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Abstract

Helianthemetea guttati communities are pioneer spring and early summer ephemeral grasslands, dominated by non-nitrophilous therophytes. In Continental Portugal, these communities have not yet been fully investigated, and thus the objectives of the present study are: (1) to identify community types in therophytic grasslands; (2) to recognize those communities that configure the European priority habitat 6220* (pseudo-steppe with grasses and annuals); (3) to establish environmental gradients underlying their spatial variation; (4) to assess how floristic composition is affected by land use factors. Vegetation sampling using phytosociological methodology was carried out on 80 grasslands. Modified Twinspan classification and canonical correspondence analysis (CCA) was applied for the classification and ordination of relevés whereas partial CCA (pCCA) and variation partitioning were used to assess the relative influence of individual land use factors. Some 270 species were identified across 11 community types whose floristic patterns were mainly explained by environmental gradients related to altitude and soil type while land use variables could only explain a small part of the floristic variation. Based on biogeography and the determination of diagnostic species, four phytosociological new associations and a new subassociation are proposed: *Holco-Brachypodietum distachyi*, *Holco-Micropyretum tenellae*, *Micropyro-Anthoxanthetum aristati* and *Leontodonto-Vulpietum bromoidis vulpietosum membranaceae*.

Keywords: *Community types, environmental factors, land use factors, therophytic grasslands, variation partitioning*

Nomenclature: Botanical nomenclature follows Aedo et al. (2005), Benedí et al. (2009), Castroviejo et al. (1986, 1990, 1993a,b, 1997a,b, 2008), Devesa et al. (2007), Morales et al. (2010), Muñoz Garmendia and Navarro (1998), Nieto Feliner et al. (2003), Paiva et al. (2001), Talavera et al. (1999, 2000, 2010), Franco (1984) and Franco and Rocha Afonso (1994, 1998), Vázquez (2004) for the genus *Celtica* and Díaz Lifante and Benito (1996) for the genus *Asphodelus.* The bioclimatological, biogeographical and syntaxonomical typologies were checked according to Pérez Prieto and Font (2005), Rivas-Martínez et al. (2001, 2002a, 2002b) and Rivas-Martínez (2007).

Introduction

It is becoming increasingly important to gain a deeper understanding of the ecological gradients underlying the floristic pattern of annual grasslands since their distribution area is likely to expand due to the increased dryness resulting from climate change. In particular, one must take into account the dynamics associated with them and the multiple variations of the ecological gradients underlying their floristic patterns.

Mediterranean natural and semi-natural grasslands are among Europe's protected ecosystems, some particular annual grasslands studied being priority habitats under the EU Habitats Directive (Natura 2000 code: 6220* "Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*").

Due to its dependence on the Mediterranean climate, habitat 6220* occurs mainly in Mediterranean regions. According to San Miguel (2008), the calcareous *Trachynietalia distachyae* communities are included in subtype 3. This order comprises the *Trachynion distachyae* alliance, which includes the pioneer and ephemeral basophilous annual grasslands of the studied territory. This alliance is thermo to supramediterranean pluviseasonal or thermo-mesotemperate mostly submediterranean and occurs on calcium carbonate or clayey soils (Rivas-Martínez et al. 2002a).

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This study also focuses on the ecological gradients across therophytic grasslands of *Helianthemetea guttati* within an extensive Mediterranean geographic area of Continental Portugal, to clarify the dynamic relationships between them as well as with other communities. The *H. guttati* communities are spring pioneer and early summer ephemeral grasslands, dominated by non-nitrophilous annual short herbs and grasses. The dynamic and ephemeral characteristics of these communities could help to explain their high variability.

Two alliance types of *H. guttati* were studied: *Helianthemion guttati* and *Thachynion distachyae*. Studies on therophytic grasslands of *H. guttati* in the Iberian Peninsula, at a descriptive level, were mainly developed by Rivas Goday (1964), Ladero et al. (1990), Amor et al. (1993), Torres et al. (2000), Rivas-Martínez et al. (2002a, 2002b), Pérez Prieto and Font (2005), Costa (2006), Vicente Orellana and Galán de Mera (2008) and Medina-Cazorla et al. (2010). Rudner (2005a, 2005b) has also approached the seasonal, temporal and environmental dynamics of therophytic grasslands in the Iberian Peninsula.

