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Impact of soil texture on plant communities of *Raphanus raphanistrum* L.

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Abstract
Our soil study of the chromic soils located in the strip of land between Sierra Morena and the Guadalquivir Valley reveals a pH-value close to neutral in 25 samples. The pH-values are close to 5.5 only in the samples taken from the arenosols of the granitic batholith of Los Pedroches. However, it is the percentage of clay, sand and silt that explains the occurrence of grassland dominated by *Raphanus raphanistrum*, in the company of species with a psammophilous character such as *Linaria spartea*, *Linaria amethystea* and *Brassica barrelieri*.
Our soil analysis reveals the presence of acid or base-poor soils. Consequently, the community of *Raphanus raphanistrum* found there displays an acidophilous, neutro-basophilous and subarenicolous character. Different types of sabulicolous plant communities appear as a result of the gradation of the soil texture. Since the *Raphanus* communities cannot be considered as genuinely sabulicolous, we have coined the term 'subarenicolous' to describe any plant community whose optimum sand content lies between 50% and 70%. The community of *Linaria spartea* and *Raphanus raphanistrum* is neutro-basophilous and is found in at least the Marianic-Monchiquensean and North Hispalensean sectors. The floristic composition of the association is made up of *Raphanus raphanistrum*, *Linaria spartea*, *Linaria amethystea*, *Medicago polymorpha*, *Hordeum leporinum*, *Bromus diandrus*, *Brassica barrelieri*.

Key words: grasslands, psammophilous vegetation, subarenicolous vegetation, subnitrophilous vegetation.

Historical context

Today's intensive farming techniques have led to an increasing need for sustainable agricultural methods. Intensive agriculture results in the degradation of the soil and a subsequent loss of productivity. Pérez-Rodríguez *et al*. (2011) indicate that research has shifted towards the study of cultivation systems that maintain soil productivity. We are currently faced with a whole range of interrelated problems, from the uncontrolled use of insecticides to the implementation of farming techniques with a negative impact on the environment. Soils are dramatically eroded, with the ensuing loss of productivity, aquifers become increasingly polluted, biodiversity decreases, invading species alter and degrade the original ecosystems, and the natural balance of populations collapses. In a country with a long history of agriculture, it is vital to address these issues that are caused by the excessive use of chemical products and changes in farming techniques, by modifying the traditional farming culture, as indicated by Covarelli (2002). To efficiently implement sustainable agricultural techniques, we must first find the most reliable ecological bioindicators (Cano-Ortiz, 2007). The analysis of pasturelands and grasslands associated with olive-growing in Spain and Portugal reveals significant differences in the concentration of soil nutrients (Cano-Ortiz *et al*., 2009a,b).

Intensive farming techniques often have far-reaching ecological consequences, and the loss of biodiversity can reach dramatic proportions. So far 120 plant communities and nearly 1,000 plant species have been described in olive groves. Olive groves cannot therefore be treated in the same way as other types of commercial crop farming. An olive grove is a genuine ecosystem in its own right, home not only to a rich flora but also to some hundred vertebrates and a large number of invertebrates. When the flora is altered, the fauna and the natural mechanisms of biological control can be so seriously affected that they become defenceless against pests. For this reason, it is essential to implement farming techniques which have no aggressive impact on the environment (Cano *et al*., 2004).

In view of the loss of floristic diversity in olive groves, we have studied the communities of *Raphanus raphanistrum* in the Guadalquivir Valley and in the Sierra Morena, where previously García Fuentes & Cano (1996) had analysed the farmland habitats in the upper Guadalquivir Valley, in which only the specie *Raphanus raphanistrum* was named. The soil study of Aguilar Ruiz *et al*. (1987) reveals the presence of a strip of land dominated by neutral-acid chromic

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cambisols from Triassic material, and albic and cambic acidic arenosols from granite from the Los Pedroches batholith in the Sierra Morena. There is thus a presence of subnitrophilous grasslands with a preference for sandy soils included by Rivas-Martínez & Izco (1977) in the alliance *Alysso granatensis-Brassicion barrelieri*, substituted on coastal dunes in the southern Iberian peninsula by non- or poorly-nitrified psammophilous grasslands of *Linarion pedunculatae*, which have been studied by various authors (Rivas-Martínez *et al*., 2001; Diez Garretas, 1984; Diez Garretas *et al*. 1978). This alliance should be considered a vicariant of *Laguro ovati-Vulpion membranaceae* described for the dunes of the coast of Corsica by Géhu & Biondi (1994), and subsequently extended to areas of the Tyrrhenian by Vagge & Biondi (1999). Cano *et al*. (1996) describe and include in the alliance *Alysso granatensis-Brassicion barrelieri* the subnitrophilous sandy grasslands of *Coincyo transtagani-Brassicetum barrelieri* growing on cambic arenosols. The species *Linaria spartea, Brassica barrelieri, Coincya transtagana, Corynephorus fasciculatus* (Cano & González, 1992) are common in these environments.

Materials and Methods

Our methodological approach involves the comparative checking of phytosociological relevés of grasses growing in olive groves. We used the abundance-dominance index suggested by Braun-Blanquet (1979), in addition to the methodological aspects highlighted by Biondi (2011) and Pott (2011), with soil analyses of the samples implemented in the UTM grids where the phytosociological relevés were taken. Our study area is located in the northern territories of the Hispalensean Sector and in the Marianic-Monchiquensean Sector. We have followed Tutin *et al*. (1964-1980), Valdés *et al*. (1987) and Castroviejo *et al*. (eds) (2001) in our floristic study. Rivas-Martínez *et al*. (2001) were used for the phytosociological study.

