

Discrimination of Scots pine forests in the Iberian Central System (*Pinus sylvestris* var. *iberica*) by means of pollen analysis. Phytosociological considerations

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Abstract: López-Sáez, J.A., Sánchez-Mata, D., Alba-Sánchez, F., Abel-Schaad, D., Gavilán, R.G. & Pérez-Díaz, S. *Discrimination of Scots pine forests in the Iberian Central System (Pinus sylvestris var. iberica) by means of pollen analysis. Phytosociological considerations. Lazaroa 34: 191-208 (2013).*

Fifty-eight modern pollen surface samples from different Scots pine forest communities (*Pinus sylvestris* var. *iberica* Svoboda) in the Iberian Central System (central Spain) were palynologically and statistically analyzed (using hierarchical cluster analysis and principal component analysis) to derive correlations between pollen assemblages and environmental gradients at the sampled points. Numerical classification and ordination were performed on pollen data to assess similarities among (central Iberian)-Scots pine forest phytosociological associations. The results show a strong relationship between altitude, temperature, rainfall, arboreal cover and variations in pollen taxa percentages. The statistic discrimination of some of these forest communities has allowed us to propose three new associations.

Keywords: *Pinus sylvestris* var. *iberica*, Iberian Central System, Palynology, Phytosociology, Multivariate Analyses, Community Ecology.

Resumen: López-Sáez, J.A., Sánchez-Mata, D., Alba-Sánchez, F., Abel-Schaad, D., Gavilán, R.G. & Pérez-Díaz, S. *Discriminación de los bosques de pino albar en el Sistema Central ibérico (Pinus sylvestris var. iberica) mediante análisis polínico. Consideraciones fitosociológicas. Lazaroa 34: 191-208 (2013).*

Cincuenta y ocho muestras de lluvia polínica actual, procedentes de distintas comunidades forestales de pino albar (*Pinus sylvestris* var. *iberica* Svoboda) en el Sistema Central ibérico (centro de España), fueron analizadas palinológica y estadísticamente (mediante análisis de cluster jerárquico y análisis de componentes principales) para establecer correlaciones entre los espectros polínicos y gradientes medioambientales. La clasificación numérica y la ordenación fueron realizadas sobre los datos polínicos para delimitar posibles similitudes entre las distintas asociaciones fitosociológicas de los bosques de pino albar centro-ibérico. Los resultados muestran que existe una fuerte correlación entre la altitud, temperatura, precipitación y cobertura arbórea respecto a las variaciones en los porcentajes de los principales morfotipos polínicos. La discriminación estadística de algunas de estas formaciones forestales nos hace proponer tres nuevas asociaciones.

Palabras clave: *Pinus sylvestris* var. *iberica*, Sistema Central ibérico, Palinología, Fitosociología, análisis multivariantes, ecología de las comunidades vegetales.

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INTRODUCTION

Pollen analysis is one of the main methods used to reconstruct vegetation patterns and landscapes of the past. However, the interpretation of the composition and structure of forest communities as well as treeless vegetation from fossil pollen assemblages is complex and sometimes difficult. Pollen production and preservation, dispersal and surface deposition differ distinctively, depending on plant species and climatic conditions (SUGITA, 1994; HICKS, 2001; BUNTING & al., 2004). In addition, pollen records vary with vegetation types, size of the depositional basin and other characteristics of the study area (JACOBSON & BRADSHAW, 1981). These facts are especially significant in mountainous environments, where climate varies strongly with altitude, largely determining the zonation of vegetation (RIVAS-MARTÍNEZ, 2005), reflected in turn by the pollen record at different elevations (CASELDINE & PARDOE, 1994; PARDOE, 2001; CAÑELLAS-BOLTÀ & al., 2009).

To date few studies of modern pollen rain have been attempted on mountain environments in central Spain (VÁZQUEZ & PEINADO, 1993; ANDRADE & al., 1994; DORADO & RUIZ-ZAPATA, 1994). However, these investigations were generally quite local in extent and tended to include only a limited number of samples. Thus any ecological interpretation of their findings had to be confined to the local scale. Consequently, whilst pollen-based reconstructions of Holocene vegetation and climate yield good results when applied to pollen sequences from low to mid elevation sites (CARRIÓN & al., 2010; GIL-ROMERA & al., 2010), the application of current methods to high-altitude pollen sequences often gives unreliable or hardly testable results. Ultimately, analyses of modern pollen rain are essential for the understanding of fossil pollen sequences in a particular mountain area, and therefore for pollen-based palaeovegetation and palaeoclimate reconstructions (LÓPEZ-SÁEZ & al., 2010a). This is particularly marked in the case of large pollen producers and wind-pollinated taxa like pine species. In this sense, CASELDINE & al. (2007) stressed the importance of making realistic

assumptions about regional background pollen, especially about high pollen producers, such as *Pinus sylvestris* s. l., in order to obtain reliable simulations in landscape modelling.

Pinus species cover large areas of the Northern Hemisphere and their forests have an ancient history of human impact that has shaped their current structure, composition and distribution (RICHARDSON & al., 2007). In the Mediterranean Basin, the distribution of pines, especially the most abundant and widespread one such as *Pinus sylvestris* s. l., has been greatly affected by human activities for thousands of years (BARBERO & al., 1998; TAPIAS & al., 2004). The human role in structuring Scots pine forests in the Iberian Central System shows how they have declined considerably as a result of livestock and agriculture activities, land abandonment, forestry, and extensive afforestation (MARTÍNEZ-GARCÍA & MONTERO, 2000), especially in the last five thousand years (FRANCO-MÚGICA & al., 2001a). The fact that wildfires in the Iberian Central System have mostly affected *Pinus sylvestris* var. *iberica* Sbovoda forests located in dry and subhumid areas implies that climate contributes to limit fire occurrence (PAUSAS & al., 2008) and, therefore, changes in future climate will be likely to modify the fire regime, and, consequently, the vulnerability to fire of Scots pine forests in the study area.

Here, we study for the first time modern pollen samples from the Iberian Central System to discriminate *Pinus sylvestris* var. *iberica* forest communities, as modern pollen studies can aid in the interpretation of fossil pollen data in terms of vegetation patterns. *Pinus sylvestris* s. l. is a widespread species in Europe (MASON & ALÍA, 2000) that has left a useful record of its distribution in central Spain during the Holocene in the form of pollen grains and macrofossils preserved in sediments (FRANCO-MÚGICA & al., 2001; RUBIALES & al., 2007, 2012; LÓPEZ-MERINO & al., 2009). Furthermore, these studies may help to disentangle the factors that triggered vegetation changes. This analysis aims to serve as a basis for further historical reconstruction of vegetation changes during the Holocene in high-mountain environments based on fossil pollen data.

MATERIAL AND METHODS

POLLEN DATA

Fifty-eight modern pollen surface samples (moss polsters) were collected in natural *Pinus sylvestris* var. *iberica* forests from the Iberian Central System (Figure 1), with positional and altitudinal data recorded using a portable Garmin Ltd. Global Positioning System (GPS) device. Moss samples were collected over an area of approximately 100 m² by taking multiple moss polsters from the concerned site to ensure an even representation (GAILLARD & al., 1992, 1994). The subsamples were sealed in plastic bags and mixed into one sample per site. Moss polsters are commonly used as surface samples for local modern pollen rain as it is assumed that they record an average of several years of pollen deposition and are a good analogue of fossil pollen assemblages.

Table 1 list the locations and gives a short description about each recorded site in the study region. A relevé of vegetation was made at each sampling site.

Palynomorphs were extracted from the moss samples following the standard protocol developed by FAEGRI & IVERSEN (1989) and mounted on microscope slides in water-free glycerol. Pollen

grains and non-pollen palynomorphs were identified according to MOORE & al. (1991), RAMIL & al. (1992) and LÓPEZ-SÁEZ & LÓPEZ-MERINO (2007) at the lowest currently possible taxonomical level. *Ononis* type was palynologically identified by its grain larger than 27 μm and its visible columellae (under phase contrast); and *Viscum album* according to LÓPEZ-SÁEZ (1999). Unfortunately it was impossible to differentiate pollen morphology of Genisteae species or genera (PRADOS & al., 1985).