Annual species are considered r-strategists, which are defined by their ability to rapidly increase their population (Pianka 1970). Therefore, annual grasslands (dominated by annual species but often with some geophytes too) are generally recognized as pioneering communities. Nevertheless, these communities are also able to adapt to edaphic extreme situations and oligotrophic soil. Grime (1974, 1977, 1979, 2002) and Grime et al. (1988), on the other hand, distinguish three main strategies amongst plants: C-competitive, S-stress-tolerator and R-ruderal. Moreover, Madon and Médail (1997) point out that annual species could be stress-tolerant in xeric habitats as well as ruderal in productive habitats, while keeping in line with Grime's model.

Annual communities of *H. guttati* are considered to be the last subseral stage of xeric Mediterranean forests and shrub communities. They occupy the clearings of woody chamaephyte communities, forming a mosaic in which the area occupied is usually small. Alterations in land use together with climate change can increase the distribution area of these grasslands and modify their currently known floristic combinations (San Miguel 2008).

Assessing the effects of management on vegetation patterns has been a central concern of recent ecological research. Variation partitioning is a method that can provide a clear understanding of species-environment relationships, by decomposing the variation into independent components that represent the relative importance of individual predictors or groups of predictors and their joint effects (Heikkinen et al. 2004).

It is of great interest to know the dynamics and response of these grasslands to different environmental and land use factors, in line with Blasi et al. (2010) and Catorc and Gatti (2010). Thus, the following questions will be addressed: (1) Which community types can be found in therophytic grasslands? (2) How can communities that configure the European priority habitat 6220* (pseudo-steppe with grasses and annuals) be recognized? (3) Which are the ecological gradients underlying the floristic composition patterns of those community types? (4) How is the floristic composition of those community types affected by land use factors?

Material and methods

The research area

Field research covered a total area of approximately 28,700 km^2 in central eastern and southeastern Continental Portugal (Figure 1) on silicious (schist and granite) and calcareous substrata. According to the biogeographic typology of Rivas-Martínez et al. (2007), the researched area is included in the Western Mediterranean Subregion, Mediterranean West Iberian Province (Carpetan-Leonese and Lusitan-Extremadurean subprovinces).

Within the study area, communities of therophytic grasslands were surveyed in areas with thermo to mesomediterranean thermotype and dry to

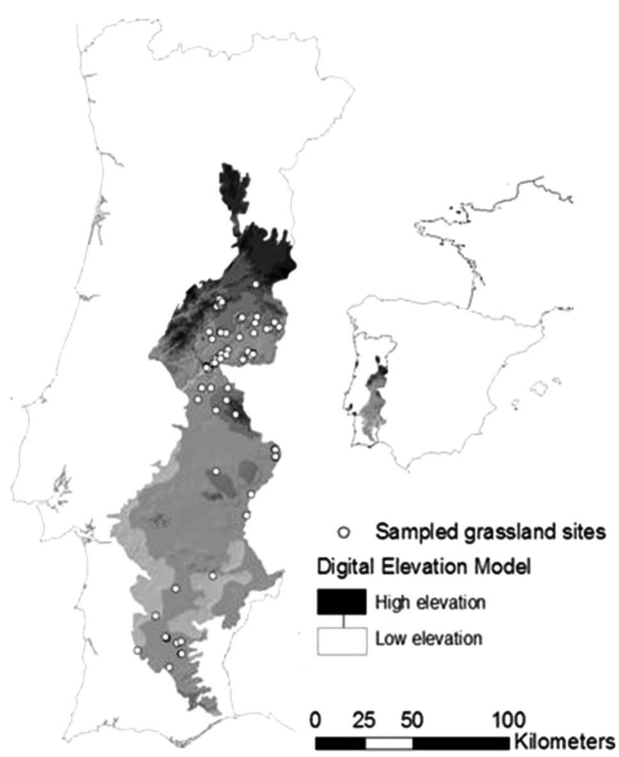


Figure 1. Researched area in eastern Portugal and the location of sampled grassland sites.

subhumid ombrotype whose altitudes ranged from 90 to 1100 m a. s. l. These communities occupied patchy fragments of grasslands in large areas of arable land, livestock grazing and forest mosaics.

