NUMERICAL TAXONOMY AND ETHNOBOTANY OF THE ELMS OF NORTHERN SPAIN

by

RICHARD H. RICHENS* & JOHN N. R. JEFFERS**

Abstract

RICHENS, R. H. & J. N. R. JEFFERS (1986). Numerical taxonomy and ethnobotany of the elms of northern Spain. *Anales Jard. Bot. Madrid* 42(2): 325-341.

Two methods of biometrical analysis were used to classify a collection of 185 leaf samples, mainly assembled in the course of an expedition to survey the elms of northern Spain in September 1979. Nearly all samples were referable to either *Ulmus glabra*, *U. minor* var. *minor*, *U. minor* var. *vulgaris* (*U. procera*), *U. minor* var. *minor* × *vulgaris* or *U.* × *hollandica*. The variation within each taxon is described. *U. glabra* is the only elm believed to be native. It exists in two forms, one identical with that of western Europe, the other, with a longer petiole, unknown elsewhere. Both *U. minor* var. *minor* and *U. minor* var. *vulgaris* are believed to have been first introduced by man, probably by Celtic or pre-Celtic Indo-European speakers early in the first millenium BC, the first variety from south-west France, the second coming from the Mediterranean coast of southern France. Hybridization within *U. minor* and between *U. glabra* and *U. minor* has probably occurred over a long period of time. Some north Spanish elms are of horticultural origin, some from overseas.

Resumen

RICHENS, R. H. & J. N. R. JEFFERS (1986). Taxonomía numérica y etnobotánica de los olmos de España septentrional. *Anales Jard. Bot. Madrid* 42(2): 325-341 (en inglés).

Se emplean dos métodos de análisis biométrico para la clasificación de una colección de 185 muestras foliares acumuladas, en su mayor parte, durante una expedición organizada con el fin de examinar los olmos de España septentrional, en septiembre 1979. Pudieron referirse casi todas las muestras a *Ulmus glabra*, *U. minor* var. *minor*, *U. minor* var. *vulgaris* (= *U. procera*), *U. minor* var. *minor* × *vulgaris* o *U.* × *hollandica*. Se describe la variación dentro de cada taxon. Se cree que el único olmo indígena es *U. glabra*. Existe en dos formas, una idéntica al *U. glabra* de Europa occidental; otra, que tiene pecíolo más largo, desconocida en otra parte. Tanto *U. minor* var. *minor* como *U. minor* var. *vulgaris* se creen introducidas por el hombre, probablemente de idioma céltico, o precéltico indo-europeo, en la primera parte del primer milenio A. C., var. *minor*, con origen del sudeste de Francia y var. *vulgaris* de la costa mediterránea de Francia meridional. Es probable que en el curso de muchos siglos se produjera la hibridación dentro de *U. minor*, y entre *U. glabra* y *U. minor*. Algunos olmos de España septentrional son de origen hortícola, algunos de fuera del país.

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INTRODUCTION

This investigation into the elm flora of northern Spain was undertaken, in the first place, to locate the source of the principal elm of the English lowlands [*Ulmus minor* Miller var. *vulgaris* (Aiton) Richens], designated *U. procera* Salisb. in the "*Flora Europaea*". It was concluded (RICHENS, 1983) that this elm had been introduced into England from the Spanish peninsula in pre-Roman times, probably the Later Bronze Age. As the material collected throws light on the taxonomy and history of the elm in the western Mediterranean region, an account of the variation encountered, and of the historical background to this variation, is presented here.

MATERIALS AND METHODS

Most of the foliar biometrical material used in this study was collected in a tour of northern Spain made in September 1979. A small supplementary collection of material was also available from elsewhere in Spain. The material collected was composed of sub-distal leaves from dwarf shoots. Specimens were chosen, as far as possible, from the sides of fields, recent amenity plantings and roadside trees being avoided. In all, 185 specimens were gathered.

For biometrical analysis, nine characters of a typical sub-distal leaf were measured: length of the longer side of the lamina; breadth, length and depth of the primary teeth at the shoulder of the leaf (illustrated in RICHENS 1983: 11); relative breadth of the lamina (maximum breadth of the lamina/length of lamina); relative petiole length (length of petiole/length of lamina); relative asymmetry (distance parallel to the mid-rib between the lower points on each side of the lamina/length of lamina); the number of primary + secondary teeth; and a measurement of petiole hairiness.

Two biometrical analytic methods were used. The first, method I, was principal component analysis and clustering by a modification of the minimum spanning tree technique of GOWER & ROSS (1969). The measurements of petiole hairiness were not used in this method. Distance constraints of 0.5, 1.0, 1.5..., were used for successive clustering cycles. In addition to the collection of Spanish samples, a Reference Collection of 65 samples, comprising specimen leaves of representative elms from the whole of Europe, was pooled with it to relate the Spanish material to that of Europe as a whole.

The second, method II, was to assign each sample to a cell in a 6-dimensional hypercube of selected foliar measurements from those described above. All the measurements are highly independent of each other, except tooth length and tooth breadth, for which reason tooth length was discarded in this method. Also, the number of samples collected was too small to represent adequately the totality of variation involved in an 8-dimensional analysis. Two further measurements, therefore, relative asymmetry and petiole hairiness, were also discarded in this method. The remaining measurements were each made to constitute a dimension in the hypercube, and the range of each was divided into three segments, a central mid-range segment, roughly one fifth of the range centred on its mode, and the segments on either side of this. Thus, the taxonomic hypercube has 3^6 cells. The definitions of the three segments of the characters used are shown in Table 1. Because the first author's herbarium of elm biometrical foliar material, which comprises some 3500 English specimens, 1500 continental European, as well as Scottish and Irish material, is indexed by hypercube cell, it is easy to compare particular Spanish samples with other material in the same cell. The Spanish material in each cell was clustered by attaching each cell to all cells differing by only one measurement segment and containing more samples (or, if there were none with more, the same number of samples) than the initial cell. By treating each occupied hypercube cell similarly, a network of attachments was built up around a set of highest frequency peaks, as shown in Figure 1. This is a slight variant of a method introduced by RICHENS & JEFFERS (1978).