A Nikon Eclipse 50i light-microscope (Melville, NY, U.S.A.) was used to identify and count pollen. Routine counting was carried out at 400x magnification. A minimum of 500 pollen grains were counted from each sample. Pollen percentages were calculated using a pollen sum excluding spores and hydro-hygrophytes, and presented as bars in a pollen percentage diagram. Tilia and TGView (GRIMM, 1992) and CorelDraw software were used to plot the pollen diagram (Figure 2).

ENVIRONMENTAL DATA

Twelve land-use and environmental variables were available for 58 sites (Table 1). Arboreal cover was graded on an ordinal scale from 0 to 5 as follows: 5 (75-100%), 4 (50-75%), 3 (25-

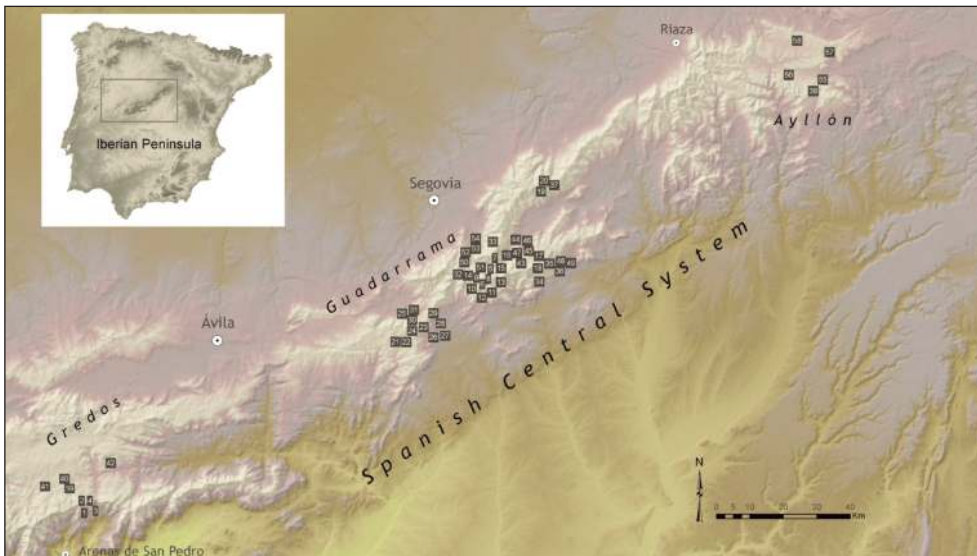


Figure 1. – Map showing the surface pollen samples in the Iberian Central System.

Table 1

Study sites and site characteristics for the 58 modern pollen surface samples from the Iberian Central System. Parameters: Tm: minimum temperature in the coldest month, TM: maximum temperature in the hottest month, TA: annual temperature, Pm: precipitation in the driest month, PM: precipitation in the wettest month, PA: annual precipitation.

| Sample | UTM X | UTM Y (m) | Altitude Cover | Canopy pressure | Grazing | Tm | TM | TA | Pm | PM | PA |
|--------|--------|--------------|-------------------|--------------------|---------|------|------|------|------|-------|------|
| 1 | 327709 | 4464812 | 1770 | 4 | 0 | -0,1 | 19,8 | 8,3 | 21,9 | 171,6 | 1205 |
| 2 | 327848 | 4464725 | 1715 | 4 | 0 | 0,6 | 20,1 | 8,8 | 21 | 173,6 | 1211 |
| 3 | 327867 | 4464350 | 1590 | 3 | 0 | 1,3 | 20,6 | 9,5 | 20,5 | 175,9 | 1220 |
| 4 | 326597 | 4464082 | 1635 | 1 | 1 | 0,7 | 20,1 | 8,8 | 19,1 | 174 | 1214 |
| 5 | 416931 | 4517116 | 1800 | 5 | 0 | -1,5 | 17,1 | 6,5 | 33,8 | 155,1 | 1207 |
| 6 | 416672 | 4516225 | 1880 | 5 | 1 | -2,3 | 16,6 | 6 | 38,2 | 165,3 | 1303 |
| 7 | 418093 | 4519516 | 1780 | 5 | 0 | -0,1 | 18,2 | 7,6 | 27,6 | 138 | 1049 |
| 8 | 416618 | 4516525 | 1816 | 5 | 0 | -1,8 | 16,9 | 6,3 | 38,6 | 166,5 | 1308 |
| 9 | 413883 | 4515273 | 1888 | 5 | 0 | -2,6 | 15,7 | 5,3 | 33,1 | 183,5 | 1381 |
| 10 | 415407 | 4515938 | 1860 | 5 | 0 | -1,7 | 16,2 | 5,9 | 30,7 | 177,7 | 1330 |
| 11 | 415337 | 4514482 | 1750 | 5 | 0 | -1,3 | 16,4 | 6,3 | 31,4 | 186,5 | 1380 |
| 12 | 414783 | 4513166 | 1650 | 4 | 0 | -0,3 | 17,7 | 7,6 | 30,5 | 174,2 | 1273 |
| 13 | 419149 | 4519056 | 1830 | 5 | 0 | -1,1 | 17,7 | 6,9 | 27,1 | 133 | 1018 |
| 14 | 416604 | 4516342 | 1874 | 5 | 0 | -2,3 | 16,6 | 6 | 38,2 | 165,3 | 1303 |
| 15 | 419040 | 4519753 | 1840 | 4 | 0 | -1 | 17,7 | 7 | 25,4 | 132 | 1001 |
| 16 | 420360 | 4520139 | 1700 | 5 | 0 | -0,4 | 18,1 | 7,5 | 23,9 | 126,5 | 957 |
| 17 | 429870 | 4519977 | 1785 | 5 | 0 | -0,8 | 18,5 | 7,6 | 27,4 | 106,8 | 862 |
| 18 | 430590 | 4519855 | 1632 | 5 | 0 | -1 | 18,5 | 7,6 | 29,4 | 106,2 | 876 |
| 19 | 431758 | 4537645 | 1816 | 5 | 0 | -0,1 | 18,5 | 7,8 | 23,4 | 91,2 | 732 |
| 20 | 430462 | 4537131 | 1921 | 1 | 0 | -0,4 | 18 | 7,2 | 22,4 | 95,3 | 751 |
| 21 | 398281 | 4500981 | 1458 | 4 | 3 | 1,3 | 19,9 | 9,2 | 19,8 | 107,2 | 794 |
| 22 | 397621 | 4500359 | 1473 | 5 | 2 | 1,7 | 20,1 | 9,6 | 19,3 | 107,3 | 789 |
| 23 | 402525 | 4506945 | 1425 | 4 | 0 | 1,4 | 19,4 | 9,1 | 23,7 | 112,5 | 851 |
| 24 | 402768 | 4506096 | 1572 | 5 | 0 | 1 | 19,3 | 8,9 | 25,2 | 118,4 | 885 |
| 25 | 399226 | 4506837 | 1350 | 5 | 0 | 1,9 | 19,3 | 9,4 | 27,5 | 103 | 815 |
| 26 | 403764 | 4502750 | 1510 | 5 | 0 | 2,7 | 20,9 | 10,6 | 19 | 130 | 860 |
| 27 | 404179 | 4505126 | 1400 | 5 | 0 | 2,2 | 20,1 | 9,7 | 17,8 | 125,2 | 852 |
| 28 | 405427 | 4504572 | 1350 | 4 | 0 | 2,7 | 20,9 | 10,6 | 18,5 | 128,3 | 859 |
| 29 | 402585 | 4506997 | 1487 | 5 | 0 | 1,4 | 19,4 | 9,1 | 23,7 | 112,5 | 851 |
| 30 | 401615 | 4506304 | 1425 | 4 | 0 | 1,5 | 19,3 | 9,1 | 25,6 | 112,2 | 859 |
| 31 | 399328 | 4507690 | 1350 | 5 | 0 | 2,8 | 19,7 | 9,8 | 20,9 | 99,9 | 743 |
| 32 | 414113 | 4517053 | 1692 | 5 | 0 | -0,4 | 17,4 | 7,3 | 31,4 | 166,9 | 1253 |
| 33 | 417166 | 4523212 | 1725 | 4 | 0 | -0,2 | 18,6 | 8 | 29,6 | 116,4 | 946 |
| 34 | 431401 | 4519460 | 1533 | 5 | 0 | -0,1 | 19,3 | 8,6 | 31,9 | 104,8 | 883 |
| 35 | 432348 | 4518261 | 1457 | 5 | 0 | 1,2 | 19,7 | 9,2 | 21,6 | 100,8 | 778 |
| 36 | 432267 | 4516523 | 1305 | 5 | 0 | 2,9 | 20,6 | 10,7 | 18,3 | 99,6 | 735 |
| 37 | 431047 | 4536158 | 1654 | 4 | 0 | 0,8 | 19 | 8,4 | 21,3 | 92,2 | 726 |
| 38 | 489594 | 4557566 | 1800 | 4 | 0 | -0,9 | 17,2 | 6,7 | 20,6 | 80,9 | 645 |
| 39 | 321560 | 4468930 | 1572 | 5 | 0 | 1,2 | 20,6 | 9,5 | 18,7 | 144,5 | 1006 |
| 40 | 320378 | 4469216 | 1575 | 4 | 0 | 1,3 | 20,5 | 9,6 | 18 | 139,3 | 966 |
| 41 | 316024 | 4467375 | 1465 | 4 | 0 | 1,6 | 21 | 10,1 | 21,1 | 138,3 | 967 |
| 42 | 330826 | 4472781 | 1340 | 5 | 1 | 1,8 | 21,1 | 10,2 | 17,4 | 141,1 | 986 |
| 43 | 423550 | 4520940 | 1400 | 5 | 0 | 1,7 | 19,5 | 9,5 | 25,9 | 119,5 | 917 |
| 44 | 424949 | 4521863 | 1320 | 5 | 0 | 1,9 | 19,3 | 9,5 | 23,8 | 113,4 | 868 |
| 45 | 425284 | 4522320 | 1300 | 4 | 0 | 2,3 | 19,5 | 9,9 | 24,7 | 113 | 870 |
| 46 | 424945 | 4523467 | 1325 | 5 | 1 | 2,2 | 19,2 | 9,8 | 23,2 | 109,4 | 843 |

