Phytocoenologia	24	383 – 399	Berlin–Stuttgart, March 28, 1994

The gypsophilous scrub communities of the Ebro Valley (Spain)

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with 4 figures and 4 tables

Abstract. A phytosociological revision of the gypsophilous scrub vegetation of the Ebro Valley using all the available data is made. For the analysis of the relevés set (initially 258) computer ordination methods, such as CA and PCA, have been applied in order to establish a relationships model between the different community-types. Along the analysis process, several groups have been distinguished and successively removed until we reached to a residual set of 178, which has been interpreted as homogeneous and representative of the nucleus of the main association. Part of this last set constitutes an example of biased sampling which favourises the distinction of two groups of relevés due to dominance of two plants. The comparison of both groups with other taken from the same area but without that bias reveals, when plotted together, the real significance of the two former groups as the cloud of the last one intermingles with the first ones of them. Discussion about the meaning and syntaxonomical recommended status for each group is also made and expressed in the accepted syntaxonomy; in it a new subassociation is described: Helianthemo thibaudii-Gypsophiletum hispanicae helianthemetosum rotundifolii. It is argued that typified syntaxa, such as associations and subassociations, in addition to a clear floristical characterisation, should have an ecological (climatic, edaphic) scope and often a phytogeographical significance. Ecotonic communities and transitional stages of internal succession could be expressed by means of variants and facies respectively.

Introduction

The Ebro river runs, in its central stretch, through a large depression (Ebro Basin) which occupies a considerable area (ca. 20 000 sq.km) of the northeastern quadrant of the Iberian Peninsula. Three main surrounding mountain ranges conceal it in a triangle-shaped depression: Pyrenees at the north, Iberian mountains and the plateau (Meseta) at the south and southwest and the Catalanidic ranges close the way eastwards (Fig. 1). This situation is responsible for some peculiarities of the climate in this territory, which is basically of Mediterranean type with a strongly marked summer-drought. This enclosure of the Ebro Basin causes an increase of the aridity as well as the continentality in the central part of its area; precipitation falls below 350 mm and the mean monthly temperatures range over 18 °C. Following the phytoclimatic typology of RIVAS-MARTÍNEZ (1990) the considered area belongs to the meso-mediterranean thermotype and to the dry and semi-arid ombrotypes.

On the other hand, the dominating substrata of this territory are constituted mainly be evaporitic miocenic materials, many of them rich in gypsum. This

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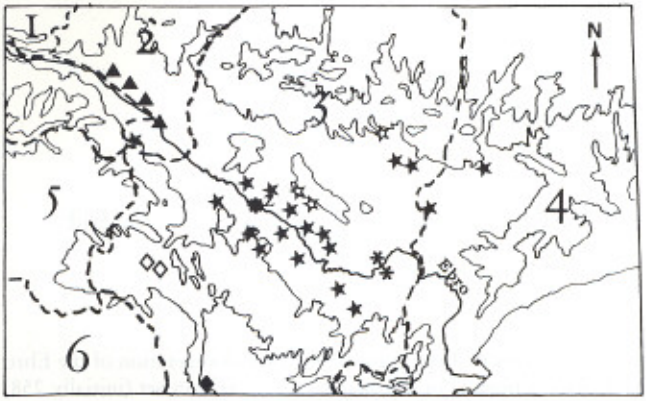

★ Helianthemo-Gypsophiletum hispanicae typicum,
☆ id. salvietosum lavandulifoliae, ✱ id. boletosum asperi,
▲ id. helianthemetosum rotundifolii,
◆ Salvio-Gypsophiletum hispanicae typicum,
◇ id. sideritetosum spinulosae.

Fig. 1. Geographical map of the Ebro Valley: 1 – Basque Provinces, 2 – Navarre, 3 – Aragon, 4 – Catalonia, 5 – Castile-Leon, 6 – Castile-La Mancha.

causes considerable proportion of the surface to be covered by gypsaceous soils which, under such a semi-arid mesomediterranean climate, support a particular vegetation type constituted by a scrub or "tomillar". That vegetation type is very sharply characterised floristically by a significant number of endemic taxa, strongly correlated to these soils, which traditionally has been included in the Iberian order Gypsophiletalia within the Rosmarinetea class. This scrub, from the successional point of view, constitutes a degradation stage in substitution of the Potential Natural Vegetation of the area which, after RIVAS-MARTÍNEZ (1987) in his study of the sigmeta of Spain, is considered to be a *Quercus rotundifolia* or *Juniperus thurifera* forest or a *Q. coccifera* and *J. phoenicea* maquis (Querceto rotundifoliae-Sigmetum, Junipereto phoeniceo-thuriferae-Sigmetum and Rhamno-Coccifereto-Sigmetum). The occurrence of this vegetation at the Ebro Basin is one of the main arguments to support the phytogeographic division accepted at present as it is shown in Fig. 2; it recognises an independent sector, called Bardenas y Monegros, inside the Aragonesa Province, which occupies its central part and includes most of our prospected area (RIVAS-MARTÍNEZ l. c.).

The aim of our study is to establish a syntaxonomical classification for this vegetation in the Ebro Valley using all the available data with the help of multivariate analysis methods and in accordance with the regulations of the Code of Phytosociological Nomenclature (BARKMAN et al. 1986).

Phytosociological studies about scrub vegetation in the Ebro Valley began in the early fifties when BRAUN-BLANQUET and O. DE BOLÒS started with

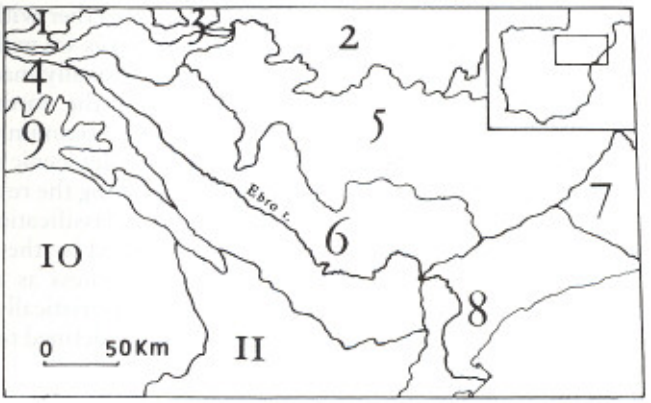

Fig. 2. Phytogeographical division in sectors of the studied territory (after RIVAS-MARTÍNEZ 1991). 1 – Cantabro-Euskaldun, 2 – Pirenaico central, 3 – Castellano-Cantábrico, 4 – Riojano-Estellés, 5 – Somontano-Aragonés, 6 – Bardenas y Monegros, 7 – Vallesano-Empordanés, 8 – Valenciano-Tarraconense, 9 – Ibérico-Soriano, 10 – Celtibérico-Alcarreno, 11 – Maestracense.