The notation used in earlier papers (RICHENS & JEFFERS, 1975; RICHENS, 1983) for the biometrical description of the leaf samples is used here too. Measurements in the mid-range segment of the characters considered above were ignored. Measurements numerically above the mid-range values were designated by a capital letter indicating the character concerned. Measurements numerically below the mid-range values received corresponding lower-case letters. The relevant letters for the range segments of each character are set out in Table 1.

For example, for method I, the leaf sample *(U. minor* var. *vulgaris)* collected at Arcos (Or) received the designation DWAn, the characters being cited in order of the listing in Table 1. The measurements were: leaf length 59 mm, not cited; tooth breadth 5.00 mm, not cited; tooth depth 3.00 mm, D; relative breadth, 0.77, W; relative petiole length 0.11, not cited; relative asymmetry, 0.15, A; tooth number, 83, n. For method II, with relative asymmetry discarded, the description was DWn.

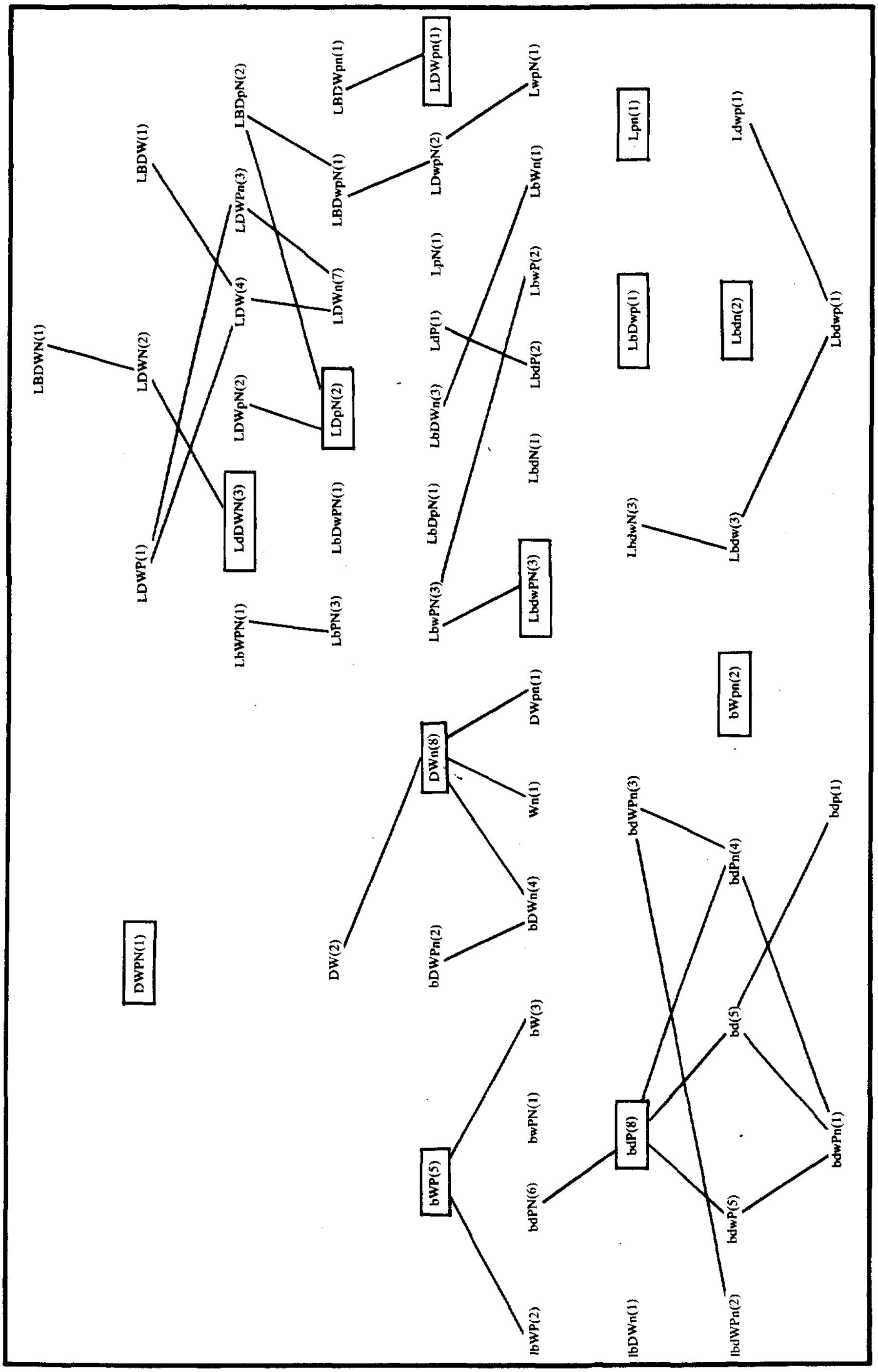
The notation is also used to designate the mode of the leaf characters of the clusters of method I. For this, the range segments of the different characters in all members of the cluster were added separately, the maximum for each character being taken as the modal value, preference being given to the mid-value when two range segments were equally frequent.

The successive orders of clusters in method I are indicated by the capital letter prefixes *A, B, C*,... Numerical subscripts are used to distinguish samples of same-order clusters with the same biometrical designation.