| Sample | UTM X | UTM Y (m) | Altitude Cover | Canopy pressure | Grazing | Tm | TM | TA | Pm | PM | PA |
|--------|--------|-----------|----------------|-----------------|---------|------|------|------|------|-------|------|
| 47 | 422678 | 4520646 | 1500 | 5 | 0 | 1,2 | 19,2 | 9 | 25,8 | 120,1 | 922 |
| 48 | 434957 | 4518806 | 1305 | 5 | 1 | 2,9 | 20,8 | 10,7 | 16,4 | 94,6 | 695 |
| 49 | 434826 | 4518377 | 1215 | 4 | 1 | 3,2 | 21,1 | 11 | 17 | 94,9 | 700 |
| 50 | 413441 | 4520519 | 1320 | 5 | 1 | 1,7 | 19,6 | 9,6 | 24,9 | 129,6 | 975 |
| 51 | 415464 | 4518224 | 1564 | 5 | 1 | -0,2 | 18,1 | 7,9 | 31,1 | 148,6 | 1141 |
| 52 | 413445 | 4520865 | 1293 | 5 | 1 | 1,8 | 19,8 | 9,7 | 24,4 | 126,6 | 955 |
| 53 | 413321 | 4522269 | 1254 | 5 | 1 | 2 | 20,1 | 10 | 26,1 | 118,6 | 917 |
| 54 | 413264 | 4523988 | 1215 | 5 | 2 | 2,4 | 20,5 | 10,4 | 23,1 | 108 | 836 |
| 55 | 491756 | 4560145 | 1685 | 3 | 0 | -0,1 | 17,6 | 7,7 | 25,5 | 82,6 | 663 |
| 56 | 484031 | 4561244 | 1520 | 4 | 0 | 0,1 | 18,1 | 7,9 | 24,5 | 82,9 | 685 |
| 57 | 493275 | 4566455 | 1445 | 3 | 0 | 0,1 | 18,2 | 8,1 | 25,5 | 78,4 | 627 |
| 58 | 485912 | 4569044 | 1370 | 3 | 1 | 0,7 | 18,9 | 8,6 | 24,2 | 76,5 | 636 |

50%), 2 (5-25%), 1 (1-5%), 0 (0%). In situ observation and the Forest Map of Spain (1:200.000) (RUIZ DE LA TORRE, 2002) were the tools used for estimating the current vegetation cover. Grazing pressure was calculated taking a 0 to 4 index into account (COURT-PICON & al., 2006). The climatic information was taken from the Digital Climatic Atlas of the Iberian Peninsula (NINYEROLA & al., 2006, 2007; PONS & NINYEROLA, 2007). Bioclimatical concepts and nomenclature follow the recent published proposals of RIVAS-MARTÍNEZ & al. (2007, 2011b). The topographic data came from the Shuttle Radar Topography Mission (FARR & al., 2007), resampled from 90 m to 200 m [(5810 x 4600 cells, Universal Transverse Mer-

cator (UTM) projection, European datum 1950 (ED50)].

CLASSIFICATION

To identify clusters of samples based on their pollen content and hence to define specific *Pinus sylvestris* var. *iberica* forest communities, we used multivariate analysis. Although 87 pollen and spore taxa were identified in the surface samples, only palynomorph taxa present at > 1% were included (44). The analyses were performed on recalculated percentages after all modifications had been made. Hierarchical cluster analysis (HCA) was performed using the matrix of the eu-

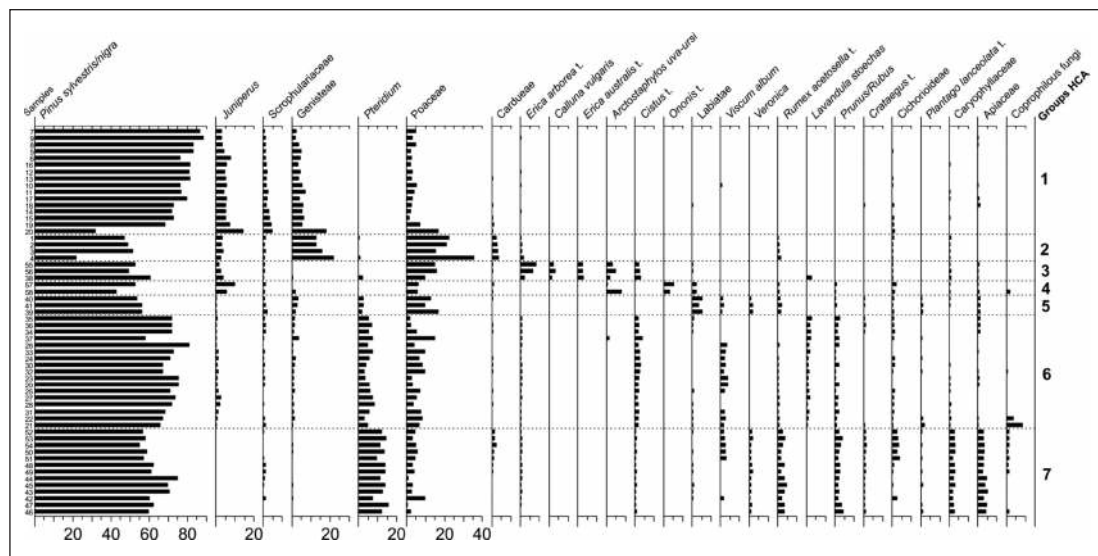


Figure 1. – Percentage pollen diagram for selected taxa.

clidean distances and Ward's minimum variance method (WARD, 1963) with the program IBM SPSS Statistics 21. The percentage values of each taxa were standardized. The hierarchical relationships between clusters are illustrated by the dendrogram in Figure 3.