their general research on the plant communities of that area. Quite simultaneously, RIVAS GODAY began his studies about gypsophilous scrub vegetation of central and eastern Spain whose results appear in 1957, one year before the monography of the former authors. These two papers establish the basic frame of the syntaxonomy of these communities in the Ebro Basin and have provided us with the essential hypotheses of this work. RIVAS GODAY establishes two associations for the Ebro Valley of different geographical distribution: Helianthemo-Gypsophiletum hispanicae for the central part of the area and Salvio lavandulifoliae-Gypsophiletum hispanicae for its southern part, quite outside of the true depression, at higher altitude, under quite colder climatic conditions and in other phytogeographic territory. Both were included in the Iberian order Gypsophiletalia. The solution of BRAUN-BLANQUET & BOLÒS (1958), based an a more intensive sampling over a smaller area, restricted to the central part of the basin, propose three associations: Helianthemetum squamati, Ononidetum tridentatae and Lepidietum subulati which occupy the same territory (superimposed to that of Helianthemo-Gypsophiletum hispanicae Rivas Goday 1957) and have a slight floristical characterisation. They were separated mainly by dominance and species richness criteria and apparently represented different successional situations. Both proposals have coexisted for over 35 years without further discussion although most of the subsequent contributions accept BRAUN-BLANQUET & BOLÒS' solution. Quite recently RIVAS-MARTÍNEZ et al. (1991) and MOLINA et al. (1994) proposed classifications which are based mainly on the original RIVAS GODAY's criterion.

All the relevés supplied by the literature, together with the new ones rapported by us, constitute the data set of 258 relevés we will use in our analysis. The ones added by us in this work were intentionally made in the area where the concentration of samples was lower i. e. in the northwestern part of the Ebro Basin which belongs to the autonomous community of Navarra. That territory bears a particular type of gypsaceous oligocenic substrata, somewhat different from the miocenic ones widespread along the rest of the Ebro Valley.

Basically we will try to find out whether a classification which establishes units occupying the same territory differentiated by the dominance of some species over the others and in the species richness as a result of different successional situations can be sustainable in a floristically based phytosociological system where syntaxa should have also a defined territory i. e. a phytogeographical characteristion.

Material and methods

The starting data set used in our numerical analyses consisted of 258 phytosociological relevés including 301 species, their sources being summarized in Table 1. BRAUN-BLANQUET cover values were transformed to the WESTHOFF & VAN DER MAAREL ordinal scale values, on which secondary scalar and vector transformations were applied. The original data set and partial data sets derived from the former by removing differentiated groups of relevés, were submitted to ordination and classifications methods performed with CANOCO (TER BRAAK 1988) and MULVA-IV (WILDI & ORLOCI 1990) program packages. Ordination plots have been produced and examined with STATGRAPHICS. The dimension of the matrices used in each analysis along with some parameters about them are shown in Table 2. Species were selected for these analysis attending to their frequency (limited by the minimum size of the relevé groups we hypothesize as syntaxonomically discernible) and their consistency (algae, lichens and mosses were removed in most of the analysis because they had only been recorded in BRAUN-BLANQUET & BOLÒS' relevés). Clustering results were used as other criterion of selection, by removing low presence species without geographical or gradiental meaning but which appeared linked to some cluster of relevés of the same source.

In general, Correspondence Analysis (CA) reported better results than centred Principan Component Analysis (PCA) in showing gradients of floristically differentiated groups of relevés. This can be explained by the gradiental complexity (involving climatic, geographical, edaphic and dynamic gradients) and the great amount of zeros (70–80 %) of the data matrices used, which could determine distortions from non-linearity despite of data transformations and similarity measures applied (NOJ-MEIR & WHITTAKER 1977). On the other hand, sensibility of double standardized ordinations like CA to small groups of relevés with divergent species composition (NOJ-MEIR et al. 1975, GAUCH et al. 1976) seems to suit to the structure of our data. Non-centred PCA ordinations (NOJ-MEIR 1973) have shown patterns on the second and the third axes related to the CA ones but with worse resolutions. Scalar

Table 1. References of the data sources, column numbers of Table 4 and group symbols of the ordination plots.

Syntaxa[1]	Column number	Plot groups	Reference
Helianthemo-Gypsophiletum:			
(Helianthemetum squamati)	1 & 3[a]	A1 B1 CD1 CD3[b] CD4[c]	Br.-Bl. & Bolòs 58: tab. 36.
(Helianthemetum squamati)	2 & 3[a]	A1 B1 CD1 CD3[b] CD4[c]	Ochoa 82: tab. 12, tab. 11: rel. 1, 6 & 9; Bolòs 73 (1 rel.); Ursúa 86: tab. 51: rel. 4, 6-9; Blanché & Molero 88: tab. 6: rel. 1-2.
(Lepidietum) (Monegros)	4	A2	Br.-Bl. & Bolòs 58: tab. 38; Bolòs 61: tab. 7, rel. 1; Ochoa 82: tab. 14.
(subass. *senecionetosum auriculae)*	5	A3	Blanché & Molero 88: tab. 6: rel. 3-8.
(Helianthemo-Gypsophiletum)	6	A1 B2 CD5	Molina & al. 93: tab. 7: rel. 1-10.
(Helianthemo-Gypsophiletum)	7	A1 B6 CD5	Rivas Goday & cols. 57: tab. 10: rel. 1-4, 9-10, rel. p. 474.
(Ononidetum tridentatae)	8 & 10[d]	A1 B2 CD2 CD3[b]	Br.-Bl. & Bolòs 58: tab. 37.
(Ononidetum tridentatae)	9 & 10[d]	A1 B2 CD2 CD3[b]	Ochoa 82: tab. 13.
(Ononidetum pinetosum halepensis)	11	A1 B2	Br.-Bl. & Bolòs 58: tab. 37: rel. 29-32.
subass. **salvietosum lavandulifoliae**	12	A1 B3	Molina & al. 93: tab. 7: rel. 11-13; Br.-Bl & Bolòs 58: tab. 36: rel. 24, 48; tab. 37: rel. 2, 6, 16; Ochoa 82: tab. 13: rel 27.
subass. **boletosum asperi**	13	A1 B4	Molina & al. 93: tab. 7: rel. 14-16; Recasens & al. 88: tab. 2: rel. 6, 9, 12; Br.-Bl. & Bolòs 58: tab. 37: rel. 16.
subass. **helianthemetosum rotundifolii:**			
(Helianthemetum squamati)	14	A1 B5	Ursúa 86: tab. 51: rel. 1-3 & 5, tab. 3: rel. 1-2.
(subass. *helianthemetosum rot.)*	15	A1 B5	Table 3: rel. 3-11.
(Ononidetum tridentatae)	16	A1 B5	Ursúa 86: tab. 53.
(Lepidietum) (Bardenas)	17	A5	Ursúa 86: tab. 52.
Salvio-Gypsophiletum hispanicae:			
subass. **sideritetosum spinulosae**	18	A6	Rivas Goday & cols. 57: tab. 6: rel. 1-6.
subass. **helianthemetosum squamati**	19	A4	Rivas Goday & cols. 57: tab. 11: rel. 5-6; Rivas Goday & Borja 61: tab. 22: rel. 1-3.
subass. **typicum**	20	A4	Rivas Goday & cols. 57: tab. 11: rel. 1-4.