TABLE 1

KEY TO NOTATION OF LEAF MEASUREMENTS

Character	Lower segment designation	Mid-range segment (not designated)	Upper segment designation
Leaf breadth	l	50-69 mm	L
Tooth breadth	b	5.0-5.5 mm	B
Tooth depth	d	2.0 mm	D
Relative breadth	w	0.60-0.69	W
Relative petiole length	p	0.08-0.11	P
Relative asymmetry	a	0.08-0.11	A
Tooth number	n	90-109	N


LBDWN(1)
LDWN(2)
LBDW(1)
LDWP(1)
LDWPn(3)
LDW(4)
LdDWN(3)
LBDpN(2)
LDWpN(2)
LDpN(2)
LbWPN(1)
LbPN(3)
LBDWpn(1)
LBDwpN(1)
LDWn(7)
LbDwPN(1)
LDWpn(1)
LDwpN(2)
LpN(1)
LdP(1)
LbDWn(3)
LbDpN(1)
LbwPN(3)
LwpN(1)
LbWn(1)
LbwP(2)
LbdP(2)
LbdN(1)
LbdwPN(3)
Lpn(1)
LbDwp(1)
LbdwN(3)
Ldwp(1)
Lbdn(2)
Lbdwp(1)
Lbdw(3)
DWPN(1)
DW(2)
DWn(8)
bDWPn(2)
DWpn(1)
Wn(1)
bDWn(4)
bWpn(2)
bdWPn(3)
bdPn(4)
bdp(1)
bWP(5)
bW(3)
bwPN(1)
bdPN(6)
lbWP(2)
bdP(8)
lbDWn(1)
bd(5)
bdwP(5)
lbdWPn(2)
bdwPn(1)

In method II, each cell of the biometrical hypercube represents a first-order cluster and the network of cells attached directly or indirectly to a highest-frequency peak represents a second-order cluster. These receive the respective prefixes *a* and *b*; the *b* cluster is designated by the highest-frequency value, those in boxes in Figure 1. Some *a* clusters may connect to two or more highest-frequency peaks. These are assigned to a *b* cluster designation in the form *b*.bdP/bWP. These will sometimes represent hybrid taxa.

In seeking affinities, the biometrical foliar characters discussed above were the entry point. Clusters obtained by either of the two methods then require further examination in respect of foliar characters less amenable to biometrical treatment, such as colour (depth of green), secondary vein number and angle with the mid-rib, tooth shape, lower-surface indumentum, and non-foliar characters such as tree habit and bark texture.

RESULTS

The multivariate analysis (method I) revealed that four principal components accounted for 91% of the variation in biometrical foliar characters. When the samples were clustered, using these components, they fell into 204 *A* clusters, 79 *B*, 22 *C*, 13 *D*, 10 *E*, 2 *G* and 1 *H* cluster. Some of these clusters only included clusters out of the Reference Collection. When these were excluded, so that only clusters involving Spanish samples were considered, the respective figures were 158 *A*, 64 *B*, 16 *C*, 9 *D*, 8 *E*, 4 *F*, 1 *G* and 1 *H* cluster. The dendrogram of the higher-order clusters is shown in Figure 2.

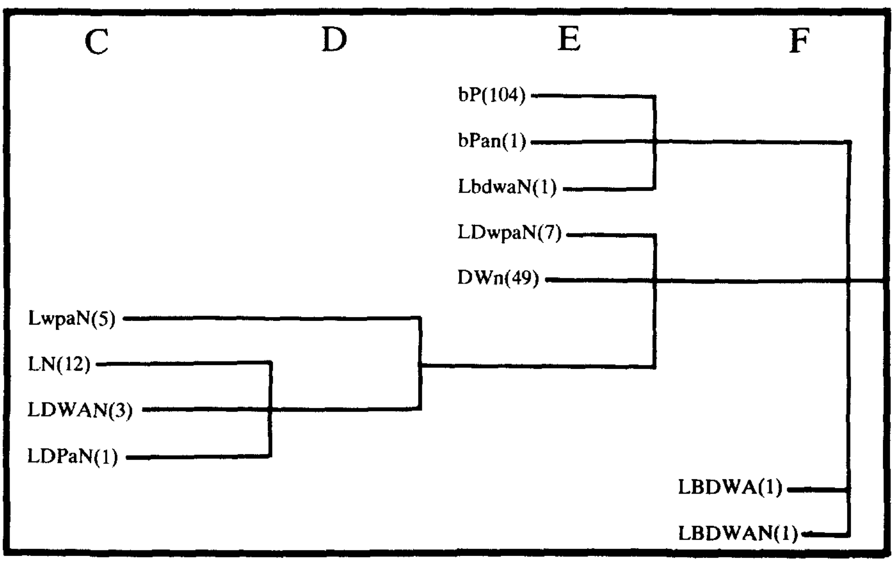


TABLE 2

CLUSTERS ARRANGED UNDER TAXA

Taxon group	Clusters: Method I	Clusters: Method II	Provincial distribution
U. glabra	(1) *E.* LDwpaN (6), B. LDpN (2), *A.* LbpN	*b.* LDpN(8), *b.* DWn/LbdwPN/LbDWN/LDpN	As3, Sa, Vi5
	(2) *B.* LDWN (2), *C.* LDWAN (2), *A.* LbDWN,	*b.* LbDWN (5)	As3, Gu3, Vi2
	B. LD, LBDpN, F. LBDWAN	*a.* LD, LBDpN, *a.* LBDWN	
	(3) *A.* LbDwpa	*b.* LbDwp	Lu
	(4) *A.* LwpAN	*b.* LwpN	Vi
U. minor var. *minor*	(1) *E.* bP (54), *A. bDaN*	*b.* bdP (29), *b.* bdP/bWP (10), *b.* LbdwPN (7)	Al3, Bu20, Le12
		bWP_1 (3) LbdPn, Lb_1	As10, Lo3, Pa2
		LbP_1	Sa2, To, Vi2
	(2) *A.* lbPan, *A.* bdPA, *A.* bwan	*a.* 1bPn, bdP_1, bwn_1, bPn	Le, Pa2, Za
	(3) *B,* bdwa (2)	*a.* bdw, bwn_2	As, Le
	(4) *A.* bdwPa	bdwP	Bu
	(5) bdpa	*a.* bdp	Bu
	(6) *A.* bda	bd_1	As
	(7) *A.* bdWPN	*a.* bdWPN	Vi
	(8) *A.* bwPn	*a.* bwPn	As
	(9) bwPN	*a.* bwPN	As
	(10) ba	b_1	Sa
	(11) *E.* LbdwaN	Lbdw	Lo
	(12) LbdPa	LbdP	Po
	(13) *A.* LbwP	$LbwP_1$	As
	(14) *A.* LbaN	LbN	Ba
	(15) LbA	Lb_2	As
U. minor var. *vulgaris*	(1) *E.* DWn (47), *F.* LBDWA	*b.* DWn (40), *b.* bWpn (2), *b.* bdP/DWn	Av, Bu, Cu3
		b. bWpn/bWP, bW_1, *b.* DWPN	Gr, Le17, Mu
		a. LDWpn, LDWpN	As2, Or15, Pa5, Po2
	(2) *A.* lbWn	lbWn	Za
	(3) *A.* bWan	*b.* bWpn/bWP/DWn	Za
	(4) *A.* bWPA	bWP_2	Le
U. minor **Granada tx.**	*B.* Lbdwpa, *A.* Lbdn, *A.* Lbwpn	*a.* Lbdwp, $Lbdn_1$, *a.* Lbwpn	Gr3