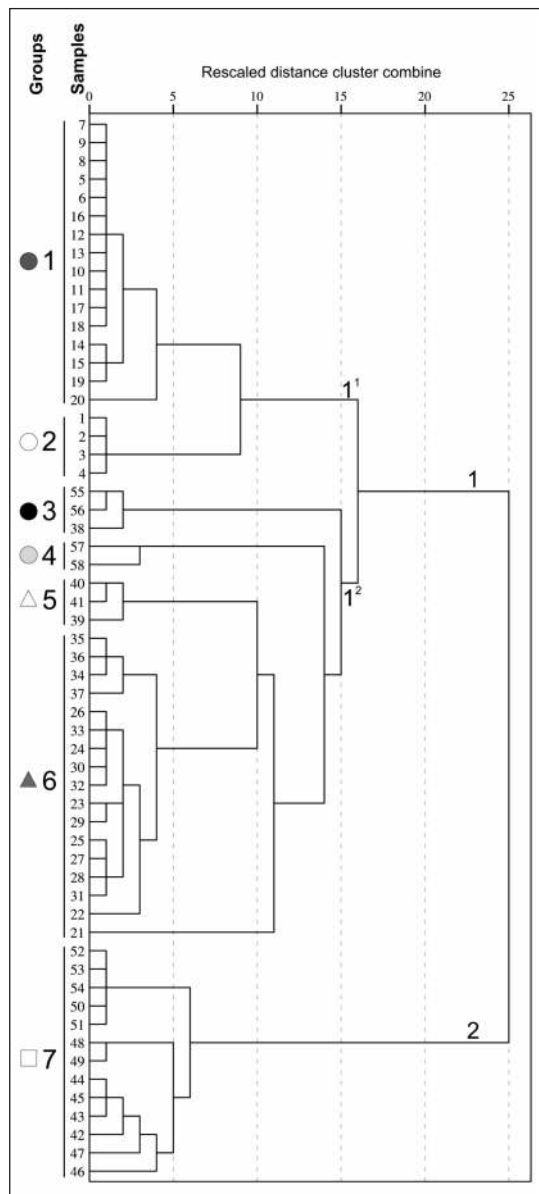


Figure 3. – Hierarchical cluster analysis (HCA) of the 58 modern pollen spectra from *Pinus sylvestris* var. *iberica* forest communities in the Iberian Central System. Dotted lines indicate the different thresholds that subdivides the dendrogram mentioned in the text, from right to left.

ORDINATIONS

Data were processed (modern surface pollen samples) by ordination analysis to obtain more information about the data structure. Principal component analysis (PCA) was used as a linear interpretation method because a previously applied detrended canonical correspondence analysis (DCCA) pointing to a linear response of pollen types (variables) to environmental gradients (ESCUADERO & al., 1994; BIRKS & al., 1998). PCA is an indirect ordination procedure that reduces the multidimensional nature of a data set to a few dimensions (defined by principal components), with minimal loss of information. PCA was used to study the dominant features of the data set in terms of variance. Samples were square-root transformed for a better comparability (AUSTIN, 2013). PCA analysis was carried out on the correlation matrix of the pollen data; principal component scores of the pollen spectra (samples) and loadings for the variables (pollen types) were positioned on the main principal components in a biplot (Figures 4 and 5).

To extract more information from the modern pollen record, supplementary environmental gradients in the ordination project were included (Table 1). These gradients were gained from the interpolated climatic information from the Iberian Peninsula or from our own observation on human impact. We included TA (annual temperature), TM (maximum temperature in the hottest month), Tm (minimum temperature in the coldest month), PA (annual precipitation), PM (precipitation in the wettest month), Pm (precipitation in the driest month) and the measure of human activity (grazing) as passive (supplementary) environmental gradients. Partial redundancy analysis (RDA) was conducted to see which environmental gradient explains better the dataset (Table 2).

The analyses were run using the C2 1.5 software (JUGGINS, 2007). Graphics of the ordination biplots were achieved by using CorelDraw. Analyses were processed with palynomorph taxa present at > 1%.

NOMENCLATURE

Taxonomic nomenclature and authorities follow the published volumes of Flora iberica (CASTROVIEJO

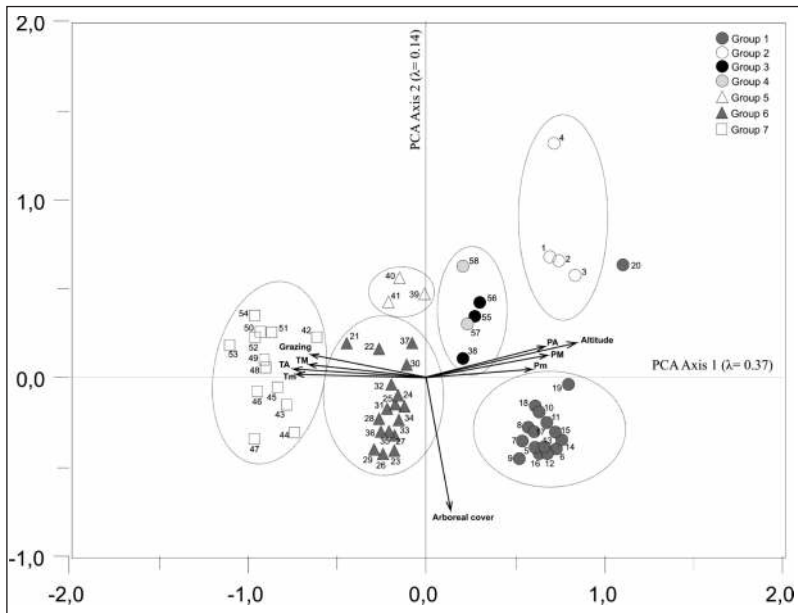


Figure 4. – PCA plot for the surface samples showing ordination of samples along the first and second PCA axis. Significance of analysis can be comprehended in Table 2. Main characteristics for the theoretical gradients are obtained from the correlation of supplied environmental gradients. Each sample is expressed by the observed vegetation types (see Figure 3).

& al., 1986-2012) and the compilations of Flora Europaea (TUTIN & al., 1964-1980); the exceptions are specifically mentioned in the floristic appendix.

Syntaxonomical scheme, nomenclature, and syntaxa authorities follow the compilations and proposals of RIVAS-MARTÍNEZ & al. (2001, 2002, 2011a).

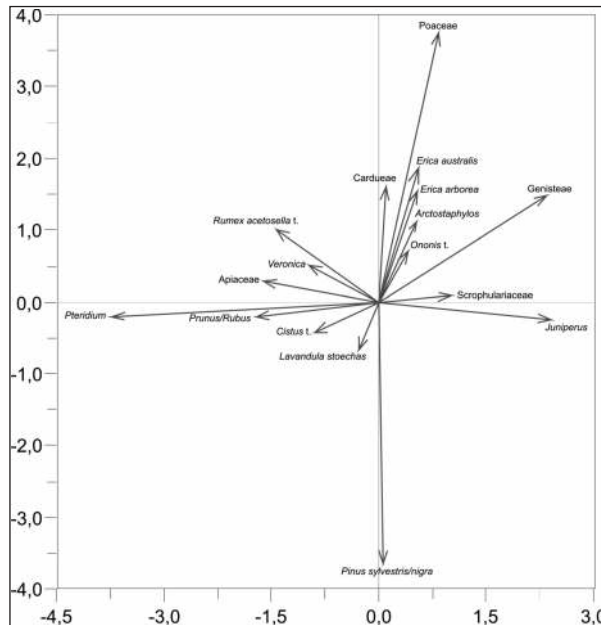


Figure 5. – PCA plot for the pollen types (variables) along the first and second PCA axis. Taxa positioned near the origin are not displayed.