Notes.- 1: accepted syntaxa in boldface, original syntaxonomic ascriptions in italic and between brackets.
a: relevés bearing *Agropyron cristatum* are included in column 3.
b: Group 3 of plots C & D corresponds to the relevés bearing *Agropyron cristatum*.
c: Group 4 of plots C & D corresponds to the relevés bearing *Eurotia ceratoides*.
d: relevés bearing *Agropyron cristatum* are included in column 10.

Table 2. Parameters of the numerical analyses.

Plot	Size of data matrix	Analysis and transformations	Eigenvalues Axis 1	Axis 2	Axis 3
A	258 rel. x. 193 spec.	CA, ln (x + 1)	.372	.296	.270
B	212 rel. x 105 spec.	CA, ln (x + 1)	.266	.185	.167
C	178 rel. x 67 spec.	CA, ln (x + 1)	.240	.170	.146
D	178 rel. x 67 spec.	PCA centred by spec., Euclidean distance	.172	.105	.060

transformations modified slightly the ordinations, but vector transformations and (in CA) downweighting of rare species introduced stronger changes. We shall present and discuss only the mot significant performed ordinations.

Results and discussion

Diagrams presented in Fig. 3 show the relevé ordinations obtained after the different numerical analysis we have submitted our data set. The upper two ordination plots represent the ordination after a CA without downweighting of low represented species of the total amount of available relevés (258). Both show comparable results in the sense that axis A1 discriminates clearly, in its positive part, two groups of relevés both determined as Lepidietum subulati by their respective authors. The more deviant group (5) corresponds to the table of URSÚA (1986) constituted by relevés made on gypsaceous cliffs excavated by the rivers in which crevices grow some graminoid hygrophilic plants such as *Limonium viciosoi, Agrostis stolonifera* and *Schoenus nigricans* together with some chasmophytes such as *Antirrhinum barrelieri* or *Sedum album* and gypsophytes such as *Lepidium subulatum*. In any case these communities are clearly paucispecific in comparison with the rest of the studied ones, and the commented circumstances are certainly responsible for the strong deviation of this group. The other group (2), identified as Lepidietum subulati, belongs to the original table of this association coming from the central part of the basin and bears a quite clear independence shown by the big accumulation of most of the relevés and the separation from group 5; the differences with the last one become even more relevant after axis A3. Floristically the presence in group 2 of *Ferula communis, Diplotaxis virgata, Artemisia herba-alba, A. valentina* and *Peganum harmala* separates it from group 5, while *Thapsia villosa* is present in both and differentiates them from the others. It is important to signify that all these mentioned plants have low frequency in these groups of relevés; they are exclusive or show a higher concentration on them but they do not necessarily characterise them. That suggests that both groups 2 and 5 have been so clearly separated in the ordination because they lack many frequent Rosmarinetea taxa as well as the commonest Lygeo-Stipetea companions. That means that axis A1 reveals floristical impoverishment towards its positive side. *Lepidium subulatum*, in spite it bears high frequency in both groups, cannot be considered exclusive of them as there ca. 15 % of frequency is to be found in the rest of the groups. Although not characteristic for group 2, *Gypsophila hispanica* disappears from group 5.

Axis A2 displays in its positive half an extreme group formed mainly by 4 and 6 relevés which correspond to the Salvio lavandulifoliae-Gypsophiletum hispanicae, well differentiated floristically and phytogeographically: Celtibérico-Alcarreño sector. Their distribution along axis A2 also reveals the proximity of group 6 to 1, which is original from the central part of the Ebro Valley: Bardenas y Monegros sector; these group 6 relevés come from the district of Calatayud, limiting to that Bardenas y Mone-