U. minor var. *minor* × var. *vulgaris*	(1) *A.* bd, *A. b*, *A. bw*	bd_2, b_2, bW_2	As3
	(2) *B.* bdWPA (2), *A.* bWA	bdP_2, bWP_3, bW_3	Le3
	(3) *A.* lbWP, *B.* lbWPA	*a.* lbWP (2)	Bu2
	(4) *A.* lban	lbn (1)	As
	(5) bdWPn (1)	bdWPn	Bu
	(6) *A.* LbdWPa	*a.* LbdWP	Bu
	(7) *A.* b	LbP_2	Lu
	(8) *A.* LaN	LN	Va
	(9) *A.* bdWPAn	*a.* bdWPn	As
U. × *hollandica* (*U. glabra* × *minor*)	(1) *A.* bPAN, *A.* LbdwP, *B.* LbdwN,	*b.* bdP/LbdwPN (2), *a.* LbdwN (2)	14, Cu2, Gu
	B. LbdwAN, *A.* bWPA, *A.* LbdwPAN,	bWP_4, LbdwPN,	As2, Le, Lu
	Lbdan, *A.* LbwpN, $LbwP_1$,	$Lbdn_2$, LbwpN, $LbwP_2$,	Sa
	B. LbPAN, *B.* LbDwPAN, *C.* LDPaN	LbPN, *a.* LbDwPN, LDPN	
	(2) *B.* LDN (2), *A.* LDAN, LbwPan	*b.* DWn/LbDWN (3), LbwPN	Al, Bu, Gu
	A. LPN, *A.* LDpaN	LPN, LDpN	As2, Sa
	(3) *A.* LdPA, *A.* Lpan	*a.* LdP, *b.* Lpn	As, Vi
	(4) *A.* bDAN	*a.* bDN	Sa
	(5) *A.* Ldwpa	*a.* Ldwp	Sa
	(6) *A.* LbwPan	*a.* LbwPn	As
	(7) *A.* LbwPAN	LbwPAN	Cd
	(8) *B.* LbWPAN	*a.* LbWPAN	Sa

Note: Numbers are attached to biometric designations and province abbreviations when more than one sample is involved.
Biometric designations lacking a cluster order prefix refer to samples atypical of the cluster into which they are aggregated. Provinces are abbreviated in the table and text as follows: Al, Álava; As, Asturias, Av, Ávila; Ba, Barcelona; Bu, Burgos; Cd, Córdoba; Cu, Coruña; Gr, Granada; Gu, Guipúzcoa; Le, León; Lo, Logroño; Lu, Lugo; Mu, Murcia; Or, Orense; Pa, Palencia; Po, Pontevedra; Sa, Santander; To, Toledo; Va, Valladolid; Vi, Vizcaya; Za, Zaragoza.

In method II, the samples fell into 95 *a* clusters. These aggregated into 12 *b* clusters around the highest-frequency peaks and 11 intermediate *b* clusters. For Europe as a whole, the first author's herbarium is distributed over ca 400 *a* clusters.

In Table 2, the clusters derived by the two methods are assigned to the conventional taxa: *U. glabra* Hudson, *U. minor* Miller var. *minor*, *U. minor* var. *vulgaris*, *U. minor* var. *minor* × var. *vulgaris* and *U.* × *hollandica* Miller *(U. glabra* × *U. minor)*. With both methods, outlying members of some clusters did not fall into the same taxon as the rest of the cluster.

The only elm certainly native to northern Spain is *U. glabra*. It occurs in two principal forms: a short-petioled form, (1) of Table 2, and a long-petioled form, (2) in Table 2. The two methods aggregate this taxon with similar efficiency. Both forms occur in the Basque depression and at moderate altitudes on the flanks of the Cantabrian mountains. Form (1) is indistinguishable from *U. glabra* elsewhere in Europe. The Spanish leaf samples can be matched in fine detail with those from Austria, England, Scotland, Sweden, Switzerland and Wales. Form (2) has not been found outside Spain. Its taxonomic status is not completely certain. Its high relative petiole length puts it outside the normal range of variation of *U. glabra*. In addition, all the samples allocated to form (2) had a higher than average relative width. Form (2) may, indeed, be a variant of *U. glabra* confined to the Spanish peninsula. Possibly, however, it may be *U. glabra* introgressed at some early date by *U. minor*, and therefore more properly placed under *U.* × *hollandica*.

U. minor var. *minor* is the characteristic elm of the north-east Meseta. It was abundant over much of the provinces of León, Palencia and Burgos. As will be seen later, it is not considered as native in this area. It is a variable assemblage comprising a principal group (1), itself highly variable, and a considerable number of samples (2-15), outside the general range of group (1). *U. minor* var. *minor* is also present north of the Cantabrian mountains but it is seldom abundant and is even more variable than south of the mountains. The densest population found was around Villaviciosa (As).

Method I aggregated all the samples of this group into one cluster, *E.*bP. In method II, it aggregated into a number of smaller clusters, reflecting the considerable within-group variability that group (1) displays. The remaining groups seem to fall into two categories, the first including what are probably aberrant clonal derivatives of group (1), the second comprising forms of *U. minor* var. *minor* likely to be horticultural introductions, e.g. groups (6), (11) and (14), not necessarily related to group (1), and some possibly introduced from overseas. The affinities of group (1) are with the small-leaved elms with small teeth that are frequent at the present time in southern France and extend northward to Brittany, Normandy and southern England.