Table 2
Results of partial RDA and PCA for pollen data of surface samples
All gradients are significant at the 5% significance level ($p \leq 0.05$)

| Gradient | Explained variance | p-value | Correlation with PCA-1 ($\lambda=0.37$) | Correlation with PCA-2 ($\lambda=0.14$) |
|--------------|--------------------|---------|--|--|
| Altitude | 17% | 0.002 | 0.80 | 0.33 |
| Canopy cover | 10% | 0.005 | 0.12 | -0.75 |
| Grazing | 3% | 0.01 | -0.62 | 0.19 |
| TA | 14% | 0.002 | -0.80 | 0.05 |
| TM | 11% | 0.005 | -0.64 | 0.09 |
| Tm | 8% | 0.005 | -0.75 | 0.02 |
| PA | 15% | 0.002 | 0.66 | 0.17 |
| PM | 12% | 0.002 | 0.69 | 0.12 |
| Pm | 9% | 0.005 | 0.61 | 0.05 |

RESULTS AND DISCUSSION

The pollen and non-pollen palynomorph percentage data for selected taxa are presented in Figure 2. *Pinus sylvestris/nigra* type pollen percentage in surface samples range from 22% to 89%. It is clearly evident from the results that *Pinus sylvestris* has, due to high pollen production and good dispersal ability, a larger pollen dispersal area than the other studied species (POSKA & PIDEK, 2010). In the study region *Pinus nigra* could also contribute to the total *Pinus sylvestris/nigra* type pollen deposition but it is likely of minor importance in comparison to the one of *P. sylvestris*.

On the first division level, the dendrogram of the HCA performed on pollen data (Figure 3) shows a clear discrimination between xerophilous *Pinus sylvestris* var. *iberica* forest communities (cluster 1; groups 1 to 6) and mesophilous ones (cluster 2; group 7). The following threshold of cluster 1 clearly separates samples from central-western orotemperate submediterranean (orosubmediterranean) communities (cluster 1¹) from those of the eastern supratemperate (suprasubmediterranean) and supramediterranean belts (cluster 1¹). The division of cluster 1¹ provides two groups (1 and 2) while cluster 1² is divided into four groups (3 to 6).

Groups 1 and 2 represent xerophilous and orophilous (> 1600 m) forest communities from the orosubmediterranean belt of the Guadarrama and the Gredos ranges respectively (Table 1). Although the average annual precipitation (PA) va-

lues are high (usually > 1200 m), these forests are considered as xerophilous because they are covered by winter snow for at least 4-5 months and grow on moderate to highly stony soils with low edaphic development (GAVILÁN & al., 1998; MARTÍNEZ-GARCÍA & MONTERO, 2000; GAVILÁN, 2005; LÓPEZ-LEIVA & al., 2009). They are characterized by noticeable percentages of *Pinus sylvestris* (> 20%) and significant frequencies of Poaceae, Genisteae and *Juniperus* (Figure 2). They are individualized by (i) higher *Pinus sylvestris* (68-89%) and *Juniperus* (3-8%) values in group 1 and lower ones in group 2 (22-51% and 2-4% respectively), (ii) lower percentages of Poaceae (3-7%), Cardueae (< 1%) and Genisteae (3-7%) in group 1 and relatively high values in group 2 (16-36%, 2-4% and 13-22%), (iii) the presence of *Pteridium* (< 1%) and *Rumex acetosella* s. l. only in group 2 while Cyperaceae, Apiaceae and Fabaceae undiff. are only present in group 1.

The first two axes of the PCA biplot (Figure 4, Table 2) explain 51% of variance in the pollen surface dataset. On the first axis (PCA-1) orosubmediterranean silicicolous *Pinus sylvestris* var. *iberica* forest communities (groups 1 to 4) are also separated from supratemperate submediterranean (suprasubmediterranean) and supramediterranean ones (groups 5 to 7). The PCA-1 explains 37% of the variance in the dataset and is positively correlated with altitude (r : 0.80), PA (r : 0.66), PM (r : 0.69) and Pm (r : 0.61) and negatively with TA (r : -0.80), TM (r : -0.64) and Tm (r : -0.75). On the

first PCA axis (PCA-1) orophilous shrub vegetation (*Genisteae*, *Juniperus*) are separated from low-elevation mesophilous taxa (*Pteridium*, *Prunus/Rubus*, *Cistus* type, *Veronica*, *Apiaceae*, *Rumex acetosella* s. l.) located at the negative side of the axis (Figure 5). On the second PCA axis (PCA-2) pollen taxa from tree species (*Pinus sylvestris/nigra*) are located on the negative side with very high values, while high-mountain meadows (*Poaceae*) and shrubs (*Genisteae*, *Erica australis* s. l., *E. arborea*, *Arctostaphylos uva-ursi*, *Ononis*) are located on the positive side of the PCA-2. The axis explains 14% of the variance in the dataset and is most highly negative correlated with arboreal cover ($r: -0.75$) (Figure 4, Table 2).

A combined modern distribution range of *Pinus sylvestris* s.l. with gridded annual precipitation and January temperature (NEW & al., 1999) shows that its modern range in Europe lies between 400 and 1500 mm year⁻¹ and -18°C to +8°C respectively. These values are reflected in the populations of central Spain (Table 1). In fact, *Pinus sylvestris* s.l. has a wider climatic range than the broadleaved deciduous trees in terms of both temperature and precipitation, and their natural populations may inhabit climates that are suboptimal for their growth and development (REHFELDT & al., 2002; GAVILÁN, 2005). In short, the PCA plot underscores the importance of thermotype (bioclimatic belts) for the arrangement of *Pinus sylvestris* var. *iberica* forest communities in the Iberian Central System. PCA-1 separates orosubmediterranean communities ($T_m \leq 0^\circ\text{C}$, $T_A < 9^\circ\text{C}$, groups 1 to 4) from suprasubmediterranean and supramediterranean ones ($T_m \geq 1^\circ\text{C}$, $T_A > 9^\circ\text{C}$, groups 5 to 7) (Table 1).

Group 1 (samples 5 to 20) represents orotemperate submediterranean (orosubmediterranean) humid and hyperhumid *Pinus sylvestris* var. *iberica* microforests (mesoforests on deep soils at lower altitudes) from the Guadarrama and surrounding mountains, corresponding to the *Avenello ibericae-Pinetum ibericae* association (RIVAS-MARTÍNEZ & al., 2001, 2002). They grow between 1,632-1,921 m asl (Table 1) in siliceous soils in the Guadarrama Range (Navacerrada, Canencia and Navafría mountain passes, Figure 1). Although most samples from group 1

are well grouped, some of the pollen assemblages were difficult to interpret in the corresponding vegetation type. This is the case of sample 20, which on the PCA-2 is separated from the remaining samples from group 1, but grouping close with those of group 2 (Figure 4). This is due to its low arboreal cover (1). Samples from group 2 have an arboreal cover of 3 or 4, except sample 4 with only 1 (Table 1), but these pine forests from the Gredos Range correspond to small and isolated nuclei or scattered trees. Instead, pine forests communities from the Guadarrama Range are very dense and extensive. This may suggest that the second axis of the PCA (PCA-2) reflects not only the tree cover but rather forest density in a regional sense.

As a result of multivariate analyses (HCA and PCA), orosubmediterranean *Pinus sylvestris* var. *iberica* forest communities from the Gredos Range (group 2, samples 1 to 4) are very well discriminated from other pine forests of the Iberian Central System (Figures 3 and 4). This fact allows us to propose a new pinewood association: *Echinosparto barnadesii-Pinetum ibericae* Sánchez-Mata, Gavilán & López-Sáez *ass. nova hoc loco* (Table 3, *holotypus*, rel. 1). It represents orotemperate submediterranean (orosubmediterranean) hyperhumid relict mesoforests growing on ranker soils at an altitudinal level ranging from 1,635 to 1,770 m asl throughout Gredos Mountains (Carpetan-Leonese biogeographical subprovince, Iberian Western Mediterranean province, Western Mediterranean subregion, Mediterranean region (RIVAS-MARTÍNEZ & al., 2007; Figure 1, Table 1). Floristically and biogeographically it is differentiated from the eastern above mentioned *Avenello ibericae-Pinetum ibericae*, from the Guadarrama and surrounding ranges, by the presence of western endemic elements such as *Echinospartum barnadesii* subsp. *barnadesii* and *Festuca elegans* subsp. *merinoi* (SÁNCHEZ-MATA, 1989, 1999; DE LA FUENTE & ORTÚÑEZ, 2001) and the absence of essentially eastern species such as *Juniperus communis* subsp. *hemisphaerica* and *Festuca braunblanquetii* (RIVAS-MARTÍNEZ & al., 2001, 2002). So far we have only been able to inventory these forests in the surrounding summits of Puerto del Pico Pass, as in the rest of the Gredos Range only