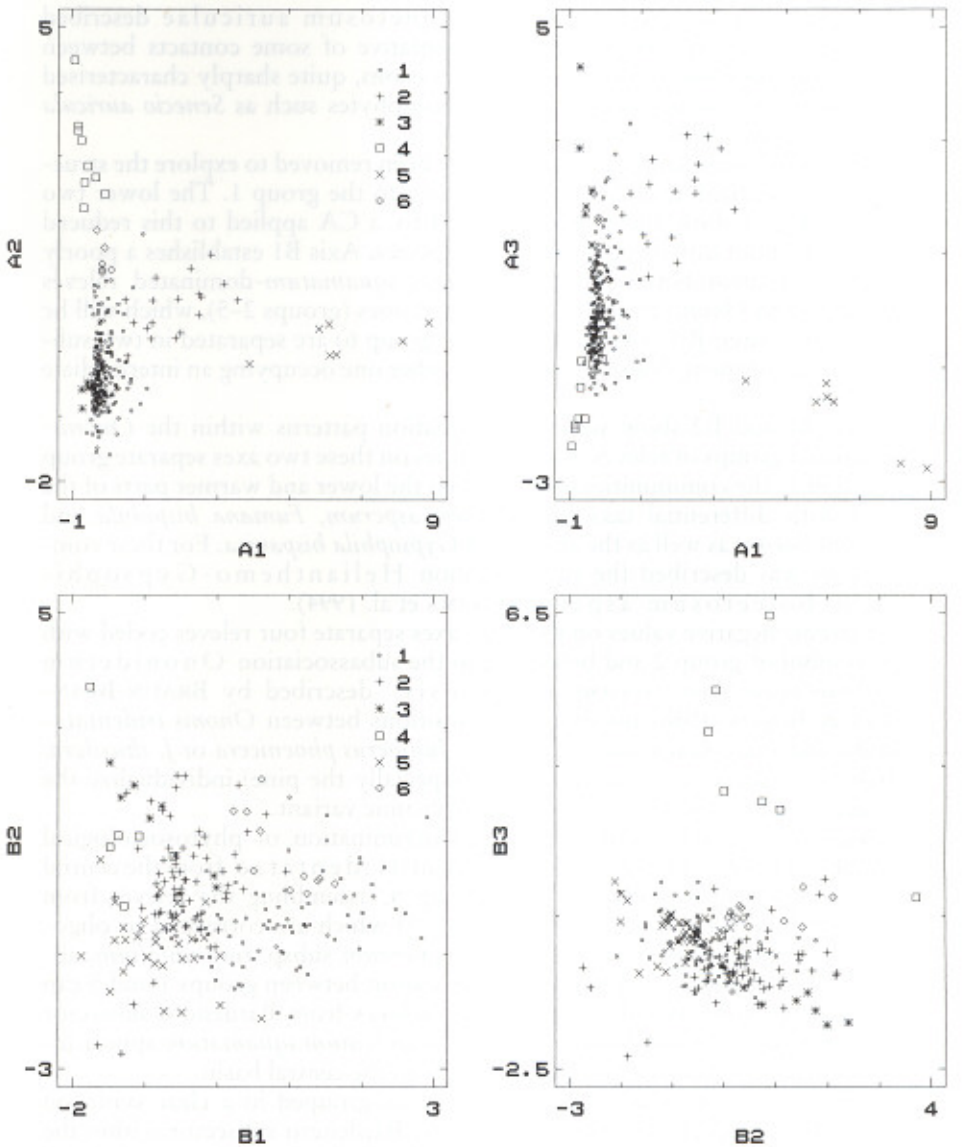

Fig. 3. CA plots for 258 relevés (axes A1-A3) and for 212 relevés (axes B1-B3). See text for explanations.

gros sector. The ordination plot of the upper right corner of Fig. 3 displays the same relevé set but axis A1 vs. A3 and shows a strong deviation of group 3 relevés along the positive half of axis A3, the same as happens with the ones of group 2 as commented above. These group 3 relevés correspond to the

Helianthemetum squamati senecionetosum auriculae described by BLANCHÉ & MOLERO (1988) representative of some contacts between gypsaceous foothills and halophytic depressions, quite sharply characterised floristically by the occurrence of some halophytes such as *Senecio auricula* and *Limonium aragonense*.

The above commented groups 2–5 have been removed to explore the structure of the remaining 212 relevés belonging to the group 1. The lower two plots of Fig. 3 show the scores produced by a CA applied to this reduced data set without downweighting of rare species. Axis B1 establishes a poorly resolved gradient between *Helianthemum squamatum*-dominated relevés (group 1) and *Ononis tridentata*-dominated ones (groups 2–5), which will be commented later. RIVAS GODAY's relevés (group 6) are separated in two subgroups, one of them close to gr. 1 and the other one occupying an intermediate position.

Axis B1 and B2 show some differentiation patterns within the *Ononis*-dominated groups of relevés. Positive values on these two axes separate group 4, related to the communities original from the lower and warmer parts of the basin with differential taxa like *Boleum asperum, Fumana hispidula* and *Thymus loscosii* as well as the absence of *Gypsophila hispanica*. For these communities was described the subassociation Helianthemo-Gypsophiletum boleetosum asperi (MOLINA et al. 1994).

Extreme negative values on the three axes separate four relevés coded with the symbol of group 2 and belonging to the subassociation Ononidetum tridentatae pinetosum halepensis, described by BRAUN-BLANQUET & BOLÒS (1958) for dynamic transitions between *Ononis tridentata*-scrubs and *Pinus halepensis* forests with *Juniperus phoenicera* or *J. thurifera*. High cover values of these small trees (specially the pine) individualize the group, which can be seen as an extreme dynamic variant.

Axes B2 and B3 establish another discrimination of phytosociological meaning between group 2 (Ononidetum tridentatae from the central basin for Monegros subsector) and group 5, assembling the relevés from southern Navarra (URSÚA 1986 and Table 3) which are correlated to oligocenic substrata and bear *Helianthemum cinereum* subsp. *rotundifolium*, absent from the rest of the Ebro Basin. Separation between groups 1 and 5 can be observed along axis B1, though some relevés from Bardenero subsector (southern Navarra) but dominated by *Helianthemum squamatum* appear intermingled with those of *H. squamatum* from the central basin.

For these reasons Navarran relevés can be grouped in a clear syntaxon which also occupies a defined territory: the Bardenero subsector within the Bardenas y Monegros sector (RIVAS-MARTÍNEZ et al. 1991). The rest of the relevés occupies a wide area in the diagram and their ordination shows two main features: 1 – axis B2 group in its positive part the relevés bearing *Ononis tridentata* while B1 does the same in its negative part. The result is that the upper part of the diagram concentrates most of the Ononidetum tridentatae relevés while the lower part concentrates the Helianthemetum squamati ones; 2 – relevés of group 6, coming from Helianthemo-Gypsophyletum hispanicae tables, representatives of the complete

Table 3. Helianthemo thibaudii-Gypsophiletum hispanicae subass. helianthemetosum rotundifolii.