U. minor var. *vulgaris* differs from var. *minor* in having leaves of greater relative width, characteristically darker colour, with large teeth, more widely spaced secondary veins and, typically, a much hairier petiole. It is the characteristic elm of the Miño valley, west of Ribadavia (Or), of the middle Sil valley, of the Bierzo, and of the north-west Meseta. It occurs also in smaller areas in north-west León (Vallenosa, Villeles de Valdavia, Olmos de Ojeda) and a quite isolated area around La Coruña. *U. minor* var. *vulgaris,* like var. *minor,* is not considered indigenous to northern Spain. It is much less variable than var. *minor,* most samples falling into one cluster *E.*DWn, by method I, and one cluster, *b.*DWn, by method II. The deviant members in groups (2-4) are clearly only extreme variants of the main taxon.

Outside the Spanish peninsula, *U. minor* var. *vulgaris* is only known from a small area along the Mediterranean coast of France, and in southern England and south Wales, where it is the principal elm. The leaves of the Spanish populations are rather more variable than the English, the leaves often being larger. Tree habit in Spain is also more variable. As will be discussed later, the English population is regarded as having been derived from the Spanish peninsula in prehistoric times.

The leaves of three specimens from Granada resembled *U. minor* var. *vulgaris* in general appearance, but were much narrower than in this variety. Only extensive collecting in southern Spain could elucidate the relationship between the Granada material and typical var. *vulgaris.* So, as a temporary measure, in Table 2 the Granada leaves are merely designated *U. minor* Granada taxon.

Twelve samples displayed various combinations of the characters of var. *minor* and var. *vulgaris* of *U. minor.* They are tentatively taken to be hybrids between the two varieties. This assemblage is quite heterogeneous and aggregates poorly with both methods I and II. These elms are seldom frequent. Sometimes they occur in regions of overlap between the two varieties, as in León and Burgos provinces. In other cases, they were found in regions where *U. minor* var. *minor* was the only putative parental variety present, as in the north Spanish coastal belt of Asturias province. It is likely that hybridization between var. *minor* and var. *vulgaris* has occurred repeatedly, and that the resulting hybrids may have been taken by man outside the regions of overlap of the two taxa. It should be added that elms with the putative parentage here assigned to them cannot always be certainly distinguished from the interspecific hybrids to be considered next.

The last group of elms are those intermediate between *U. glabra* and *U. minor,* and likely to be hybrids between these two species. What are probable F_1 hybrids, combining the large leaves of *U. glabra* with other foliar characters normally confined to *U. minor,* constitute group (2). F_1 hybrids of this parentage have long been favourite subjects with nurserymen, and a number of samples collected are likely to be of recent horticultural introduction, in some cases probably of foreign origin. In other cases, they are likely to have originated from hybridization *in situ* between *U. glabra* and *U. minor* introduced by man, notably in the Basque provinces and in the foothills of the Cantabrian mountains. The largest group of interspecific hybrids is (1). In these, the leaves are smaller than in group (2) though larger, on the whole, than in Spanish *U. minor.* In general appearance, they are quite close to *U. minor.* Two of the characters indicative of *U. glabra* which are frequently encountered are high tooth number and mucronate leaf apex. This group probably comprises F_2 hybrids and further hybrid generations of the interspecific combination. Its distribution is wide and scattered. As with group 1, it probably comprises samples that have originated *in situ* and horticultural introductions, some, quite likely, from abroad. Groups (3-9) are represented by only 1-2 samples each. They each have some characteristic that differentiates them from the main groups (1) and (2). It is likely that many are horticultural introductions.

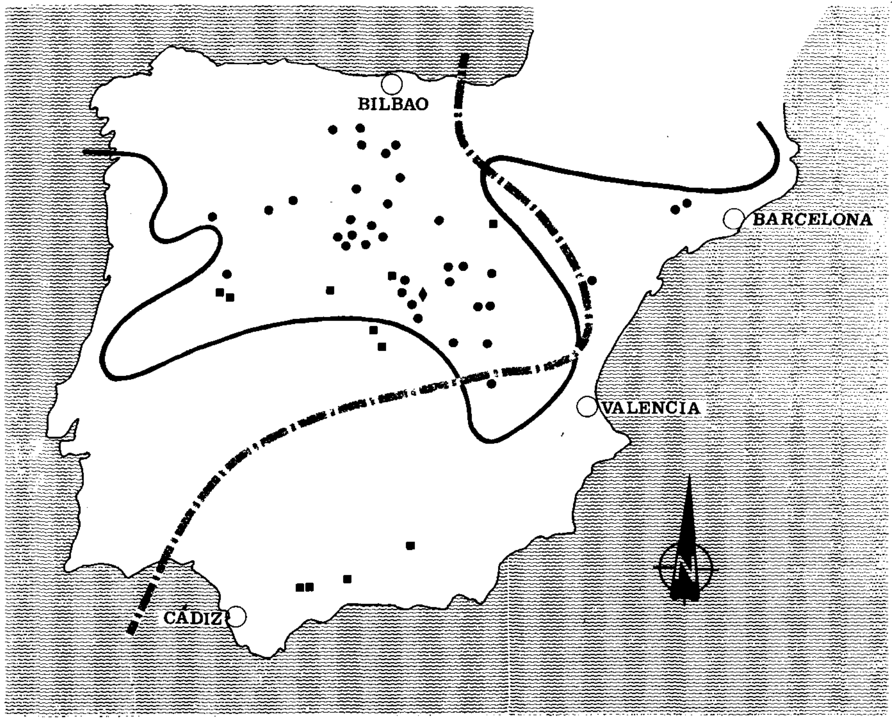
HISTORY

The only elm that can be accepted confidently as native to northern Spain is *U. glabra*. This occurs in what appear to be natural assemblages either in riverain or in beech wood communities together with other plants characteristic of temperate west Europe. The overall distribution is northern in the Spanish peninsula: the Pyrenees and Cantabrian mountains, but with outliers in mountainous areas as far south as the Sierra de Guadarrama. This distribution alone suggests immigration from France early after the post-glacial amelioration in temperature. There is no evidence pointing to a glacial refugium of *U. glabra* in southern Spain and the few relevant pollen profiles available (BELLOT RODRÍGUEZ & VIEITEZ CORTIZO, 1945; MENÉNDEZ AMOR & FLORSCHÜTZ, 1961 a, b, 1962; BUTZER & FREEMAN, 1968; FLORSCHÜTZ & *al.*, 1971; DUPREÉ & RENAULT-MISKOVSKY, 1981) are remarkable in the almost complete absence of elm pollen. Indeed, elm appears to have been virtually absent from the Spanish peninsula in the previous inter-glacial period.