Table 3

Echinosparto barnadesii-*Pinetum ibericae* Sánchez-Mata, Gavilán & López-Sáez *ass. nova* (1-4)*Festuco merinoi*-*Pinetum ibericae* Sánchez-Mata, Gavilán & López-Sáez *ass. nova* (5-8)*(Avenello ibericae*-*Pinion ibericae*, *Junipero sabiniae*-*Pinetalia sylvestris*, *Junipero sabiniae*-*Pinetea sylvestris*)

| Altitude (1=10 m) | 177 | 180 | 175 | 171 | 150 | 153 | 146 | 157 |
|--|-----|-----|-----|-----|-----|-----|-----|-----|
| Number of species | 15 | 15 | 17 | 20 | 23 | 27 | 30 | 34 |
| Relevé number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Characteristics | | | | | | | | |
| <i>Pinus sylvestris</i> var. <i>iberica</i> | 5 | 4 | 4 | 4 | 5 | 4 | 4 | 4 |
| <i>Cytisus oromediterraneus</i> | 1 | 2 | 1 | 1 | 1 | 1 | + | 1 |
| <i>Avenella iberica</i> | 1 | 2 | + | + | 1 | 1 | 1 | + |
| <i>Festuca elegans</i> subsp. <i>merinoi</i> | . | . | + | + | 2 | 2 | 2 | 2 |
| <i>Genista cinerascens</i> | . | . | . | . | 1 | 2 | 2 | 2 |
| <i>Echinospartum barnadesii</i> | 2 | 3 | 3 | 4 | . | . | . | . |
| <i>Juniperus communis</i> subsp. <i>alpina</i> | 1 | + | 1 | 2 | . | . | . | . |
| Shrubby, forest and perennials companions | | | | | | | | |
| <i>Festuca gredensis</i> | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| <i>Luzula lactea</i> | 1 | 1 | 1 | + | + | + | + | + |
| <i>Erica arborea</i> | . | + | + | + | + | 1 | . | + |
| <i>Pteridium aquilinum</i> | . | . | + | + | 1 | 1 | 1 | 1 |
| <i>Poa bulbosa</i> | . | + | + | . | + | 1 | 1 | + |
| <i>Agrostis castellana</i> | 1 | + | 1 | 1 | . | 1 | . | . |
| <i>Cytisus scoparius</i> | . | . | . | . | + | + | 1 | 1 |
| <i>Genista florida</i> | . | . | . | . | + | + | 1 | 1 |
| <i>Santolina oblongifolia</i> | . | . | . | . | + | + | 1 | + |
| <i>Cytisus striatus</i> subsp. <i>eriocarpus</i> | 1 | + | + | + | . | . | . | . |
| <i>Festuca paniculata</i> subsp. <i>multispiculata</i> | . | . | . | . | + | . | + | + |
| Others | | | | | | | | |
| <i>Arrhenatherum elatius</i> s. l. | 1 | 1 | + | + | + | . | . | + |
| <i>Cerastium ramosissimum</i> | . | + | 1 | + | . | + | + | + |
| <i>Rumex acetosella</i> | + | . | . | + | . | 1 | 1 | 1 |
| <i>Carduus carpetanus</i> | + | . | . | . | + | + | + | + |
| <i>Leucanthemopsis pallida</i> subsp. <i>alpina</i> | . | + | + | + | + | . | . | + |
| <i>Armeria caespitosa</i> | 1 | 1 | + | + | . | . | . | . |
| <i>Hieracium castellanum</i> | . | . | . | . | + | + | 1 | 1 |
| <i>Achillea millefolium</i> | . | . | . | . | + | + | 1 | + |
| <i>Silene nutans</i> | . | . | . | . | + | + | 1 | + |
| <i>Hypochoeris radicata</i> | . | . | . | . | + | 1 | 1 | + |
| <i>Spergula morisonii</i> | . | . | . | . | + | + | + | + |
| <i>Jasione montana</i> subsp. <i>echinata</i> | . | . | . | . | + | . | 1 | + |
| <i>Lotus corniculatus</i> s. l. | . | . | . | . | . | + | 1 | 1 |
| <i>Anthoxanthum odoratum</i> | . | . | . | . | . | 1 | + | + |
| <i>Arenaria montana</i> | . | . | . | . | . | + | + | 1 |
| <i>Conopodium pyrenaicum</i> | . | . | . | . | . | + | + | + |
| <i>Viola riviniana</i> | . | . | . | . | . | . | 1 | + |
| <i>Ornithogalum concinnum</i> | . | . | . | . | . | + | . | + |

Other species: shrubby, forest and perennials companions: *Sorbus aucuparia* + in 4 and *Ilex aquifolium* + in 7. Others: *Thymus mastichina* and *Nardus stricta* + in 1; *Jasione sessiliflora* and *Urtica dioica* + in 4; *Senecio adonidifolius* and *Tanacetum corymbosum* + in 7; *Arenaria quereioides*, *Hieracium murorum* and *Centaurea amblensis* + in 8.

Localities: Ávila, Gredos Range. 1-4: Surrounding summits of Puerto del Pico, La Rubia, Hoyos del Espino and Navarredonda de Gredos, *holotypus Echinosparto-Pinetum* rel. 1; 5,6,8: Navarredonda de Gredos mountain summits, *holotypus Festuco-Pinetum* rel. 5; 7: Hoyos del Espino summits.

isolated and scattered trees remain today (GÉNOVA & al., 1992; LÓPEZ-SÁEZ & LÓPEZ-GARCÍA, 1994; LÓPEZ-LEIVA & al., 2009).

The division of cluster 1² provides four main groups (3-6, Figure 3). First, it separates eastern orosubmediterranean forests (groups 3 and 4) from samples from xerophilous suprasubmediterranean and supramediterranean forests (groups 5 and 6). Then, the following threshold discriminates between basiphilous (group 4) and silicicolous forests (group 3). The first principal component axis (PCA-1) separates samples from groups 3 and 4 with low positive values from those of groups 5 and 6 with negative values (Figure 4). Groups 3 and 4 represent easternmost *Pinus sylvestris* var. *iberica* forest communities from the Ayllón and Pela ranges respectively. They are placed together on PCA-1 because they have less Tm (≤ 0 C) and TA ($< 9^{\circ}\text{C}$) but also because their PA (< 700 mm) and Pm (< 83 mm) values are lower; and along PCA-2 (positive values) by their low arboreal cover (3 or 4) (Figure 4, Table 1).

Group 3 (samples 38, 55 and 56) represents supramediterranean, suprasubmediterranean and orosubmediterranean subcontinental humid and hyperhumid *Pinus sylvestris* var. *iberica* mesoforests from the Ayllón Range growing between 1,520-1,800 m asl (Table 1) on siliceous soils (quartzites, slates and sandstones) in the oromediterranean belt of the Ayllón Range (Alto Rey Range, Figure 1). These forests were studied by DE LA CRUZ & PEINADO (1996) without assigning any specific association, but pointing out their differences with western communities from the Guadarrama Range (*Avenello ibericae*-*Pinetum ibericae*) by the absence of *Cytisus oromediterraneus* and *Juniperus communis* subsp. *alpina*. Floristically they are characterized by *Avenella iberica*, *Juniperus communis* subsp. *hemisphaerica*, *Cistus laurifolius*, the relative abundance of Ericaceae (*Arctostaphylos uva-ursi*, *Calluna vulgaris*, *Erica australis* subsp. *aragonensis*, and *E. arborea*) and the virtual absence of broom species (*Genisteae*, ABAD-GARRIDO & MARTÍNEZ-LABARGA, 2009). The pollen diagram (Figure 2) clearly indicates the importance of the above mentioned taxa (*Cistus* type 2-3%, *Calluna vul-*

garis 1.5-3%, *Juniperus* 2-4%, *Erica arborea* 2-8%, *E. australis* 2-3%, *Arctostaphylos uva-ursi* 2-5%) and the sporadic percentages of Genisteae ($< 0.5\%$). Samples from group 3 in the PCA plot (Figure 4) are arranged close to the relevant pollen indicator taxa (Figure 5) and therefore represent quite well the observed vegetation conditions quite well. According to these facts, we propose a new association for these forests: *Erico aragonensis*-*Pinetum ibericae* Sánchez-Mata, Gavilán & López-Sáez *ass. nova hoc loco* (DE LA CRUZ & PEINADO 1996: 340, Table 1, *holotypus* rel. 1).

