the south, 8310 ^{14}C yr BP in Padul.

Betula is present continually, with important oscillations throughout the Holocene period, but its percentages are lower than to those of the accompanying taxa (*Quercus, Corylus*), excepting the local episode indicated by RAMIL (1992) in Tremoal da Gañidoira (6895 ± 50 ^{14}C yr BP). Of a recent character it could be said that, after 1625 ± 70 ^{14}C yr BP (Turbera de Brins: VAN MOURIK, 1986), to cite a date for an event that is habitual in the diagrams for this part of Spain, a slight increase of *Betula*, synchronised with a generalised decrease of arboreal vegetation, was perceived. The increase of this taxon, together with *Alnus* and, in some cases, *Salix*, could signify that the deforestation limited the trees to the margins of the rivers, streams and irrigation canals for pastures.

There is evidence for the presence of *Fagus sylvatica* during the last glaciation in the Cantabrian mountains (RODRÍGUEZ-GUITIÁN & al., 1996; PEÑALBA, 1994; RAMIL, 1993; RAMIL & al., 1996). There were glacial refugia for beech on the southern slopes of the Cantabrian mountains, which have been dated to ca. 7500 ± 70 ^{14}C yr BP (RAMIL, 1993) at the Portuguese Galician border region on the north-west Iberian Peninsula (RUÍZ ZAPATA & al., 1993). These data confirm the hypothesis of Spanish palaeoecologists (IZCO, 1987; RIVAS & al., 1987), that beech persisted in the Cantabrian mountains and the southern margin of the Pyrenees from which it later spread northwards (POTT, 2000). In view of the pollen data of the present study (it is present before 7930 ± 70 ^{14}C yr BP), it cannot be said that *Fagus* has established itself as an important component of Galician vegetation. Its eventual presence has been dated from 3680 ± 35 ^{14}C yr BP in Montes do Buio (VAN MOURIK, 1986), during a stage of arboreal increase, but at no time, there was a continuous curve mentioned. For the rest of the Cantabrian region, its presence has been dated at about 3840 ^{14}C yr BP, in Lago de Ajo (MC KEEVER, 1984), linked to the decline of *Corylus*. The start of the continuous curve occurred at 2860 ± 50 ^{14}C yr BP, in Cueto de la Avellanosa (MARISCAL, 1983), related to the beginning arboreal decline. For more eastern enclaves of the Cantabrian region, including the eastern sector, earlier presences have been dated, such as: 6600 ^{14}C yr BP in Belate and before 8200 ^{14}C yr BP (PEÑALBA, 1989); in Valle de la Nava (III)

(MENÉNDEZ-AMOR, 1968); before 8000 yr BP in Sidera and at 7340 ± 80 ^{14}C yr BP in Les Palenques (PÉREZ-OBIOL, 1988). Some authors (PÉREZ-OBIOL, 1988; BURJACHS, 1990; BURJACHS & al., 1985/86; RIERA 1990a, 1990b; RIERA & PARRA, 1990) even indicate continuous record after 4500 yr BP in Los Tornos. In Lobeiras their momentary presence has been found in the zone defined for 9800 yr BP (Zone **a3**). Most of southern and western Europe, during the early Holocene was occupied by mixed deciduous forest, but of varying composition with predominance of boreal trees such as *Picea*, *Betula* and *Alnus* (HUNTLEY, 1988; POTT, 2000), and *Quercus* and *Corylus* in northwest of the Iberian Peninsula. (GONZÁLEZ & SAA, 2000). This event would be the explication a their small representation.

The taxa with a truly significant importance in the arboreal vegetation have been, in order of priority, *Quercus, Corylus* and *Betula*, although they do not appear to have formed a closed and compact cover. Therefore, it should be considered that the Galician countryside, in mountains of medium height and before the beginning of deforestation caused by man, consisted of a mosaic of woods and open spaces, or perhaps a sparse forest-type association containing Ericaceae. *Alnus* has had a discrete and constant presence from the Atlantic period.

The arboreal taxa typical of mountain zones and present in other nearby peninsula diagrams, such as *Fagus, Abies* and *Pinus*, have not played an important role in the regional vegetation during the Holocene period. Only a recent reference to an episode of *Pinus*, due to reforestation campaigns, can be mentioned, even though it has a constant, but momentary, presence in all the Galician diagrams.

On the other hand, the early and possibly synchronous expansion of *Quercus* and *Corylus*, is also a factor worth noting, in accordance with the results published for Serra da Estrela in Portugal (VAN DER KNAAP & VAN LEEUWEN, 1995).

The representation of Mediterranean taxa, such as Oleaceae in zones such as Cuadramón or Lagozas, could be explained by their capacity for diffusion over long distances, from areas at lower latitudes. According to MUÑOZ (2001), these taxa, never representing a dominant vegetal formation, have remained since the end of glaciar stage until now and they have supported an important local development in some sites, competing with forests.

CONCLUSIONS

The dynamics of the Holocene vegetation is strongly marked by the variations of pollen percentages of *Quercus*, *Corylus* and *Betula* among the arboreal

taxa and Poaceae, *Calluna* and other Ericaceae in the non-arboreal taxa. The non-arboreal taxa at the beginning of the Holocene period and the end of Lateglacial are characterised by the presence of *Thalictrum* and *Armeria.*

As a result, it can be established that the development of Poaceae and Ericaceae, during the Holocene period, shows a certain parallelism of presence in the diagrams, which makes it difficult to determine the moment of implantation of degradation heathland.

Until now, the data available for the Galicia mountains (northern Iberian Peninsula) showed *Quercus* appearance before *Corylus*, placing the former at ca. 9500-8500 yr BP (RAMIL, 1992). From the data presented in this work, it would appear to be more synchronous and before 9800 ^{14}C yr BP. Therefore, an earlier date of appearance for both taxa is proposed.

The development of *Corylus* has been dated between 8000 yr BP and 7830 ^{14}C yr BP, for this area of northern Spain. From the results presented here, it could be considered that development was earlier, at 8770 ^{14}C yr BP, in accordance with the Atlantic influenced Europe.

The early appearance (possibly regional presence) of *Alnus* at about 9800 ^{14}C yr BP, contemporary with the initial expansion of deciduous trees such as *Quercus* and *Corylus* at 8770 ^{14}C yr BP, is proposed.

On the other hand, *Pinus sylvestris* L. presents an early retreat, with respect to known data from other locations of northern Spain (Basque Country, Asturias) at before 9800 ^{14}C yr BP.

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