The fact that *U. glabra* is known by a Celtic name in Asturias ("llamera" or "tsamera") and a Basque name ("zumarr" and variants) in the Basque provinces indicates that it was present before the romanization of northern Spain.

As noted above, the principal form of *U. glabra* [group (1)] is indistinguishable from material of this species in western Europe. The nature and origin of group (2), with the longer petiole, are, however, uncertain. If it is a form of *U. glabra*, it presumably came from a glacial refugium to the east of the Spanish peninsula, but it appears not to have established itself in France. If, on the other hand, it is *U. glabra* introgressed by *U. minor*, this introgression could only have occurred after *U. minor* had been introduced into its vicinity, presumably by man. Alternatively, it is possible to envisage an introgression of *U. glabra* outside the Spanish peninsula before its post-glacial immigration.

Several reasons tell against the native status of *U. minor* in northern Spain. First, *U. minor* appears not to enter into what can be confidently taken as indigenous communities in the north of the Spanish peninsula. Here, it is essentially a plant associated with human presence. Even in central Spain, the *Fraxino angustifoliae-Ulmion minoris* community described by RIVAS MARTÍNEZ (1975) from riverain sites in Avila province, of which *U. minor* is a component, is doubtfully a natural assemblage. Even less likely to be native is the *U. minor* in the *Alneto-Ulmion* described by BELLOT RODRÍGUEZ (1966) for Galicia. *U. minor* appears to be a genuine component of natural assemblages along rivers draining into the Mediterranean, in the *Alneto-Ulmion* and *Populion albae* associations described by BOLÒS (1965) and LAPRAZ (1966) in Catalonia, by RIVAS GODAY & BORJA CARBONELL (1961) in Valencia, and by TCHOU (1948-49) in southern France. *U. minor* also appears to be native in riverain sites in Cádiz province (CEBALLOS, 1929), but, significantly, it is not scheduled as a component of the riverain alliance *Alnion lusitanicum* of central and north Portugal (BRAUN-BLANQUET & *al.*, 1956). Second, the majority of the observed sites of *U. minor* in this area were south of the Cantabrian mountain chain, and in a climatic area of intense spring frost, and it is doubtful whether this species regularly reproduces sexually north of the olive limit, which, in the Spanish peninsula, does not extend as far north as the present area of study (see Figure 3).



Third, the patterns of distribution of *U. minor* as a whole, and of its subordinate taxa var. *minor* and var. *vulgaris,* appear not to be correlated with the climatic and edaphic factors which generally determine the distribution of wild species. The pattern can only be accounted for, and then only partially, from lack of sufficient detailed evidence, in historical terms through introduction and subsequent spread by man.

The biometrical analyses suggest that most of *U. minor* in northern Spain falls into two categories, representing var. *minor* and var. *vulgaris* respectively, and that it is not necessary to seek for more than two sources for these two populations.

It has already been pointed out that the main var. *minor* population of northern Spain, which is mainly to be found in the north-east Meseta, can be matched with similar material from south-west France, and indeed with material in north-west France, believed (RICHENS & JEFFERS, 1975) to have been taken there by man in prehistoric times. Southern France is then a possible source for the *U. minor* in north-east Spain. A less likely possibility is that it was derived from wild *U. minor* behind the Spanish Mediterranean coast. Adequate material was not available from there to make the necessary comparison. The few elm samples from the Spanish Mediterranean coast utilized in the present study had only remote relationships with the main *U. minor* population of the north-east Meseta. *U. minor* from the Mediterranean coast of France was available, however, and this was quite different from the *U. minor* of the north-east Meseta.

Var. *vulgaris,* as already noted, was found in three main locations. The largest covered the valleys of the Miño and Sil, and the north-west Meseta. The other two much smaller areas were near La Coruña, and in an area mainly occupied by var. *minor* in north-east León. As with north Spanish var. *minor,* these populations are almost certainly well north of the natural range of var. *vulgaris,* which, outside the Spanish peninsula, is only known from the Mediterranean coast of France and in the British Isles. The latter population, as will be discussed later, is believed to have been introduced from the Spanish peninsula. North Spanish var. *vulgaris* must then either have been introduced from southern France or, possibly, if var. *vulgaris* occurs wild somewhere along the Mediterranean coast of Spain, from there.

The overall distribution of *U. minor* in the Spanish peninsula is not known in detail. Outside the main area of the present study, it appears to be generally absent from terrain above 1000 m altitude, from much of the southern Meseta, from the more arid sections of the Spanish Mediterranean coast and from southern Portugal. In Portugal, var. *vulgaris* is confined to the north-west of the country (FRANCO, 1971). In Spain, the material of the present study indicates its presence in Zaragoza, Ávila and Murcia. Var. *minor* is widespread in parts of central Portugal and probably in central and southern Spain.

Direct evidence for the presence of elm in the Spanish peninsula in early historical times is scanty. Elm timber of Roman age has been found in Cáceres (PAULSEN, 1930). In the period between the Roman withdrawal and the Arab invasion, Isidore of Sevilla (LINDSAY, 1911) wrote about elm in terms that suggest he was familiar with its presence and edaphic requirements in southern Spain.

Linguistic evidence for the occurrence of elm in the Spanish peninsula involves a number of difficulties. The Latin word *ulmus* was presumably current throughout in Roman times because it gave rise to more or less regular derivatives in all the major local Romance languages and dialects (Catalan "om", Valencian "olm", Aragonese "urmo", Castilian "olmo", Asturian "umero", Galician and Portuguese "ulm(eir)o").