Group 4 (samples 57 and 58) represents semi-continental subhumid basiphilous relict mesoforests of the *Ononido aragonensis*-*Pinetum ibericae* from the oromediterranean belt of the Pela Range (Figure 1). The occurrence of these basiphilous forests can be recognized in the pollen diagram (Figure 2) by relatively high percentages of *Ononis* t. (3.3-5.6%), *Juniperus* (6-10%), *Arctostaphylos uva-ursi* (1-8%) and *Labiatae* (2%), although *Pinus sylvestris/nigra* (43-53%) is the dominant pollen type in the dataset. Floristically they are rich in *Ononidetea* species and they are characterized by *Juniperus communis* subsp. *hemisphaerica*, *Ononis aragonensis*, *Bupleurum gramineum*, *Vicia pyrenaica* and *Pulsatilla rubra* (DE LA CRUZ & PEINADO, 1996; GAVILÁN & al., 2012). Although these forests occupy low altitudes (1,370-1,445 m asl, Table 1), the climatic parameters that characterize them, particularly their thermicity index (It 43.4-62.4), leads to define these forests as orophilous, occupying the lower oromediterranean belt (DE LA CRUZ & PEINADO, 1996; MARTÍNEZ-GARCÍA & MONTERO, 2000). Both samples 57 and 58 are arranged close to *Ononis* type and other above mentioned pollen taxa in the PCA plot (Figure 5).

Group 5 (samples 39 to 41) included pollen assemblages from xero-mesophilous *Pinus sylvestris* var. *iberica* forest communities (TA $\sim 10^{\circ}\text{C}$, Tm $> 1^{\circ}\text{C}$, PA ~ 1000 mm) from the northern Gredos Mountains developing at an altitudinal level ranging from 1465 to 1575 m (Figure 1, Table 1) on granite soils. These three samples are individualized in the same cluster (Figure 3), as well as in the PCA biplot (Figure 4), because they produce pollen assemblages with low values of *Pinus*

sylvestris/nigra (53-56%), Poaceae (10-17%), Genisteae (1.5-3%) and *Juniperus* (< 0.3%) – major differences separating these samples from those of group 2 –, and average percentages of mesophilous taxa such as *Pteridium* (2.3%), *Veronica* (1-2%) and *Prunus/Rubus* (0-1%). They are also characterized by the presence of the hemi-parasitic plant *Viscum album* (1-2%), which currently only parasitizes *Pinus sylvestris* populations of the northern slopes of the Gredos Range (LÓPEZ-SÁEZ, 1992, 1993; LÓPEZ-SÁEZ & SANZ DE BREMOND, 1992). Groups 5 and 6 are placed close in the cluster 1² and the PCA-1 due to their palynological affinities (Figures 3 and 4), but they are individualized on the PCA-2 by high percentages of *Pteridium* in group 6 and the absence of *Cistus* type in group 5 (Figure 2). These two palynomorph taxa are positioned with negative values on PCA-2 (close to samples from group 6) while samples from group 5 show positive values on this axis (Figures 4 and 5).

Floristically, group 5 represents *Pinus sylvestris* var. *iberica* relict mesoforests from the supratemperate submediterranean and supramediterranean humid belt of the Gredos Mountains only present in the northern slopes of the Gredos Range in scattered nuclei (Navarredonda de Gredos, Hoyos del Espino). They are characterized by western endemic elements such as *Festuca elegans* subsp. *merinoi*, *Centaurea amblensis*, *Ornithogalum concinnum* and *Genista cinerascens* (MARTÍNEZ-GARCÍA & MONTERO, 2000; DE LA FUENTE & ORTÚÑEZ, 2001), as well as dense broom communities mainly composed by *Cytisus scoparius* and *Genista florida* (GAVILÁN & al., 2011). This fact allows us to propose a new pinewood association: *Festuco merinoi-Pinetum ibericae* Sánchez-Mata, Gavilán & López-Sáez ass. nova hoc loco (Table 3, *holotypus*, rel. 5).

Finally, group 6 (samples 21 to 37) and group 7 (samples 42 to 54) represent xero-thermophilous and mesophilous *Pinus sylvestris* var. *iberica* forests respectively, from the Guadarrama Range, except sample 42 from the Gredos Range. Their pollen assemblages are characterized by noticeable percentages of *Pinus sylvestris/nigra* (55-81%), *Cistus*, *Pteridium*, Poaceae, and significant frequencies (< 5%) of Scrophulariaceae, Car-

dueae, *Erica arborea*, Labiatae, *Prunus/Rubus*, *Crataegus* and *Viscum album* (Figure 2). The PCA axis 1 separates samples from group 6 (score 0 to -0.5) and group 7 (score -0.5 to -1) on the left part of the axis with negative values (Figure 4), in relation to altitude and climatic parameters (Table 1). Our results coincide with those obtained by MARTÍNEZ-GARCÍA & MONTERO (2000). However, some overlap is detected on the PCA-2 (Figure 4). Higher values of anthropogenic pollen taxa (Cichorioideae, *Cardueae*, *Plantago lanceolata*) and coprophilous fungi in samples from group 7 (Figure 2) indicates that pine forests at lower altitudes are subjected to greater human impact, especially livestock grazing (LÓPEZ-SÁEZ & LÓPEZ-MERINO, 2007).

Groups 6 and 7 are individualized both in the HCA (clusters 1² and 2) and PCA-1 (Figures 3 and 4) by the following features: (i) higher percentages of *Pteridium* (7.5-15.7%), *Rumex acetosella*, *Prunus/Rubus*, *Crataegus*, Cichorioideae, *Plantago lanceolata*, Caryophyllaceae, Apiaceae and coprophilous fungi in mesophilous forests (group 7); (ii) higher values of xerophilous taxa such as Poaceae, Genisteae and *Cistus* in xerothermophilous pollen assemblages (group 6); and, (iii) the presence of *Veronica* only in group 7 and *Lavandula stoechas* in group 6. Sample 21 is included in group 6 although it is placed into a different cluster in the HCA, but in an intermediate position close to group 7. On PCA-1 this sample is also situated between groups 6 and 7. Its pollen assemblage is similar to those from group 6 but with high percentages of coprophilous fungi like samples from group 7.

Groups 6 and 7 represent supratemperate submediterranean and supramediterranean subhumid and humid semicontinental *Pinus sylvestris* var. *iberica* mesoforests of the *Pteridio aquilini-Pinetum ibericae* association from the Guadarrama Range (RIVAS-MARTÍNEZ & al., 2001, 2002). These forests have been probably extended by human activities and sometimes it is difficult to discriminate between natural and cultivated stands. Floristically, they are characterized by *Avenella iberica*, *Conopodium pyrenaicum*, *Festuca braun-blauquetii*, *Galium rotundifolium*, *Juniperus communis* subsp. *hemisphaerica* and

Pteridium aquilinum. In the oromediterranean belt they are replaced by the *Avenello ibericae-Pinetum ibericae* microforests. Pollen types for taxa almost exclusively found in groups 6 and 7, such as *Pteridium*, *Prunus/Rubus*, *Cistus*, *Veronica* and *Lavandula stoechas* have been found on the negative side of the first axis (Figures 4 and 5), and thus characterize samples from the *Pteridio aquilini-Pinetum ibericae*.

CONCLUSIONS

Recent years have seen a very controversial discussion among paleoecologists (CARRIÓN & FERNÁNDEZ, 2009; CARRIÓN, 2010; LÓPEZ-SÁEZ & al. 2010b) and phytosociologists (FARRIS & al., 2010; LOIDI & al., 2010; MUCINA, 2010; LOIDI & FERNÁNDEZ-GONZÁLEZ, 2012) in reference to (i) different interpretations of the 'potential natural vegetation' (PNV) concept, and (ii) the conceptualization of vegetation dynamics from a historical perspective. This debate has even reached to other researchers concerning the possibilities of mapping PVN (CHIARUCCI & al., 2010; LOIDI & FERNÁNDEZ-GONZÁLEZ, 2012; SOMODI & al., 2012).