Vegetation series related to the sampled grasslands are mainly oak climatophilous series: Arbuto unedonis-Querco pyrenaicae S., Sanguisorbo agrimonioidis-Querco suberis S. and Pyro bourgaeanae-Querco rotundifoliae S.

Sampling design and data collection

Field sampling was carried out on 80 grasslands sites, following the phytosociological concepts of Braun-Blanquet (1964, 1979) modified by Géhu and Rivas-Martínez (1981). The therophytic communities were surveyed using the minimum area method (the smallest area which adequately represents community composition) in line with Mueller-Dombois and Ellenberg (1974). Thus, the representative plot size of homogenous floristical composition was 3.24 ± 0.98 m^2 with 2 as minimum and 4 as maximum for *Helianthemion guttati* communities and 12 m^2 for *T. distachyae* communities. To allow multivariate analysis, percentage cover was recorded for each taxon (Podani 2006). In addition, percentage cover for lichens and bryophytes was recorded for each relevé.

The stratified sampling of therophytic grasslands (Figure 1) was based on potential distribution mapping of annual communities in the study area (Ribeiro & Espirito-Santo 2008). Thus, stratified sampling took into account lithology, bioclimatology and management, allowing the selection of nine grasslands with frequent soil tillage, 31 extensive grasslands and 40 not grazed grasslands. The number of sampling plots per stratum was based on the ecological and floristic variability. The latter are mainly the result of pedological heterogenity and the area's microtopography which influences soil humidity. The geographic position of each sample unit was recorded with GPS and digitalised through the geographic information system (GIS) ArcGis (version 9.0; ESRI). The study period was from late winter (March) to summer (July) in 2008 and 2009.

Predictor variables were recorded for each grassland, including both qualitative and quantitative environmental and land use variables. These predictor variables were assigned into two groups: (i) environmental and (ii) land use.

The environmental factors included: (a) bioclimatic values that define thermotypes and ombrotypes (Rivas-Martínez 2005; Monteiro-Henriques 2010); (b) physiographic factors (altitude, aspect and slope); (c) geological factors (substrate rock type) and (d) pedological factors that include the percentage of stone, soil texture and parameters obtained by standard soil analysis with determination of pH (H_2O), potassium and phosphorus by the Égner-Rhiemn method, and organic substrate by the Walkey-Black method.

Land use influence was evaluated by using: (a) grazing variables (number of months with/without grazing); (b) management variables (time without soil mobilization, type of crop) and (c) other land use history (number of years without incidental fire).

Data analysis

The data set included 202 relevés and 270 species. Twenty-six relevés were removed due to their deviating floristic composition, corresponding to a high level of human perturbation or a transition to other vegetation classes. To clarify some differences between vegetation types of the *Helianthemion guttati* alliance, six relevés available from the literature were included in the data set. They were obtained by Rivas Goday (1964) in Spain and by Vicente Orellana and Galán de Mera (2008) in Portugal. The raw matrix was analysed with the software JUICE 7.0.33 (Tichý 2002) and plant community types were recognized with modified TWINSPAN classification (Roleček et al. 2009) using Jaccard distance as a dissimilarity measure (a minimum dissimilarity of 0.745 was accepted).

From a pedological point of view, soil in the study area varies from acid to basic, with *Helianthemion guttati* and *T. distachyae* alliances differentially distributed. The first alliance is limited to sandy–loamy soils while the second has more affinity with calcium carbonate or clayey soils (Rivas-Martínez et al. 2002a). Thus, due to their pedological affinities, modified TWINSPAN was applied separately in the classification of relevés of *Helianthemion guttati* (acid soils).