Parallel with this series of words for elm was another, represented by modern Castilian "álamo", Portuguese "álemo". Though now usually applied to *Populus* spp., it is clear from contextual information that, in earlier times, it was used also, and in many areas mostly, for elm. Its etymology is uncertain. COROMINAS & PASCUAL (1980) discuss a number of possible etymologies, most of which involve 'word hybridization', such as *alnus* × *ulmus* and *albus* × *ulmus*. It appears now to be generally agreed that the word from which álamo is directly derived must have been formed no later than Roman times and the authors just quoted prefer a 'hybrid' origin from Latin *albus* × Celtic **lemos* or **elmos*, the latter supposedly being names applied to elm or poplar by Celtic speakers in Spain. It is immaterial for present purposes how the name came into existence. What is important here is that the antecedents of the word date back to Roman times, and that, in the later Middle Ages, it was applied often, and sometimes exclusively, to elm.

The Arabs of Spain had two words for elm, "nasham" and "hawar", neither in standard Arabic. Both, moreover, were used as blanket terms for several trees, namely *Ulmus minor, Populus* spp. and *Celtis australis* L. When qualified as black, as "nasham aswad", the meaning is restricted to elm alone. The Arab use of 'black' in this context seems to have affected usage by Romance language speakers. Thus, there are found such expressions as Valencian "olm negre", Castilian "olmo negro", "olmo negrale", Portuguese "olmo preto", Castilian "álamo negro", "álamo negrillo", Portuguese "alamo preto", "álemo negro", all meaning elm. It was only lately that "álamo negro" came to designate the relatively later introduced *Populus nigra* L. Indeed, it seems that "álamo negrillo" might well be the source for the term "negrillo" ("negrilho") used latterly for elm in León and Galicia and Portugal. Place names provide significant evidence for the distribution of *U. minor* at the end of the Middle Ages. The distribution of "municipio" (Spain) and "freguesia" (Portugal) place names based on "ulmus", "álamo" and "hawaris" is shown in figure 3. It is immediately obvious from this figure that elm place names are mostly to be found in northern Spain. They lie in two groups, one centred in the northern Meseta and its surrounding foothills and the other in Catalonia. Names based on "álamo", some of which may refer to *Populus* spp., are more southern in distribution than names based on "ulmus". The one based on "hawar", Alovera in Guadalajara province (ASÍN PALACIOS, 1944), is in north-central Spain, which had passed from Arab occupation by the 13th century.

Valuable evidence on the distribution of *U. minor* in the 16th century is provided by the "relaciones" returned to Felipe II. Those published cover the provinces of Ciudad Real, Guadalajara, Jaén, Madrid and Toledo, and frequently specify the species of trees available in each "municipio" for building purposes. In these, elm was only cited frequently in Guadalajara and was very seldom mentioned in the others. This difference confirms the patterns of the place name evidence. Neither place name evidence nor the "relaciones" differentiate between var. *minor* and var. *vulgaris* of *U. minor*.

The evidence so far quoted clearly indicates the presence of some elm in southern Spain from Roman times onwards. The earliest place names based on "ul mus", such as Valle de Olmos and Olmedo (Va), establish the presence of *U. minor* in northern Spain in the 10th century (ANDRÉS, 1915; CARLÉ, 1973). It is most unlikely that here, also, they were not present in Roman times.

The time of introduction of the two varieties into northern Spain must now be considered, and it is convenient to take var. *vulgaris* first. Evidence for its presence in the neighbourhood of Ponferrada in the Sil valley in the 16th century is provided by COLÓN (1908). The most significant fact concerning var. *vulgaris*, however, is its widespread distribution in the British Isles. Its occurrence there is well documented back to the 8th century, and, if the arguments advanced by RICHENS (1983) are valid, this variety was certainly present in Roman times and had been introduced considerably earlier, probably in the Later Bronze Age, and from the Spanish peninsula. If this is so, var. *vulgaris* must have been present in the peninsula at this time, and in a site or sites in trading contact with the British Isles. This variety now, and presumably earlier, is practically absent from the whole of the northern and western coasts of the Spanish peninsula, except at one point, near La Coruña, which was on the route used by the tin traders sailing between Cádiz and the British Isles (HAWKES, 1969). The small var. *vulgaris* population near La Coruña is somewhat over 100 km from the much larger population of the Miño and Sil valleys, and, though it seems improbable at first sight that so small an elm population should be of such antiquity, this possibility must be envisaged. In tree habit, the La Coruña population exactly resembles that in the British Isles. The alternative is to suppose that var. *vulgaris* was taken to the coast from the population in the Miño valley, which would be a distance of ca 40 km.

Trading contacts between Galicia and the British Isles are well authenticated for the Later Bronze Age (HAWKES, 1969; RICHENS, 1983), and trading in other tree cultigens in the prehistoric period in western Europe is also well authenticated. The Phenicians brought the cultivated olive to Spain before the Roman invasion (SIMMONDS, 1976), and also the date palm and pomegranate (BLÁZQUEZ & *al.*, 1980: 172, 415). The appearance of *Castanea* in Valencia in the Earlier Bronze Age (MENÉNDEZ AMOR & FLORSCHÜTZ, 1961) and of *Castanea* and *Juglans* in pollen profiles just north of the Pyrenees before this (MARDONES & JALUT, 1983) would seem to indicate introduction of trees into south-west Europe by man at an even earlier date.

If the early presence of var. *vulgaris* in the north-west of the Spanish peninsula is accepted, it has next to be inquired what people introduced it there and who dispatched it to the British Isles. These could be the same or different. There are really only two possibilities: first, the people of the indigenous castreña culture of Galicia, and, second, the Celts or pre-Celtic speakers of an Indo-European language, who entered the Spanish peninsula ultimately from central Europe in the earlier half of the first millenium BC. It is extremely difficult to differentiate satisfactorily between the archaic Celtic of the north-western Spanish peninsula and earlier pre-Celtic Indo-European tongues (BLÁZQUEZ & *al.*, 1980).