It is not our goal to keep on feeding this absurd misunderstanding and the best evidence is the presented paper demonstrating precisely that both positions should not be so far away but the opposite: the convenience of a multidisciplinary and interdisciplinary approach to an integrated framework for the study of plant communities from a dynamic, temporal and spatial perspective.

It is true that for a long time phytosociological literature obviated *Pinus sylvestris* var. *iberica* forests from the Iberian Central System; in some cases they have been considered as vegetation complexes and framed within different geographical races (GALÁN DE MERA & al., 1999); the remaining relict forests from the Gredos, Ayllón and Pela ranges, as well as those from the supramediterranean belt of the Guadarrama Range, have been assumed to be derived mainly from afforestation (RIVAS GODAY, 1956; RIVAS-MARTÍNEZ, 1963, 1964, 1968, 1975, 1982, 1987; IZCO, 1984; RIVAS-MARTÍNEZ & al., 1987a, 1987b, 1990; PEINADO & MARTÍNEZ-PARRAS, 1985;

RIVAS-MARTÍNEZ & CANTÓ, 1987; MONJE-ARENAS, 1988; SÁNCHEZ-MATA, 1989; FERNÁNDEZ-GONZÁLEZ, 1991). However, in some cases it has been recognized the potential character of *Pinus sylvestris* var. *iberica* communities in the Gredos Range taking into account fossil pollen records (SÁNCHEZ-MATA, 1999). RIVAS-MARTÍNEZ & MOLINA (1997, nom. inval. ICPN, art. 3; in Rivas-Martínez & al., 1999) defined for the first time the silicicolous and climatophilous pinewood communities *Avenello ibericae-Pinetum ibericae* from the orotemperate submediterranean territory and *Pteridio aquilini-Pinetum ibericae* (*Galio rotundifolii-Pinetum ibericae* Rivas-Martínez & Molina 1997, nom. inval. ICPN, art. 3; in Rivas-Martínez & al., 2002) from the supramediterranean and supratemperate submediterranean of the Guadarrama Range, representing both the natural potential vegetation. DE LA CRUZ & PEINADO (1996) proposed simultaneously the *Galio idubedae-Pinetum sylvestris* association for the basiphilous pinewoods from the Pela Range. Later studies have continued accepting them (PEINADO & al., 2009), although the latter has been corrected as *Ononido aragonensis-Pinetum ibericae* (RIVAS-MARTÍNEZ & al., 1999, 2001, 2002).

According to these new phytosociological proposals, modern pollen rain studies and multivariate analyses allow us to discriminate the peculiarities of *Pinus sylvestris* var. *iberica* forest communities from the Gredos Range and to propose two new phytosociological associations: *Echinosparto barnadesii-Pinetum ibericae* and *Festuco merinoi-Pinetum ibericae*.

In fact, fossil pollen data have revealed the existence of a continuous band of Scots pine forests on both orosubmediterranean and suprasubmediterranean areas (reaching some supramediterranean sites) of this range during at least the last seven thousand years. Pollen records from Puerto de la Peña Negra (1,909 m asl), Puerto de Chía (1,701 m asl), Puerto de Serranillos (1,700 m asl), Nariillos del Rebollar (1,560 m asl), Hoyos del Espino (1,450 m), Navarredonda de Gredos (1,550 m asl), Garganta de los Caballeros (1,365 m asl), Hoyocasero (1,250 m asl), Baterna (1,140 m asl), and Riatas (1,120 m asl) peat bogs provide clear evidence of these facts (FRANCO-MÚGICA, 1995;

ANDRADE & al., 1996; FRANCO-MÚGICA & al., 1997; DORADO & al., 2001; ANDRADE & GONZÁLEZ-JONTE, 2007; LÓPEZ-MERINO & al., 2009; LÓPEZ-SÁEZ & al., 2009a, 2009b; RUIZ-ZAPATA & al., 2011).

The development of La Mesta system, the organization of high-mountain pastoral spaces with the use of montane areas as summer pastures, as well as the repeated use of fire, since 13th century, but more particularly after its dissolution in 1836, were the main reasons of the abrupt disappearance of most *Pinus sylvestris* forests from the Gredos Range (LÓPEZ-SÁEZ & al., 2009b), where only small groups are currently represented on the northern slope and scattered trees on both northern and southern slopes (GÉNOVA & al., 1992; MARTÍNEZ-GARCÍA & MONTERO, 2000). A similar picture

is observed in other mountains such as Guadarrama and Ayllón ranges (FRANCO-MÚGICA, 1995; FRANCO-MÚGICA & al., 1998, 2001b; GÓMEZ-GONZÁLEZ & al., 2009) although with much lesser intensity allowing the current existence of wide forests; and even in the Pela Range where pinewoods deforestation occurred since the Roman period (CURRÁS & al., 2012). It is particularly noteworthy that the fossil pollen record also demonstrates the existence of *Pinus sylvestris* forests in western areas of the Iberian Central System where they have currently disappeared, such as the Béjar and Francia ranges for most of the Holocene (ATIENZA & al., 1996; LÓPEZ-JIMÉNEZ & LÓPEZ-SÁEZ, 2005; RUIZ-ZAPATA & al., 2011; ABEL-SCHAAD, 2012; ABEL-SCHAAD & LÓPEZ-SÁEZ, 2013; MORALES-MOLINO & al., 2013).

SYNTAXONOMICAL SCHEME

JUNIPERO SABINAE-PINETEA SYLVESTRIS Rivas-Martínez 1965 nom. inv. propos.

Junipero sabinae-Pinetalia sylvestris Rivas-Martínez 1965 nom. inv. propos.

Junipero sabinae-Pinion ibericae Rivas Goday ex Rivas Goday & Borja 1961 corr. Rivas-Martínez & J.A. Molina in Rivas-Martínez, Fernández-González & Loidi 1999

Ononido aragonensis-Pinetum ibericae (Rivas Goday & Borja 1961) Rivas-Martínez 1969 corr. Rivas-Martínez, T.E. Díaz, Fernández-González, Izco, Loidi, Lousã & Penas 2002

Avenello ibericae-Pinion ibericae Rivas-Martínez & J.A. Molina in Rivas-Martínez, Fernández-González & Loidi 1999

Avenello ibericae-Pinetum ibericae Rivas-Martínez & J.A. Molina in Rivas-Martínez, Fernández-González & Loidi 1999

Pteridio aquilini-Pinetum ibericae Rivas-Martínez & J.A. Molina in Rivas-Martínez & al. 2002

Echinosparto barnadesii-Pinetum ibericae Sánchez-Mata, Gavilán & López-Sáez *ass. nova*

Festuco merinoi-Pinetum ibericae Sánchez-Mata, Gavilán & López-Sáez *ass. nova*

Erico aragonensis-Pinetum ibericae Sánchez-Mata, Gavilán & López-Sáez *ass. nova*

FLORISTIC APPENDIX

Avenella iberica (Rivas Mart., Izco & Costa) Rivas Mart.

Cytisus striatus subsp. *eriocarpus* (Boiss. & Reut.) Rivas Mart.

Erica australis subsp. *aragonensis* (Willk.) Cout.

Festuca braun-blaunquetii (Fuente, Ortúñez & Ferrero) Rivas Mart., Fern. Gonz. & Loidi

Festuca durandoi Clauson

Festuca elegans subsp. *merinoi* (Pau) Fuente et Ortúñez

Festuca gredensis Fuente & Ortúñez

Jasione montana subsp. *echinata* (Boiss. & Reut.) Rivas Mart.

Festuca paniculata subsp. *multispiculata* Rivas Ponce & Cebolla

Leucanthemopsis pallida subsp. *alpina* (Boiss. & Reut.) Rivas Mart., Fern. Gonz. & Sánchez-Mata

Pinus sylvestris var. *iberica* Svoboda

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