The following soil features were analysed, with their units of measurement in parentheses: cation exchange capacity (meq/100g), assimilable phosphorus (ppm), exchangeable magnesium (meq/100g), oxidisable organic matter (%), total nitrogen (%), pH 1/2.5, exchangeable potassium (meq/100g), pF 15 atm (%), clay texture (%), sand texture (%), silt texture (%) and salinity (mmhos/cm).

Following the indications of Bini *et al*. (2002), a plant-soil correlation was established in order to determine the soil parameters with the greatest influence on the community of *Raphanus raphanistrum*. A canonical correlation analysis (CCA) was performed on the 12 soil parameters and the associations *Anacyclo clavati-Hordeetum leporini* (AcH), *Anacyclo radiati-Hordeetum leporini* (ArH), *Bromo scopari-Hordeetum leporini* (BH), *Linaria spartea* and *Raphanus raphanistrum* (LR), *Papaveri rhoeadis-Diplotaxietum virgatae* (PD), *Anacyclo radiati-Papaveretum rhoeadis* (ArP), *Anacyclo radiati-Chrysanthemetum coronarii* (ArChr), *Resedo albae-Chrysanthemetum coronarii* (RChr), *Urtico urentis-Malvetum neglectae* (UM), *Plantago bellardi-Aegilopetum geniculatae* (PA), and *Trifolio cherleri-Taeniatheretum caput-medusae* (TT).

For the study of the communities, the DECORANA statistical ordination analysis was applied to 76 samples from the associations AcH, BH, PD, LR and CB. Finally, to establish the alliance in which to include the new community, a synthesis table was made with the associations AcH, BH, PD, LR and *Coincyo transtgani-Brassicentum barrelieri* (CB).

Results and Discussion

The plant community under study is found in the northern areas of the Hispalensean sector, in the Lusitan-Extremadurean subprovince, and in the Marianic-Monchiquensean sector. This plant community is found at altitudes of about 260 m, that is, with a thermo- and lower mesomediterranean thermotype and a dry ombrotype. The minimum area where the highest biodiversity value per square meter is recorded is 2 m^2. As a result of the impact of the farming techniques used in these territories, the state of conservation of the *Raphanus raphanistrum* community is poor. Aggressive farming techniques include the use of soil compaction rollers and pre-emergence weed killers, which eliminate any existing seed bank.

The grassland dominated by *Rhaphanus raphanistrum* develops on the chromic soils of Hispalensean olive groves and on Marianense arenosols with a given content of nitrogen and organic matter. For this reason, we include it in the group of subnitrophilous pasturelands (Rivas-Martínez & Izco, 1977). The presence of the sand-loving *Brassica barrelieri and Linaria spartea* brings this community closer to *Coincyo transtagani-Brassicetum barrelieri* Cano, Sánchez Pascual & Valle 1996 described by the authors (Cano *et al*., 1996) for the Sierra Morena. Differential features of the former are its occurrence on soils with higher nitrogen content, the absence of the endemic *Coincya transtagana*, the presence of *Linaria spartea* and the abundant presence of *Raphanus raphanistrum*. The DECORANA and RA cluster and ordination analyses (Fig. 1) reveal a clear separation between the CB community of *Alysso granatensis-Brassicion barrelieri* and those of AcH, BH and PD included in *Hordeion leporini*; whereas the proposed new community is situated beside those of *Hordeion leporini* (Fig. 2), and comprises the inventories belonging to LR, a group that is clearly delimited in the RA correspondence analysis (Fig. 3). The synthesis table (Table 1) shows clear floristical