Altitude (1 = 10 m)	35	49	36	28	25	32	42	31	49	37	50
Area (1 = 10 m^2)	10	10	10	10	10	10	10	10	10	4	20
Relevé number	1	2	3	4	5	6	7	8	9	10	11
Gypsophilion and *Gypsophiletalia* character-taxa											
Herniaria fruticosa	1	2	2	1	1	1	2	1	1	1	2
Helianthemum squamatum	2	1	1	+	+	1	2	1	1	2	.
Launaea pumila	1	1	1	+	1	.	1	+	1	1	1
Ononis tridentata	.	.	+	+	+	2	3	2	2	3	3
Launaea fragilis	.	.	.	.	1	+	.	.	.	.	.
Lepidium subulatum	.	.	.	.	.	.	.	.	.	.	1
Differential-taxon of the subassociation											
Helianthemum rotundifolium	1	1	1	+	1	1	.	.	1	.	.
Rosmarinetalia and *Rosmarinetea* character-taxa											
Thymus vulgaris	1	2	2	2	2	1	1	2	2	2	1
Genista scorpius	2	1	2	2	2	1	2	1	2	+	+
Teucrium capitatum	1	+	+	+	1	+	1	1	1	1	1
Atractylis humilis	+	+	+	+	+	+	1	+	+	1	+
Fumana ericoides	1	1	1	1	1	+	1	+	1	1	1
Helianthemum thibaudii	1	2	2	1	1	1	1	1	2	1	.
Rosmarinus officinalis	3	3	.	3	3	3	.	3	3	.	.
Coris monspeliensis	+	1	.	.	+	+	.	+	1	1	.
Fumana thymifolia	.	1	1	+	.	.	.	+	+	.	.
Asperula aristata	.	.	+	.	.	.	+	+	1	.	.
Thesium divaricatum	.	+	.	.	.	.	.	.	+	+	.
Bupleurum fruticescens	.	+	.	.	.	+	.	.	.	.	.
Linum suffruticosum	.	.	.	1	1	.	.	.	.	.	.
Astragalus incanus	.	.	.	.	.	.	.	.	+	1	.
Companions *(Lygeo-Stipetea, Salsolo-Peganetea,* etc)											
Helichrysum stoechas	1	+	1	+	+	+	1	+	1	.	+
Brachypodium retusum	.	+	1	1	.	2	2	1	2	2	1
Koeleria vallesiana	+	1	1	.	.	.	.	.	1	2	2
Lygeum spartum	+	.	.	.	+	.	+	.	.	.	+
Stipa parviflora	.	.	+	.	+	.	1	.	.	.	.
Santolina chamaecyparissus	.	.	+	.	.	.	.	.	.	1	+
Juniperus phoenicea	+	.	.	+	.	.	.	.	.	.	.
Asphodelus ramosus	.	+	.	.	.	.	.	.	+	.	.
Avenula bromoides	.	.	+	.	.	.	.	.	+	.	.
Cheirolophus intybaceus	.	.	.	.	.	+	2	.	.	.	.
Convolvulus lineatus	.	.	.	.	.	.	1	+	.	.	.
Plantago albicans	.	.	.	.	.	.	1	.	.	.	+
Ruta angustifolia	.	.	.	.	.	.	.	+	+	.	.

Species present in only one relevé. – *Odontites longiflora* 1 (1), *Matthiola fruticulosa* + (2), *Camphorosma monspeliaca* + (2), *Eryngium campestre* + (3), *Hedysarum confertum* + (4), *Lavandula latifolia* + (6), *Sedum sediforme* + (6), *Coronilla lotoides* 1 (7), *Dorycnium pentaphyllum* 1 (7), *Euphorbia serrata* + (7), *Reseda phyteuma* + (7), *Plantago maritima* + (9), *Reseda stricta* + (10), *Helianthemum hirtum* + (10), *Artemisia herba-alba* + (11).

Localities, dates and UTM coordinates of the relevés. – 1: Caparroso, 5.6.1990, 30TXM18; 2: Sesma, 7.6.1990, 30TWN70; 3: Lodosa, 7.6.1990, 30TWM79; 4: Bardena Blanca, Arguedas-Ermita Nuestra Señora del Yugo, 5.6.1990, 30TXM17; 5: Bardena Blanca, Arguedas-Murillo de las Limas, 5.6.1990, 30TXM26 *(typus subass.)*; 6: Peralta, 7.6.1990, 30TWM98; 7: Rincón de Soto-Azagra, 24.06.1986, 30TXM07; 8: Peralta, towards Andosilla, 7.6.1990, 30TWM99; 9: Sesma, 7.6.1990, 30TWN70; 10: Andosilla-Peralta, 9.6.1988, 30TWM89; 11: Autol, 23.6.1986, 30TWM87. Relevés 1-10 from province of Navarra, 11 from Logroño.

floristical gypsophilous flora of the territory, are randomly distributed over the area covered by the Ononidetum tridentatae-Helianthemetum squamati cloud (a preferential concentration in its central part is

however observed). If we consider this, it suggests that the Ononidetum tridentati and Helianthemetum squamati relevés were made following a biased criterion trying to distinguish diverse successional situations that, in spite of it, are weakly characterised from the floristical point of view. The status of facies could be sufficient to shelter them.

Furthermore, positive values on B2 and negative ones in B3 slightly separate group 3, corresponding to some relevés coming from the colder, northern parts of the central basin, mainly differentiated by the occurrence of *Salvia lavandulifolia*. This group, tightly closed to the central basin Ononidetum, corresponds to the subassociation Helianthemo-Gypsophiletum salvietosum lavandulifoliae (MOLINA et al. 1993).

Next step concerns the analysis of the remaining 178 relevés which constitute the nucleus of the gypsophilous scrubs in the Monegros subsector. Differentiation between Helianthemetum squamati and Ononidetum tridentatae is particularly critical and decisive for the syntaxonomy of these communities. First we have applied a Jancey's ranking upon F-values (program DIAN of MULVA-IV) to the set of relevés ascribed by BRAUN-BLANQUET & BOLÒS (1958) and OCHOA (1982) either to Ononidetum tridentatae (65) or to Helianthemetum (73 relevés) and not segregated in previous analyses. The more discriminant species between these two groups were *Ononis tridentata* and *Helianthemum squamatum*; the F-value of the former was roughly twice as the second, and this was twice as the next ranked species, irrespective of scalar transformations applied. Several plants of Rosmarinetalia (*Helianthemum marifolium, Thymus vulgaris, Genista scorpius, Atractylis humilis, Linum suffruticosum*, etc.), *Brachypodium retusum, Avenula bromoides* and *Echinops ritro* appear among the most differential species of Ononidetum; on the other hand, differential plants of Helianthemetum are fewer at high ranks: *Plantago albicans, Thymus zygis, Agropyron cristatum*, some therophytes (*Aegilops geniculata, Neatostema apulum*, etc.) and some lichens. None of these species is exclusive of one of the groups; the first ranked exclusive vascular plants has less than 10 % presence. Regardless the weakness of their floristical differentiation, a Fisher's discriminant analysis (not showed) performed by the same program with the 30 first ranked species resolved the two groups structure on the first axis with a moderate ambiguity zone (which increases if presence-absence transformation is applied) and reallocated a few relevés. The reallocation of relevés based on group centroids by H-means algorithm of program REAL (MULVA-IV) produces around 10 % of fluctuating reclassifications, depending on the transformations and similarity measures applied.