One line of evidence, in particular, suggests that immigrants speaking an Indo-European tongue were responsible for the introduction of var. *vulgaris* into the north-west of the Spanish peninsula. This is the correlation between the area of distribution of this taxon in northern Spain and that of strong Celtic influence in the same area. Celtic infiltration was strongest in the northern Meseta. It was much less north of the Cantabrian mountains and in Galicia (GARCÍA Y BELLIDO, 1971). It is noteworthy that there is only one Celtic settlement with a characteristic *-briga* name, Flaviobriga near Bilbao, north of the mountains, and only two, Calubriga near El Barco de Valdeorras (Or) and Ardobriga near La Coruña (UNTERMANN, 1963), both sites of var. *vulgaris* today.

It is also relevant that the name of the Galician Celtic tribe, Lemavii, who gave their name to Monforte de Lemos (Lu) not far from where the Sil runs into the Miño, is based on the Celtic root for elm **lemos*. It is supposed by BOSCH-GIM-

PERA (1942) that this tribe was affiliated to the Lemovices of southern France and the Lemovii of northern Germany. The supposition that Celtic speakers were largely responsible for the taking of *U. minor* into cultivation in western Europe has already been argued by RICHENS (1983), the particular use of the tree being fodder for cattle. It would have to be assumed that Celtic immigrants introduced var. *vulgaris* from southern France, or, less probably, from the Mediterranean coast of Spain, into their settlements in the north-west. It is possible that they were also responsible for the introduction of another plant, *Triticum spelta* L. into Asturias, though Roman introduction has also been suggested (SEÑAS ENCINAS, 1961).

Trading contacts between the Spanish peninsula and the British Isles lapsed at the end of the Later Bronze Age (HAWKES, 1969) and did not resume till Roman times. It seems necessary, then, to date the dispatch of var. *vulgaris* to the British Isles no later than the end of the Later Bronze Age, and consequently to date its introduction into northern Spain even earlier. It is not clear, as already indicated, whether the Indo-European immigrants into Galicia at this early period spoke a Celtic language or some pre-Celtic tongue, and the suggestion of RICHENS (1983) that the Celts were chiefly responsible for the introduction of *U. minor* outside its natural limits may have to be modified to apply to pre-Celtic Indo-European speakers.

With regard to *U. minor* var. *minor* the earliest evidence of its local occurrence in north-east Spain is from the 10th century place names. There is little likelihood, however, that this variety was introduced here only shortly before. The distribution pattern with var. *minor*, of infrequent occurrence north of the Cantabrian mountains, reflects the limit of strong Celtic influence and intense romanization in this region. The fact that var. *vulgaris* is seldom found in the north-west Meseta suggests that another elm had already been introduced. These two observations, taken together, suggest that var. *minor* is most likely, too, to have been introduced from south-west France by Celtic-speaking peoples.

The fact that *U. minor* in general, as shown by the place name distribution and the evidence of the "relaciones", is centered in the northern Meseta lends further support for Celtic rather than Roman introduction. Romanization was far more intense in the south of the peninsula. The area of Celtic infiltration, moreover, in contrast to the non-Celticized area where Iberian occupation persisted, was in the north (see Figure 3). It covers most of the later place names alluding to elm. However, it is likely, if the two varieties of *U. minor* were introduced by the Celts, that they were further distributed within the Spanish peninsula by the Romans via their newly constructed road network.

It is likely that the Arabs planted elms in the parts of the peninsula that they occupied, but there is no reason to suppose that they introduced further stocks from abroad. The re-occupation of Arab territories by the Christian armies is unlikely to have been accompanied by much elm planting because Christian farmers had developed a marked antipathy to trees of any sort near cultivated land, an antipathy which persisted till the 19th century (SARRAILH, 1948; TORRES BALBÁS, 1950).

The *U. minor* of the northern coast is relatively infrequent and highly heterogeneous. It is likely to have been introduced later, perhaps much later, than south of the mountains. It appears to have two sources: first, the *U. minor* populations south of the mountains, and, second, horticultural material, often quite recent and in several cases probably foreign.

Some elm planting under royal auspices at the Escorial, Pardo and Aranjuez took place in the 16th century (BERTAULT, 1669; ANON., 1923) and a well-supported tradition asserts that the var. *vulgaris* at Aranjuez (EVELYN, 1664; FANSHAWE, 1905) was introduced from England by Felipe II.

In the 18th century, the scarcity of timber led to a number of laws being passed to plant trees adapted to various conditions, and elm was amongst the trees recommended for riverain sites (SALVÁ, 1854). It appears that these laws were widely disregarded, and it is likely that, when they were implemented, the elms planted were those locally available, and that the overall elm distribution patterns remained unchanged. Commercial tree nurseries hardly existed in the Spanish peninsula till much later, and it is known that some amenity planting in that century, both in Spain and Portugal, was based on elms imported from the Netherlands or England (GONZÁLEZ, 1958; PIRES, 1924).

In the 19th and 20th centuries, further elm planting material was certainly introduced from overseas and this would be expected in amenity plantings and along road verges. Moreover, the claim that the Duke of Wellington introduced elm from England into the Alameda of the Alhambra at Granada has been shown to be false (LOWE, 1973). The general pattern of elm distribution, if the arguments adduced above are correct, can only be explained in terms of much more ancient activity in prehistoric times.

As regards the two categories of hybrid elms, *U. minor* var. *minor* × var. *vulgaris,* is likely to have arisen repeatedly in the zone of overlap of the two varieties. It may then have been taken by man to other areas. *U.* × *hollandica* has a two-fold origin. Much could have originated in the indigenous area of *U. glabra* into which man had introduced *U. minor,* as in the Basque provinces. Other samples derive from nurseries, either in Spain or overseas, especially in the Netherlands and England.

The foregoing account is primarily concerned with northern Spain. A definitive and detailed interpretation of the history of the elm in the Spanish peninsula as a whole could only be constructed from a mass collection of elms from the whole of Spain and Portugal which, hopefully, will some day be done.

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