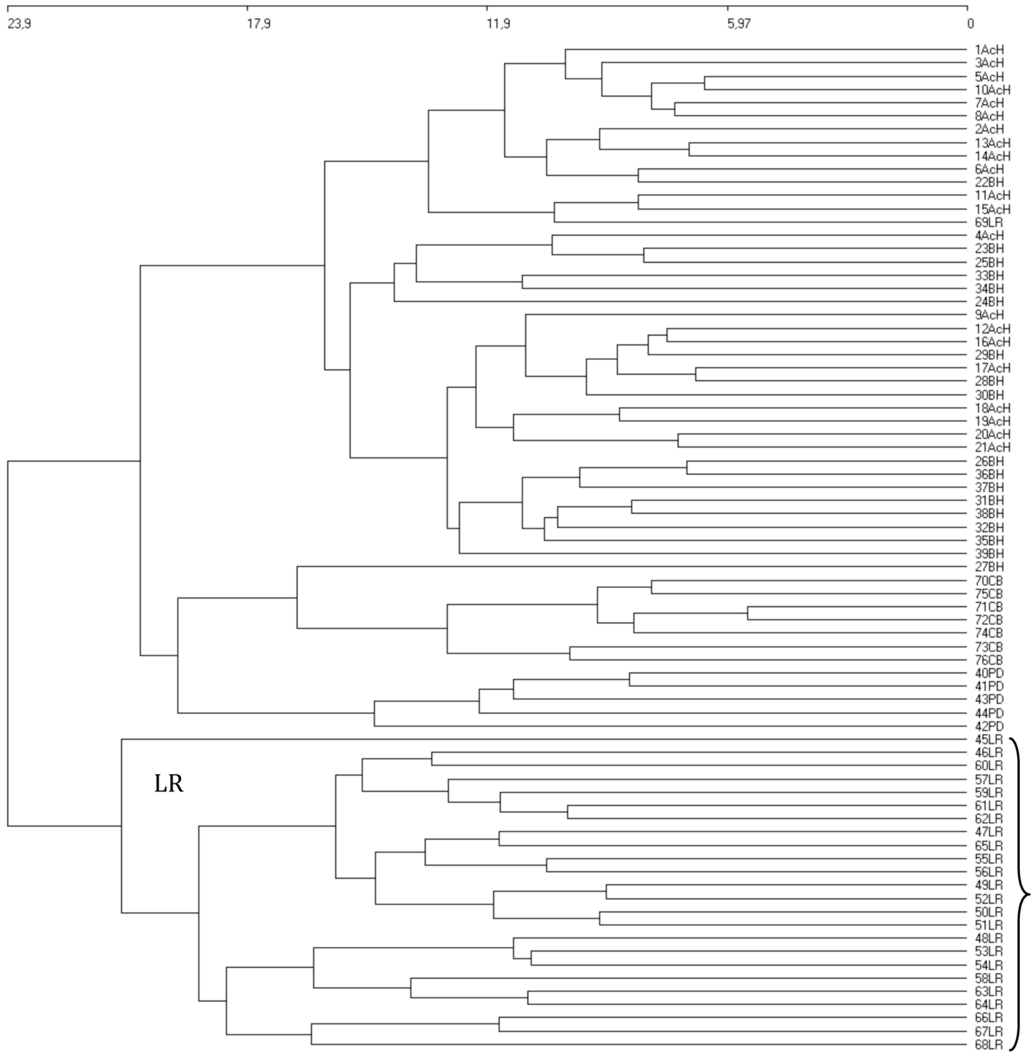

Fig. 1 - Dendrogram of the communities in the study in which the new LR community

differences between the CB association, in which it is very frequent to find *Brassica barrelieri* and *Alyssum granatense*. The absence of *Hordeum leporinum* in CB but a high presence of LR, together with other species of Hordeion such as *Bromus hordeaceus*, *Bromus diandrus* and *Medicago polymorpha*, justifies the inclusion of the new LR community in *Hordeion leporini*.

For all these reasons, we propose the new community *Linaria spartea* and *Raphanus raphanistrum*. This community tends to occur on acid or base–poor soils. This is the case of the strip of land of the Guadalquivir Valley which makes contact with the siliceous materials of the Sierra Morena. The canonical correspondence analysis (CCA) between the soil variables and the dominant species in the communities AcH, ArH, BH, LR, PD, ArP, ArChr, RChr, UM, PA, and TT (Fig. 4a,b) reveals that in this correlation the variable with the greatest influence on the abundance of *Raphanus raphanistrum* (Rr) is Txar. The species *Taeniatherum capus-medusae* (Tcm) is indifferent to texture. The LR community requires soil values of 0.75% MOO, 6.61 pH, 0.211 mmhos/cm of salinity, very low values of Kc (exchangeable potassium) and Pa (phosphorous assimilable), with a low value of pF 15 atm in all the associations in which the Txar value (sandy texture) is high, thus indicating a water shortage due to the high rate of drainage (Table 2). The sand texture parameter is the one that most affects the abundance of *Raphanus raphanistrum*.

Conclusion

Our study of the grasslands in the Guadalquivir Valley and the Sierra Morena indicates the presence of a new community, *Linaria spartea* and *Raphanus raphanistrum*. This is a transitional community between the subnitrophilous-nitrophilous pasturelands of *Hordeion leporini* and the subnitrophilous-psammophilous pasturelands of *Alysso granatensis-Brassicion barrelieri* Rivas-Martínez & Izco 1977. However, we suggest maintaining it within the alliance *Hordeion leporini* due to its structure and subarenicolous soil

Tab. 1 - Synthesis table of the associations AcH = *Anacyclo clavati-Hordeetum leporini*, BH = *Bromo scopari-Hordeetum leporini*, PD = *Papaveri rhoeadis-Diplotaxietum virgatae*, LR = *Linaria spartea and Raphanus raphanistrum*, CB = *Coincyo transtagani-Brassicetum barrelieri*.