All these considerations suggest that Ononidetum tridentatae and Helianthemetum squamati relevés were made following a biased criterion, largely based on dominance of name-giving species and trying to distinguish diverse succesional situations that, in spite of it, are weakly characterised from the floristical point of view. When we add the relevés of RIVAS GODAY (1957) and those of MOLINA et al. (1984) to the data set, the main trend separating *Ononis*-dominated from *Helianthemum*-dominated relevés is maintained, but the cloud of points adopt a globular shape denoting a large

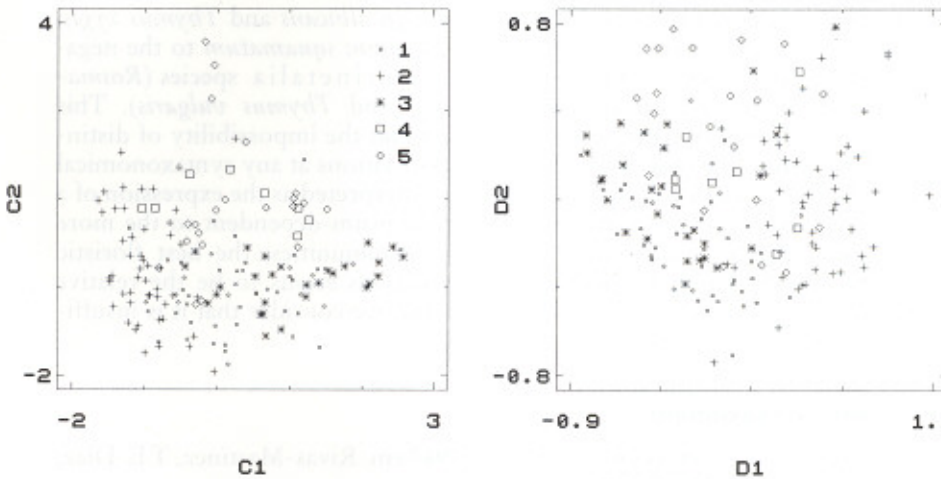

Fig. 4. CA (axes C1-C2) and PCAS (axes D1-D2) plots for 178 relevés. See text for explanation.

intermediate zone between the extreme nodes. This is shown in the CA axes C1–C2 and the PCA axes D1–D2 of Fig. 4.

Axis C1 of CA discriminates Helianthemetum (groups 1 and 3, at the positive end) versus Ononidetum (group 2) with a large central zone occupied by transitional relevés of Helianthemetum bearing *Genista scorpius* or *Thymus vulgaris* and low presence of *Thymus zygis* or *Plantago albicans*, as well as *Ononis*-dominated relevés with poorer representation of Rosmarinetalia elements, or even with "differential" species of Helianthemum, like the MOLINA et al. and RIVAS GODAY's ones (relevés of group 5, most of them *Ononis*-dominated). The most "typical" Helianthemetum, with (group 3) or without (group 1) *Agropyron cristatum*, is projected to the positive extreme of the axis while Ononidetum relevés, with more species of Rosmarinetalia, is sent to the opposite end. Axis C2 establishes minor differentiations of some deviating relevés with *Teucrium aragonese, Santolina chamaecyparissos* or *Eurotia ceratoides* (group 4). It also differentiates slightly Ononidetum relevés bearing *Atractylis humilis* and *Brachypodium retusum* versus the ones bearing *Helichrysum stoechas* and *Helianthemum marifolium*, as well as some of the RIVAS GODAY's relevés (group 5) versus the remaining ones of Helianthemetum. Axis C3 (not shown) only introduces a slight separation of relevés with *Eurotia ceratoides* (group 4).

Ononis tridentata and *Helianthemum squamatum* are respectively projected to the positive and negative ends of both PCA D1 and D2 axes. The already commented differential species of Helianthemetum and Ononidetum are also projected to the corresponding ends of component D1, but on component D2 the contribution of *Ononis* is strengthened by some differ-

entials of Helianthemetum, like *Plantago albicans* and *Thymus zygis*, and *vice versa*, the contribution of *Helianthemum squamatum* to the negative part of the axis is accompanied by Rosmarinetalia species (*Rosmarinus officinalis, Helianthemum marifolium* and *Thymus vulgaris*). This reveals the reticulate patterns of the data set and the impossibility of distinguishing with some objectivity these two associations at any syntaxonomical level. Both CA and PCA first axes could be interpreted as the expression of a gradient which goes from the pioneer and gypsum-dependent to the more developed and less substratum-influenced communities; the best floristic criterion to discriminate these extreme situations seems to be the relative dominance of *Ononis* and *Helianthemum*, but we consider that it is insufficient to support phytosociological entities.

Accepted syntaxonomy

Rosmarinetea officinalis Br.-Bl. 1947 em. Rivas-Martínez, T.E. Díaz, Fernández Prieto, Loidi & Penas 1991
+ Gypsophiletalia Bellot & Rivas Goday in Rivas Goday 1957
* Lepidion subulati Bellot & Rivas Goday in Rivas Goday 1957
** Gypsophilenion hispanicae (Br.-Bl. & Bolòs 1958) Molina, Loidi & F. Fernández-González 1994
1. Helianthemo thibaudii-Gypsophiletum hispanicae Rivas Goday 1957, corr. Rivas-Martínez, Báscones, T.E. Díaz, F. Fernández-González & Loidi 1991
   1a. subass. typicum Rivas Goday 1957
   1b. subass. salvietosum lavandulifoliae Molina, Loidi & Fernández-González 1994
   1c. subass. boleetosum asperi Molina, Loidi & F. Fernández-González 1994
   1d. subass. helianthemetosum rotundifolii nova
2. Salvio lavandulifoliae-Gypsophiletum hispanicae Rivas Goday 1957
   2a. subass. typicum Rivas Goday 1957
   2b. subass. sideritetosum spinulosae (Rivas Goday 1957) Molina, Loidi & Fernández-González 1994

Conclusions

Along the analysis process we have learned that:
1 – numerical analyses reveal deviations of relevés due to differences in floristical combinations at different levels
2 – the meaning of these differences in combinations is diverse: a) some are due to variations in dominance with or without additional impoverishments, b) others to dynamic transitions between communities of different successional role or c) to phytogeographical (or climatic) factors. From the phytosociological point of view, these three cases have a growing importance as far

as dominance variations could be treated as facies, transitional situations due to ecotones or to dynamism as variants and the last ones as subassociations or associations depending on the floristical independence and the territorial scope of the considered unit.