Determination of diagnostic species is linked to the concept of fidelity, understood as a species' occurrence or abundance within the group or community type relative to other groups or to the complementary part of the data set. Species with high fidelity to the target site group are considered as its diagnostic species. According to Dengler et al. (2009) and Otýpková and Chytrý (2006), species constancy and co-occurrence patterns are affected by plot size. Therefore, Dengler et al. (2009) showed that only constancy values between units sampled from the same or similar plot sizes are comparable, otherwise, ''diagnostic species'' could be artificial. Similar results were obtained by Otýpková and Chytrý (2006) when the difference in plot size is more than 10-fold. Therefore, it is important to note that in the present study the diagnostic value of species was determined within sets of relevés with identical plot sizes. Fidelity was assessed through the coefficient phi (Sokal & Rohlf 1995; Chytrý et al. 2002) and Fisher's exact test was applied to test statistical significance (Chytrý et al. 2002; Tichý & Chytrý 2006). Only fidelity values of species with significance ($p < 0.05$) were displayed and all groups were standardized to equal size.

Relationships between a species' occurrence and the main explanatory variables were assessed through canonical correspondence analysis (CCA) and partial CCA (pCCA) performed using CANOCO 4.5 software (ter Braak & Šmilauer 2002). All data were log-transformed (log x+1) to improve normality. To detect collinearity between explanatory variables, a forward selection was used (Borcard et al. 1992; Heikkinen et al. 2004), performed by the Monte Carlo permutation test (9999 permutations), which allowed the exclusion of variables that did not contribute significantly ($p < 0.05$) to the ordination pattern. Still, variance inflation factors for the explanatory variables were examined to detect collinearity.

According to Otýpková and Chytrý (2006), variation in plot size does also influence ordination patterns. Thus, to know and eliminate the effect of plot size variation in the studied communities, we introduced plot size as co-variable in the ordinations.

Variation partitioning has been proposed for spatial variation analysis with multivariate ecological data (Borcard et al. 1992; Borcard & Legendre 1994). In this study, variation partitioning was used to decompose the floristic variation among the two groups of predictors: environmental (E) and land use (LU). The pCCA was used to assess the relative contribution to each of the different sets of explanatory variables. It allows variance partitioning between several user-defined groups of predictor variables (two groups: Borcard et al. 1992; Heikkinen & Birks 1996).

Results

Classification and ordination of Helianthemion guttati *alliance*

Modified Twinspan classification showed five main distinct groups (Figure 2) which represent: (A) *Vulpia bromoides* communities (clusters 1–4); (B) *Trifolio cherleri-Plantaginetum bellardii* (clusters 5–8) and *Brachypodium distachyon* communities (clusters 9–19); (C) *Holco setiglumis-Anthoxanthetum aristati* made by Rivas Goday (1964) and Vicente Orellana and Galán de Mera (2008) (cluster 20); (D) *Paronychia cymosa-Micropyrum tenellum* communities (clusters 21–24 which include the association *Paronychio cymosae-Pterocephaletum diandri*); and (E) *Anthoxanthum aristatum-Micropyrum tenellum* communities (cluster 25–30). These groups reveal an altitude gradient from A to E. A phytosociological correspondence was established for each one of these groups which revealed that groups A and B match the *Helianthemenion guttati* suballiance, while the others match *Evacenion carpetanae*. Figure 3 displays the relationship between these groups and environmental and land use variables.

Some of the groups identified in Figure 2 did not match any phytosociological association, therefore, detailed analysis based on diagnostic species determination and biogeographical attributes led us to