	AcH	BH	PD	LR	CB
	.	.	.	.	.
Plantago lagopus L.	II	II	I	I	I
Hedypnois cretica (L.) Willd.	I	I	I	I	III
Leontodon longirrostris (Finch & P.D. Sell) Talavera in Valdés & al.	I	I	I	I	III
Erodium cicutarium (L.) L´Hér.	I	I	I	.	I
Bromus hordeaceus L.	II	III	.	.	III
Bromus rubens L.	I	I	.	.	I
Bromus madritensis L.	.	.	I	I	I
Capsella rubella Reuter	I	I	.	.	I
Hordeum leporinum Link	V	V	I	II	.
Bromus diandrus Roth.	IV	II	II	II	.
Medicago polymorpha L.	III	II	III	III	.
Erodium malacoides (L.) L´Húr.	IV	I	III	I	.
Sinapis alba L. subsp. mairei(H. Lindb.) Maire	V	I	I	I	.
Calendula arvensis L.	III	II	IV	III	.
Carduus bourgaeanus Boiss. & Reuter	II	II	I	I	.
Euphorbia helioscopia L.	I	I	I	I	.
Echium plantagineum L.	I	II	I	I	.
Sonchus oleraceus L.	I	I	II	I	.
Avena sterilis L.	I	I	I	I	.
Anagallis coerulea Schreber	I	I	I	II	.
Anacyclus clavatus (Desf.) Pers.	IV	II	.	I	.
Diplotaxis catholica (L.) DC.	I	.	IV	I	.
Geranium molle L.	I	V	.	I	.
Nonea vesicaria (L.) Reichenb.	I	I	I	.	.
Diplotaxis siifolia G. Kunze	I	I	.	I	.
Senecio gallicus Chaix	I	I	I	I	.
Plantago lanceolada L.	I	.	I	I	.
Galium aparine L.	I	I	I	I	.
Fumaria parviflora Lam.	I	I	I	.	.
Trifolium tomentosum L.	I	I	.	I	.
Foeniculum vulgare Miller subsp. Piperitum (Ucria) Coutinho	I	I	I	.	.
Cerastium glomeratum Thuill.	I	I	I	I	.
Bromus rigidus Roth	I	I	.	I	.
Erodium moschatum (L.) L´Hér.	.	III	I	II	.
Carduus pynocephalus L.	.	I	.	.	.
Chrysanthemum coronarium L. var. discolor d´Urv.	.	I	I	I	.
Silybum marianum (L.) Gaertner	I	I	I	.	.
Avena barbata Potter	I	II	.	.	.
Capsella bursa-pastoris (L.) Medicus	.	.	II	.	.
Raphanus raphanistrum L.	.	III	.	V	.
Sherardia arvensis L.	.	I	I	I	.
Malva neglecta Wallr.	.	I	II	.	.
Lactuca serriola L.	.	.	I	I	.
Lolium temulentum L.	.	.	II	II	.
Sonchus tenerrimus L.	.	.	I	I	.
Sonchus asper (L.) Hill.	I	.	I	.	.
Silene vulgaris (Moench) Garke	I	.	I	.	.
Centaurea pullata L. subsp. baetica	I	.	.	I	.
Galactites tomentosa Moench.	.	I	.	I	.
Leontodon taraxacoides (Vill.) Merat	I	I	.	.	.
Convolvulus arvensis L.	I	I	.	.	.
Filago lutescens Jordan	III	.	.	.	.
Avena fatua L.	I	.	.	I	.
Dactylis glomerata L. var. hispanica (Roth) Nyman	I	I	.	.	.
Medicago arabica (L.) Hudson	.	I	I	I	.
Stellaria media (L.) Vill.	.	I	II	I	.
Euphorbia peplus L.	I	.	.	I	.
Torilis nodosa (L.) Gaertner	I	.	I	I	.
Chrysanthemum segetum L.	.	.	.	II	.
Malva parviflora L.	.	I	.	I	.
Senecio vulgaris L.	.	.	I	I	.
Diplotaxis virgata (Cav.) DC.	.	I	I	.	.
Papaver rhoeas L.	.	.	II	.	.
Ornithopus compressus L.	.	I	.	I	.
Anthriscus caucalis Bieb.	.	I	.	I	.
Lathyrus cicera L.	.	I	.	I	.
Anthemis praecox Link	.	I	.	I	.
Anthemis arvensis L.	.	I	I	II	.
Poa infirma Kunth	.	I	I	I	.
Phalaris minor Retz.	.	I	.	.	.
Geranium dissectum L.	.	I	I	.	.
Cerastium brachypetalum Pers.	.	I	.	I	.
Lamium amplexicaule L.	.	.	II	I	.
Silene colorata Poiret	.	.	I	I	.
Poa annua L.	.	.	I	I	.
Rumex crispus L.	.	.	I	I	.
Ononis biflora Desf.	.	.	I	I	.
Erodium aethyopicum (Lam) Brumh	.	.	I	I	.
Anchusa puechii Valdés	.	.	I	.	.
Arenaria hispanica Sprengel	.	.	I	.	.
Linaria spartea (L.) Chaz.	.	.	.	II	.
Chamaemelum nobile (L.) All.	.	.	.	I	.
Leontodon salzmannii (Schultz Bip.)	.	.	.	I	.
Vicia sativa L. subsp. cordata	.	.	.	I	.
Veronica cymbalaria Bordard	.	.	.	I	.
Linaria voscosa L.	.	.	.	I	.
Erodium botrys (Cav.) Bertol var.	.	.	.	I	.
Corrigiola telhephiipholia Pourret	.	.	.	I	.
Brassica barrelieri (L.) Jancka	.	I	.	I	V
Rumex bucephalophorus L.	.	.	.	I	III
Lamarckia aurea (L.) Moench	I	.	.	I	III
Plantago coronopus L.	.	I	.	.	III
Alyssum granatense Boiss. & Reuter	.	.	.	.	V
Coinzya transtagana (Coutinho)	.	.	.	.	IV
Trifolium stellatum L.	.	.	.	.	III
Petrorhagia nanteuilli (Burnat) P. W.	.	.	.	.	I
Taeniatherum caput-medusae (L.)	.	.	.	.	I
Brachypodium distachyon (L.) Beauv	.	.	.	.	III
Logfia gallica (L.) Cosson & Germ.	.	.	.	.	I
Aegilops triuncialis L.	.	.	.	.	I
Filago pyramidata L.	.	.	.	.	I
Viola kitaibeliana Schultes	.	.	.	.	I
Trifolium campestre Schreber	.	.	.	.	I
Trifolium glomeratum L.	.	.	.	.	I
Crucianella angustifolia L.	.	.	.	.	I
Sedum caespitosum (Cav.) DC.	.	.	.	.	I

character. The community presents a lower content of phosphorus, CEC, assimilable nitrogen, etc. which is indicative of the presence of relatively poorer soils which are rich in sand content and therefore undergo washing by rainwater. The proposed new community grows on soils with a high quantity of sand (64.3%), and indicates a premature water deficit for cultivation.