After the successive steps of the ordination procedure, we have been removing groups of relevés as long as they were being placed in eccentric positions in the ordination plot. The order in this successive removal is not correlated with the syntaxonomical status or rank we have finally accepted for each of these groups. The reasons for this are various and some of them have already been explained above in a certain degree, specially when groups diverged because of species poverty or presence of rare plants.

Computer-assisted ordination cannot be the main criterion to perform a classification of a relevés set, even more when that classification is based in the floristic composition of relevés and fidelity of taxa to the different groups of them. Even more, phytogeographical criteria, as determinant for climate and history, are decisive in our syntaxonomical arrangement and often the determination of a floristically well characterised group to be an association or a subassociation is decided by the meaning of its distribution. Both syntaxa are defined essentially by a charactristic taxonomic composition but phytogeographical significance should give us an important criterion to rank them in the way that associations and subassociations (i. e. typified syntaxa) have a phytogeographical significance while variants have an ecological (e. g. transitions, contacts by means of edaphic factors) or successional one and faciations could be the expression of dominance situations within the community-type internal succession. Although this is in a certain opposition to classical thinking within phytosociology (WESTHOFF & VAN DER MAAREL 1973), we believe that type fixation has to be linked to a circumstance from which results a constant floristical independence such as the strong ecological or succesional characterisation as well as to phytogeography. This last feature is climatically and historically significant and has a comparable, or even sometimes higher, constancy than ecotonic transitions between different associations or subassociations and even more than dynamical situations which can be quite ephemeral.

As a consequence of the results obtained from the different analysis and in application of the mentioned criteria, we have constructed the synthetic Table 4, in which all considered data are represented and ordinated in order to justify the accepted classification. In it predominates the synthetic phytogeographical criterion for which each association has a territory over which it exercises a sort of jurisdiction within its ecological (edapho-topographic, successional and climatic) conditions. Slight variations due to management or to topographical situations which result in inconspicuous floristical differences or sometimes just in an impoverishment of its species composition are not considered as different syntaxa. This last case could lead us to consider as similar two poor relevés of quite alike floristical composition located in two different territories in which there exist a diverse floristical context for each of them. If two vegetation tables are made for each of these territories and, as a result of this comparison, two different syntaxa can be recognised, each of

Table 4. Synthetic table of the suballiance Gypsophilenion hispanicae in the Ebro Valley.

Number of relevés	31	23	27	18	6	8	11	22	30	6	4	9	7	6	9	19	7	6	5	4
Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Gypsophilion and *Gypsophiletalia* character-taxa																				
Hemiaria fruticosa	4	5	4	4	5	5	5	4	5	4	3	4	3	5	5	4	3	5	4	5
Helianthemum squamatum	5	5	5	4	1	5	5	2	3	4	4	3	3	5	5	3	1	5	3	
Launaea pumila	3	2	2		3	2	5	2	2	2	2		2	5	5	1	2	5	2	
Ononis tridentata	2	1	1	1		5	4	5	4	5	5	5	5		5	5		5	5	5
Gypsophila hispanica	3	5	4	4	4	5	5	3	4	5	3	4						5	5	5
Launaea fragilis	1	2	2	1		2	3	1	1	2			3		2	1		5	3	3
Lepidium subulatum	1	2	1	5			1	1	1		3	3			1	1	5	5	2	
Reseda stricta	1		1	2		3		1			3				1	2				
Differential-taxa																				
Helianthemum pilosum	2	2	3	1	2	3	1	2	3	4	3	2	2							
Helianthemum marifolium	2	1	1	1	2	1		2	5	3	4	4	3							
Sideritis cavanillesii	1	1	1	1		1	2	3	1	2		2	3							
Agropyron cristatum			5	1	2		2			5	2	2								
Diplotaxis virgata	1			3																
Senecio auricula					5															
Limonium aragonense					4															
Pinus halepensis											5									
Salvia lavandulifolia												5							4	5
Boleum asperum													5							
Fumana hispidula													3							
Thymus loscosii						1							3							
Helianthemum rotundifolium														3	3	4				
Limonium viciosoi																1	3			
Schoenus nigricans																1	1			
Antirrhinum barrelieri																	3			
Sideritis hirsuta																		4		4
Sedum gypsicola																		5		2
Aster aragonensis																		3		2
Teucrium expansum																			4	5
Astragalus macrorrhizus																			2	3
Digitalis obscura																			1	3
Jurinea pinnata																			2	
Kochia prostrata																			2	
Festuca hystrix																				3
Rosmarinetalia and *Rosmarinetea* character-taxa																				
Teucrium capitatum	3	2	4	2	4	4	5	3	3	4	5	3	3	5	5	3		5	3	2
Genista scorpius	3	3	2	1		4	3	4	5	5	3	5	5	4	5	4		4	4	2
Helianthemum thibaudii	4	5	4	1	3	4	5	4	4	5	5	4	5	5	5	5	3	5		
Rosmarinus officinalis	4	3	4	3	1	4	1	3	5	3	5	4	5	5	3	5		1	1	
Linum suffruticosum	3	2	2	1		5	3	4	3	3	3	5	4	1	2	2		5	2	4
Atractylis humilis	1	1			2	2	5	4	2	1		2	5	4	5	2		5	4	5
Fumana ericoides	2	1			1	1	3	2	1	1	3	1	1	4	5	4		3	3	
Helichrysum stoechas	2	2	1	1	5	5		2	3	2	3	2	3	4	5	3		4		
Thymus vulgaris	3	4	3	3	2	5		5	5	5	5	5	5	4	5	5	5			
Matthiola fruticulosa	1	1	1	1		1	2	2	1	1	3	4	3	3		1		1		
Coris monspeliensis	1	2	1			2	2	1	1	1	4	2		2	3	2		3		
Asperula aristata	1	1	1			2	1	1	1			1			3	1		5	3	2
Fumana thymifolia	1	1				1	5	1	2	1		1	3	1	3				2	2
Lithodora fruticosa	1	1	1				2	1	1	2		3	3			1		3	3	5

these two apparently similar relevés should be classified in its corresponding syntaxon and not together. They belong to different phytogeographical territories and statistically this is reflected in the respective vegetation tables: syn-

Table 4. (cont.)