Syntaxonomical scheme

STELLARIETEA MEDIEAE Tüxen, Lohmeyer & Preising ex von Rochow 1951
CHENOPODIO-STELLARIENEA Rivas Goday 1956
SISYMBRETALIA OFFICINALIS J. Tüxen in Lohmeyer & al. 1962 em. Rivas-Martínez, Báscones, T.E. Díaz, Fernández-González & Loidi 1991
Hordeion leporini Br.-Bl. in Br.-Bl., Gajewski, Wraber & Walas 1936 corr. O. Bolòs 1962
Papaveri rhoeadis-Diplotaxietum virgatae Rivas-Martínez 1978
Bromo scoparii-Hordeetum leporini Rivas-Martínez 1978
Anacyclo clavati-Hordeetum leporini Cano-Ortiz, Pinto Gomes, Esteban & Cano 2009
Community of *Linaria spartea* and *Raphanus raphanistrum*

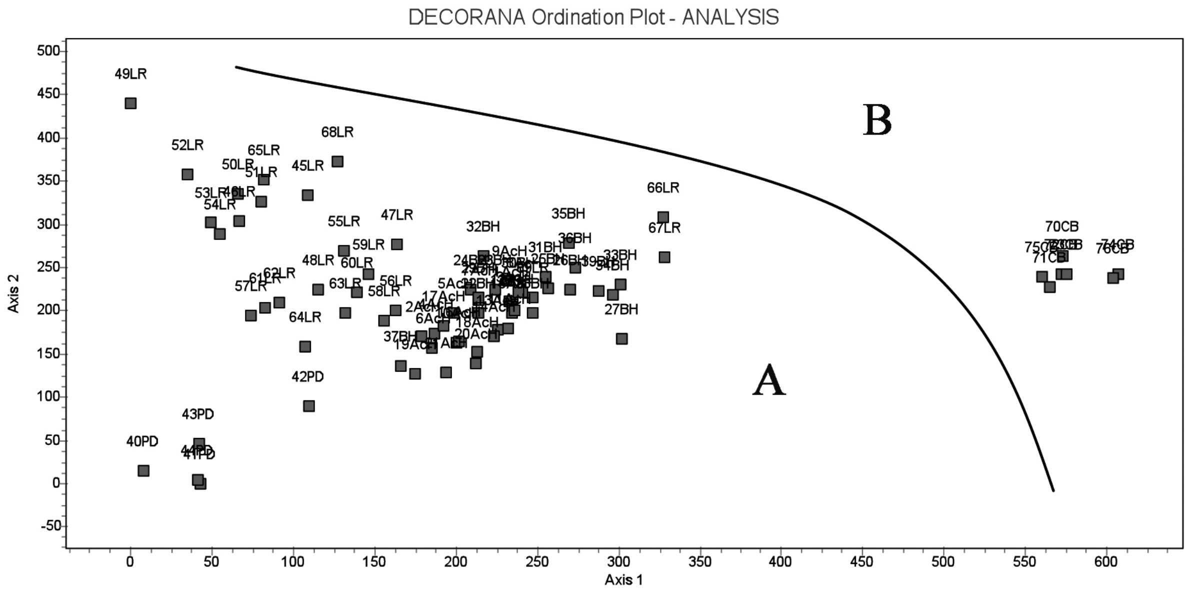

Fig. 2 - DECORANA ordination analysis. A) Communities of *Hordeion leporini*. B) Community of *Alysso granatensis-Brassicion barrelieri*.

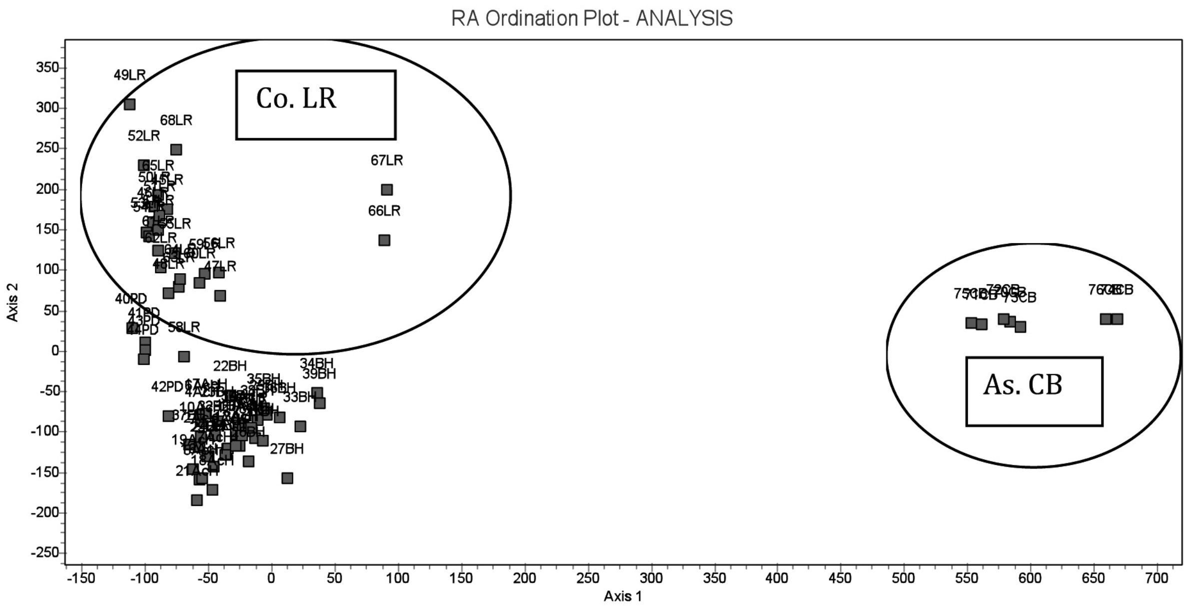

Fig. 3 - RA correspondence analysis. LR community included in *Hordeion leporini* and CB ass. included in *Alysso granatensis-Brassicion barrelieri*

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Table 2 - Community of *Linaria spaertea* and *Raphanus raphanistrum* (LR)

Number of order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Presences
Number of cluster	45LR	46LR	47LR	48LR	49LR	50LR	51LR	52LR	53LR	54LR	55LR	56LR	57LR	58LR	59LR	60LR	61LR	62LR	63LR	64LR	65LR	66LR	67LR	68LR	
Field number	5	7	61	62	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	81	84	153	154	51	
Inclusion	0	0	0	0	0	0	0	0	0	0	5	2	2	3	1	0	2	1	0	2	0	0	0	0	
Exposure	-	-	-	-	-	-	-	-	-	-	NE	S	NW	S	NE	-	SW	NE	-	W	-	-	-	-	
Cover rate (%)	100	100	100	100	85	100	100	75	90	100	100	100	80	100	80	100	100	90	100	100	90	100	100	90	
Minimum area (m2)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Altitude (m)	261	256	252	258	266	308	280	300	301	295	261	204	236	236	239	256	228	247	288	301	243	591	624	331	
Vegeation average height (m)	0.500	0.600	0.900	0.600	0.400	0.900	0.900	0.900	0.900	0.900	1.000	1.000	0.700	0.900	0.700	0.600	0.800	0.700	0.800	0.900	0.900	0.450	0.500	0.400	
Dominant vegetation average height	0.700	0.800	1.000	0.900	0.500	1.100	1.000	1.000	1.100	1.000	1.200	1.200	0.800	1.000	0.800	0.700	0.900	0.900	0.900	1.100	1.100	0.650	0.600	0.500	
Characteristic of the community																									
Raphanus raphanistrum	5	5	5	5	4	5	5	3	4	5	5	5	4	5	4	5	5	5	5	5	4	5	5	4	24
Linaria spartea	1	1	.	.	.	+	.	.	.	1	.	.	.	.	+	.	+	.	.	1	+	.	.	.	8
Erodium aethiopicum	.	.	.	.	.	.	.	.	1	1	.	.	2	.	.	.	1	2	.	.	.	.	.	.	5
Characterisctic syntaxonomic of higher units *Stellarietea mediae*																									
Medicago polymorpha	.	4	.	.	+	2	+	+	+	.	2	+	2	2	3	3	4	3	3	2	.	.	.	.	16
Calendula arvensis	2	+	+	+	.	.	+	.	+	2	.	+	.	1	.	1	.	.	2	+	.	.	.	.	12
Bromus diandrus	2	3	1	.	.	.	.	1	.	.	.	+	+	.	1	2	.	1	.	1	+	.	.	.	11
Malva neglecta	+	.	+	+	.	.	.	.	.	+	+	.	.	1	.	.	+	+	+	1	.	.	.	.	10
Lolium temulentum	.	.	.	.	.	.	.	1	.	.	.	.	1	+	1	2	1	1	2	3	.	.	.	.	9
Hordeum leporinum	.	.	+	.	.	2	1	.	1	.	1	.	.	2	2	2	.	.	.	.	.	.	.	.	8
Erodium moschatum	.	.	.	1	.	.	1	.	.	1	.	.	.	1	.	1	.	.	2	1	1	.	.	.	8
Erodium malacoides	.	.	1	1	.	.	.	.	.	.	.	1	.	1	+	.	1	.	.	1	.	.	.	.	7
Chrysanthemum segetum	.	.	.	.	.	.	.	.	.	.	2	2	+	.	+	+	.	.	.	.	.	1	1	3	8
Bromus rigidus	.	.	.	3	.	.	.	.	2	3	.	.	.	1	.	.	.	1	+	.	.	.	.	1	7
Anthemis arvensis	+	+	2	.	2	.	.	.	.	.	+	.	+	.	.	2	.	.	.	.	1	.	.	.	8
Anagallis coerulea	+	.	.	.	.	+	.	.	.	+	+	+	.	.	.	.	+	.	1	.	.	.	.	+	8
Rumex angiocarpus	1	.	.	.	+	1	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	7
Ornithopus compressus	.	.	.	.	.	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	6
Diplotaxis catholica	.	.	.	+	.	.	.	.	.	.	.	+	.	1	.	.	.	+	.	+	.	.	.	.	5
Sonchus oleraceus	.	.	+	.	.	.	.	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	5
Geranium rotundifolium	.	.	.	+	.	1	.	.	.	.	1	+	.	.	.	.	.	.	.	+	.	.	.	.	5
Erodium botrys	.	1	.	.	2	1	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Echium plantagineum	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.	+	.	1	.	.	.	.	1	.	5
Chamaemelum nobile	2	.	.	.	1	1	.	2	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
Sporadic species	7	8	3	3	7	3	3	2	4	6	3	4	7	7	8	4	6	1	8	5	5	15	14	9	