Column number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Astragalus incanus	1	1	2	1		2	4	2	1	1		1			2					
Bupleurum fruticescens							2	1	1			1	1	1	1	1		3	3	2
Helianthemum hirtum	1	1	1			1							1	2	1	1				
Hedysarum confertum	1		1					1	1		2		2		1	2				
Thymelaea tinctoria	1	1					1	1	2			1	1							
Sideritis spinulosa	1					2	1	1				1						5	2	
Cistus clusii						1		1	1		3	1	3			1				
Thesium divaricatum	1								1			2		1	2	1				
Lavandula latifolia									1						1	1		2	2	3
Astragalus monspessulanus	1		1				2	1	1											
Astragalus alopecuroides	1		1					2	1	1										
Centaurea linifolia		1			1			1				1	2							
Ononis pusilla			1				1												2	3
Euphorbia nicaeensis				1				1											2	2
Euphorbia minuta	1						1	1												
Teucrium aragonense							2		1											
Sideritis ilicifolia							1					2								
Companions (*Lygeo-Stipetea, Salsolo-Peganetea*, etc)																				
Brachypodium retusum	2	2	2	1	1	4	5	5	4	4	3	4	5	4	5	5		5	4	3
Koeleria vallesiana	3	4	5	1	4	4	5	4	4	3	4	5	4	5	3	4		5	4	5
Avenula bromoides	1	1	1		2	1	2	2	1	1	2	1	2	1	2	2			3	2
Artemisia herba-alba	1	1	2	4		1	2	1	1	1	2	1	1	3	1	1		1		
Plantago albicans	3	3	5	3		4	5	2	1	2		2	2	1	2			5	5	5
Sedum sediforme	1	1		1		2	2	1	1		3	1	1	1	1	2	5	2	1	
Stipa parviflora	1	3	2	1		4	3	2	1		2		4	3	2	1		2		
Lygeum spartum	1	2	2		5	2	3	2	1	3			3	3	2	2				
Thymus zygis	2	3	3		4		5	1	1	1		2				1		4	4	4
Echinops ritro	1	1	1				2	3	2	4	3	3	2			2	1			
Stipa offneri	1	1	1	1	1			1	1		3	2	1							
Asterolinon linum-stellatum	1	2	1	1	1			1	3	3	2		1							
Salsola vermiculata	1	1	1	1				1	1	2						1		1		
Stipa lagascae	1	1	2				1		1									5	3	4
Asphodelus fistulosus	1	1	1			1	1		1	1										
Juniperus phoenicea	1		1						1		5			1	1	1				
Juniperus thurifera		1	1					1	1	2	3		1							
Santolina chamaecyparissus		1				2	2					2			2				3	4
Neatostema apulum	1	2	1	1					1				1							
Polygala rupestris	1	1	1					1	2		2									
Stipa barbata	1	1	2					2	1				2							
Hippocrepis ciliata	1	1	1	1					1											
Catapodium rigidum		2					1		2			1	1							
Leuzea conifera										1		1	1						2	3
Scabiosa stellata	1	1	1				1													
Aegilops geniculata	1	2	1						1											
Thapsia villosa	1	1		1													3			
Eurotia ceratoides	1		1					1				1								
Odontites longiflora		1												4		1	3			
Sedum album		1							1			1					5			
Artemisia glutinosa		1		1									1							
Peganum harmala		1		1																

See Table 1 for explanation of relevé groups synthetized in each column.

taxonomy needs a statistical basis. The local episodes, such as impoverishment of species composition, cannot lead us to accept a chaotic synsystematic where syntaxa have lost its phytogegraphical character.

Our case is essentially the opposite: three associations: Ononidetum tridentatae, Helianthemetum squamati and Lepidietum subulati, were described in the same area where previously Helianthemo-Gypsophiletum hispanicae was established. If we accept that the three former syntaxa are the result of the topo-successional segregation of the last one and that all of them constitute a single association, according to the CPN, priority corresponds to the last name.

Finally, as quoted in the accepted syntaxonomy, we accept two associations which are very sharply distinguishasble from the floristical and phytogeographical point of view: Salvio lavandulifoliae-Gypsophiletum hispanicae and Helianthemo thibaudii-Gypsophiletum hispanicae. Inside the first one, two subassociations are recognised: the typical one and sideritetosum spinulosae, original from the southern part of its scope. The second association is divided into three subassociations besides the typical one: salvietosum lavandulifoliae of climatic, and secondarily geographic, amplitude, and other two with strong floristic and phytogeographic significance: boleetosum asperi of the lower and warmer areas of the scope of the association and helianthemetosum rotundifolii (typus: rel. 5 Tab. 3) which develops on the oligocenic gypsum of the northwestern part of the area, with somewhat colder and more rainy climate. These last two units could be considered as true associations if floristical independence would be only regarded. Nevertheless, if we consider that the nucleus of this vegetation in the Ebro Basin lies in its central part, the periphery of its scope experiments a decrease in true gypsophytes which are substituted by transgressive plants of a Rosmarinetalia optimum. This peripherical impoverishment of genuine elements of a so sharply characterised vegetation type has lead us to consider them as subordinate parts of the nucleus and this opinion has been expressed in the syntaxonomical arrangement. To give up to a blind classification constructed by bare floristical differences is, in our opinion, a loss of information and, even worse, an impoverishment of the interpretation capabilities about the phytogeographical, environmental and even historical circumstances of a studied vegetation type.

About the rest of the units described in the literature, as commented above, they do not merit a typified status in our syntaxonomy as most of them represent either a situation of dominance of a particular plant, an extreme floristical improverishment or insufficiently sampled ecotonic communities.

Acknowledgements. This research has been supported by the funds of the project UPV 118.310-EB108/92, PGV 9229, financed by the University of the Basque Country and the Basque Government.

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