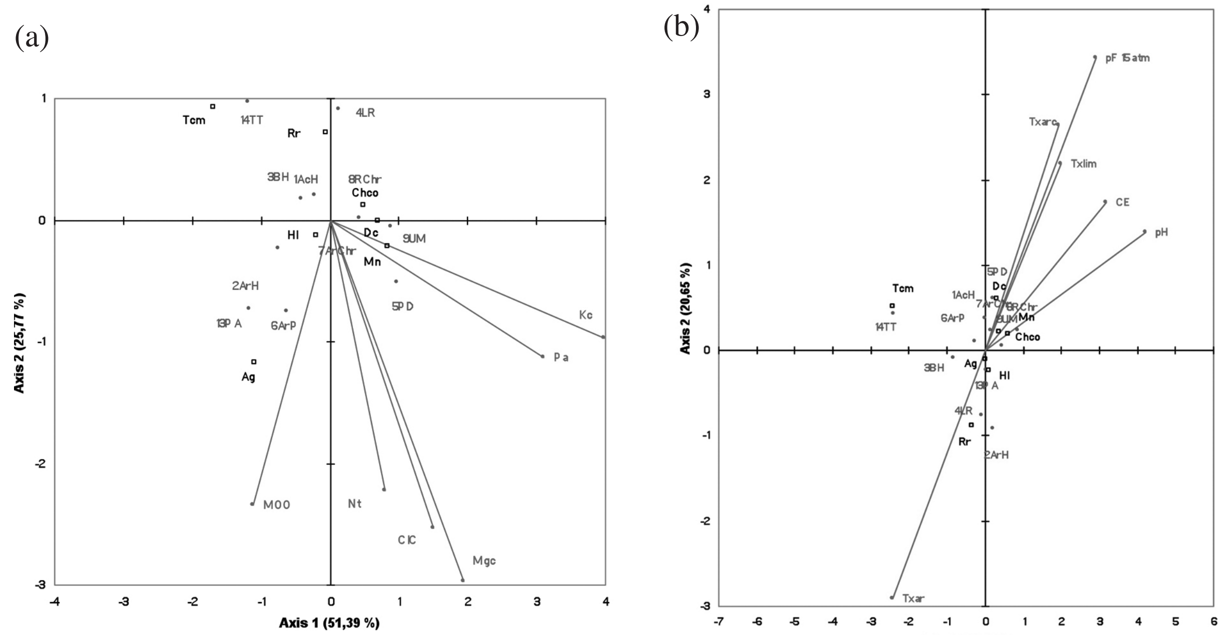

Fig. 4 - (a) Canonical correspondence analysis (CCA) in which the variables Kc, Pa, Mgc, CIC, Nt and MOO do not affect LR and TT (Tcm = *Taeniatherum caput-medusae*, Rr = *Raphanus raphanistrum*, Chco = *Chrysantemum coronarium*, Hl = *Hordeum leporinum*, Dc = *Diplotaxis católica*, Mn = *Malva neglecta*, Ag = *Aegilops geniculata*. (b) Canonical correspondence analysis (CCA) in which the variable Txar affects LR.

Tab. 3 - Average values of the soil parameters obtained from the soil samples of the 11 communities.

	CIC	MOO	Nt	Pa	Mgc	Kc	pF 15 atm	Tx arc	Tx ar	Tx lim	CE	pH
1AcH	H	1.541	0.115	9.789	1.683	0.79	15.322	17.758	20.448	61.794	0.355	8.275
2ArH	9.131	1.56	0.102	13.957	1.856	0.256	8.613	19.78	62.411	17.803	0.209	7.43
3BH	10.544	1.667	0.133	15.4	1.068	0.375	8.203	14.503	54.254	31.245	0.122	7.475
4LR	6.661	0.75	0.064	4.824	0.835	0.259	7.366	17.28	64.238	18.51	0.211	6.616
5PD	14.304	1.02	0.09	15.35	2.351	1.002	19.117	40.015	19.986	40	0.286	8.085
6ArP	10.869	1.803	0.14	14.722	1.864	0.412	13.001	25.394	45.694	28.906	0.162	7.633
7ArChr	12.328	1.622	0.105	26.9	2.131	0.698	11.975	19.763	55.826	24.413	0.193	7.77
8RChr	11.68	1.574	0.129	20.95	2.716	1.476	14.24	24.24	37.85	37.94	0.491	7.943
9UM	10.889	1.904	0.179	36.19	1.698	1.266	13.197	21.293	46.001	32.712	0.565	7.776
13PA	10.54	1.8	0.136	5.605	1.713	0.206	11.82	25.83	44.98	29.2	0.105	7.581
14TT	9.63	1.458	0.084	5.111	1.097	0.156	6.673	13.59	64.93	21.49	0.049	6.13

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Appendix 1: Sporadic species

Table 2:

Other characteristic of the community:

Rel. 3: Sinapis alba ssp mairei (+), Rel.5: Leontodon salzmanii (+), Rel. 6: Leontodon salzmanii (+), Rel. 10: Leontodon salzmanii (+), Rel. 17: Sinapis alba ssp mairei (+), Rel. 22: Brassica barrelieri (3), Rel. 23: Brassica barrelieri (2) and Anthyllis lotoides (+).

Other characterisctic syntaxonomic of higher units Stellarietea mediae: Characteristic species:

Rel 1: Spergula arvensis (2), Senecio vulgaris (1), Medicago coronata (3). Rel. 2: Senecio vulgaris (+), Vicia sativa ssp. cordata (1), Veronica cymbalaria (+), Plantago lanceolata (+). Rel. 3: Medicago arabica (2). Rel. 4: Sherardia arvensis (+), Medicago arabica (+), Vicia lutea (+). Rel. 5: Spergula arvensis (+), Linaria amethystea (+), Veronica cymbalaria (+), Asperula arvensis (+). Rel. 6: Astragalus echinatus (+), Misopates orontium (+). Rel. 7: Chrysanthemum coronarium (1), Astragalus echinatus (+). Rel. 8: Galium aparine (+). Rel. 9: Silene colorata (2), Linaria amethystea (1), Taraxacum obovatum ssp. Ochrocarpum (+), Euphorbia peplus (1). Rel. 10: Silene colorata (2), Plantago lanceolata (+), Diplotaxis siifolia (+), Chrysanthemum coronarium (1). Rel. 11: Senecio vulgaris (+), Diplotaxis siifolia (+), Torilis leptophylla (+). Rel. 12: Malva parviflora (+), Sonchus tenerrimus (1), Lactuca serriola (+), Bromus madritensis (+). Rel. 13: Linaria amethystea (+), Lactuca serriola (+), Sherardia arvensis (1), Plantago lagopus (+), Glossopapus macrotus (+), Allium chamaemoly (+). Rel. 14: Geranium molle (1), Anacyclus clavatus (1), Euphorbia helioscopia (+), Tolpis barbata (+), Centaurea pullata ssp. baetica (+), Avena sterilis (2). Rel. 15: Sonchus tenerrimus (+), Vicia sativa ssp. cordata (+), Silena gallica (+), Hedypnois cretica (1), Bellardia trixago (+). Rel. 16: Linaria amethystea (+), Sonchus tenerrimus (+), Galium aparine (+). Rel. 17: Spergula arvensis (+), Silene colorata (+), Medicago sativa (1), Anthemis praecox (+). Rel. 18: Silene colorata (+). Rel. 19: Senecio gallicus (+), Malva parviflora (+), Galium aparine (+), Lupinus angustifolius (+), Vicia sativa ssp nigra (1), Anthriscus caucalis (+). Rel. 20: Malva parviflora (1), Lactuca serriola (+), Hedypnois cretica (+), Vicia hybrida (+). Rel. 21: Erodium ciconium (+), Aira cupaniana (2). Rel. 22: Spergula arvensis (+), Senecio gallicus (+), Plantago lagopus (1), Lupinus angustifolius (+), Linaria viscosa (+), Geranium molle (+), Erodium botrys var. brachycarpum (1), Leontodon longirrostris (+), Lathyrus cicera (+). Rel. 23: Senecio gallicus (+), Linaria viscosa (2), Erodium botrys var. brachycarpum (1), Anacyclus clavatus (+), Lamium amplexicaule (+), Corrigiola telephiifolia (+). Rel. 24: Silena gallica (2), Stellaria media (+), Lupinus luteus (1), Galactites tomentosa (+), Chamaemelum mixtum (2), Avena fatua (1).

Other species:

Rel. 1: Poa infirma (2), Hypochoeris radicata (3), Conyza albida (+), Cerastium glomeratum (2). Rel. 2: Poa annua (+), Conyza canadensis (+), Hypochoeris radicata (+), Conyza albida (+). Rel. 3: Rumex crispus (+). Rel. 5: Poa annua (2), Moenchia erecta (+). Rel. 7: Poa annua (2) and (1). Rel. 8: Poa annua (2). Rel. 10: Poa annua (2) and (1). Rel. 13: Daucus muricatus (2). Rel. 14: Carduus bourgaeanus (+). Rel. 15: Conyza canadensis (+), Trifolium tomentosum (1), Scorpiurus vermiculatus (+). Rel. 16: Rumex crispus (+). Rel. 17: Scorpiurus vermiculatus (2). Rel. 19: Conyza canadensis (+), Trifolium tomentosum (+). Rel. 20: Daucus muricatus (+). Rel. 21: Conyza canadensis (1), Poa infirma (1), Juncus bufonius (+). Rel. 22: Trifolium tomentosum (+), Hypochoeris radicata (1), Myosotis ramosissima (+), Crassula tillaea (+), Cerastium brachypetalum (1). Rel. 23: Poa infirma (+), Spergularia purpurea (1), Rumex bucephalophorus (1), Myosotis discolor ssp. dubia (+), Muscari comosum (+), Lamarckia aurea (1). Rel. 24: Spergularia purpurea (1), Carduus bourgaeanus (+), Lolium perenne (1).

Appendix 2: Localities

Table 2:

5.- Loma de la Marquesa (Marmolejo, Jaén). 7.- Loma de la Marquesa (Finca los Pobres). 61.- Near Ruinas Marquesa. 62.- Finca el Cañuelo (Jaén). 64, 65, 66 and 67.- Presa del Yeguas (Córdoba-Jaén). 68, 69, 70 and 71.- Villa del Río-Cardeña road (Córdoba). 72, 73, 74, 75 and 76.- Loma de la Marquesa. 77.- Near Finca el Cañuelo (Jaén). 78.- Near Pantano del Yeguas (Córdoba-Jaén). 81 and 84.- Carril del Pilar (substation of Marmolejo, Jaén). 51, 153 and 154.- Alcaparrosas (Las Viñas de Andújar, Jaén).

Appendix 3: Coordinates of relevè

Table 2:

Field 5: X 392378 m; Y 4212017 m. Field 7: X 392534 m; Y 4212168 m. Field 61: X 393166 m; Y 4210923 m. Field 62: X 392304 m; Y 4212184 m. Field 64: X 388635 m; Y 4214307 m. Field 65: X 388825 m; Y 4214062 m. Field 66: X 388778 m; Y 4214024 m. Field 67: X 388680 m; Y 4214186 m. Field 68: X 388239 m; Y 4214122 m. Field 69: X 387997 m; Y 4213691 m. Field 70: X 388229 m; Y 4210824 m. Field 71: X 394127 m; Y 4212522 m. Field 72: X 394015 m; Y 4210520 m. Field 73: X 393793 m; Y 4210449 m. Field 74: X 393526 m; Y 4210684 m. Field 75: X 393259 m; Y 4210807 m. Field 76: X 393027; Y 4212169 m. Field 77: X 393369 m; Y 4212374 m. Field 78: X 393263 m; Y 4214511 m. Field 79: X 393034 m; Y 4214573 m. Field 81: X 393017 m; Y 4214393 m. Field 84: X 395101 m; Y 4211822 m. Field 153: X 412808 m; Y 4218786 m. Field 154: X 412010 m; Y 4218389 m. Field 51: X 648173 m; Y 4429000 m.