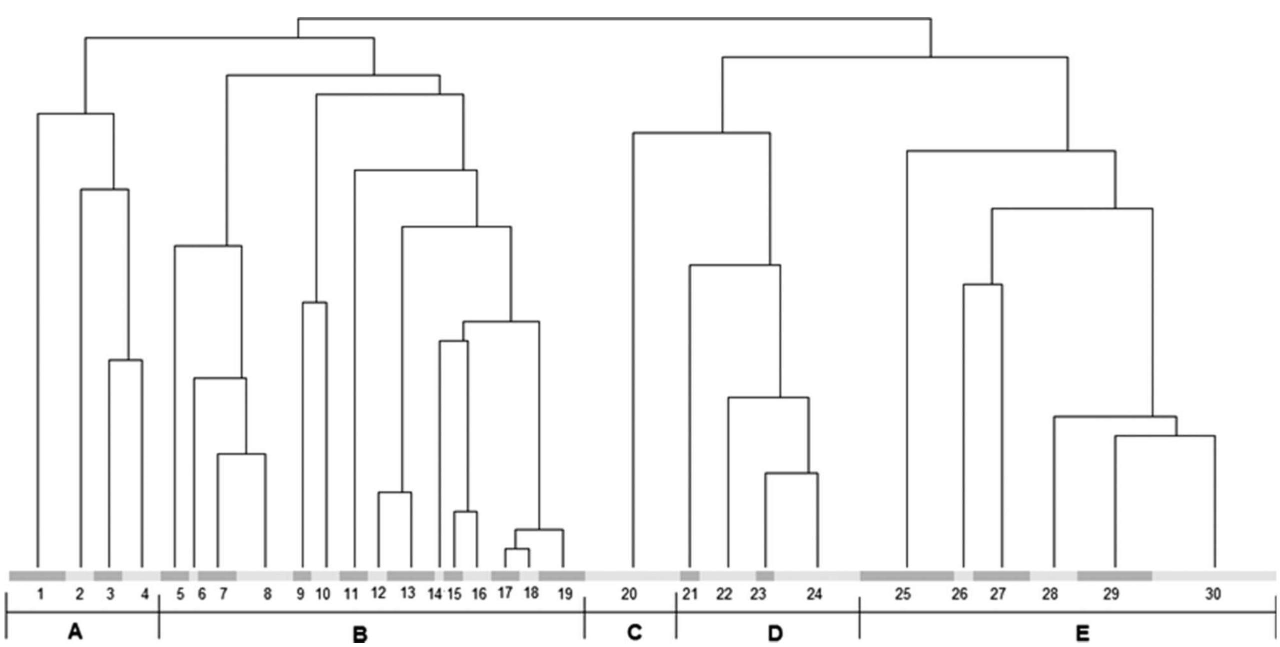


Figure 2. Modified TWINSPAN classification tree using average Jaccard dissimilarity (min. diss. 0.745).

propose four phytosociological new associations and a new subassociation (see synoptic Table I and phytosociological Tables I–IV in the Appendix I): *Holco-Brachypodietum distachyi* ass. nova hoc loco, *Holco-Micropyretum tenellae* ass. nova hoc loco, *Micropyro-Anthoxanthetum aristati* ass. nova hoc loco and *Leontodonto-Vulpietum bromoidis* ass. nova hoc loco *vulpietosum membranaceae* subass. nova hoc loco. Species are sorted by decreasing percentage species frequencies. An alphabetical list of abbreviated *taxa* is listed here and in the phytosociological tables is shown in Appendix II.

Relationship between species composition data and environmental and land use variables

Floristic and ecological patterns in *Helianthemion guttati* and *Poa bulbosa* communities were identified through CCA. In these grasslands, the plot size variation was less than 10; therefore, its influence on ordination patterns was negligible and there were no changes in the patterns of ecological communities such as tested by Otýpková and Chytrý (2006).

Following the Monte Carlo permutation test ($p < 0.05$), only environmental and land use variables such as altitude, pH, granite, fine texture, soil humidity, soil tillage, *rañas*, grazing (sheep) and N, NE, NW aspect were selected as key variables that better explain the ordination model.

The CCA ordination diagram (Figure 3) shows the relationship between the groups obtained previously by the modified TWINSPAN classification and the selected environmental and land use variables. Mesomediterranean associations are related to higher altitude and lower human influence, whereas thermomediterranean associations are related to lower altitude and higher human influence.

Axis 1 separates communities that occur at lower altitude (*Trifolio-Plantaginetum bellardii*, *Holco-Brachypodietum distachyi* ass. nova hoc loco, *Holco-Micropyretum tenellae* ass. nova hoc loco) from the others. Axis 2 represents a humidity gradient that separates the associations *Holco-Anthoxanthetum aristati*, *Leontodonto-Vulpietum bromoidis* ass. nova hoc loco and *vulpietosum membranaceae* subass. nova hoc loco from others that are not linked to soil humidity.

The new associations and subassociation proposed are described below.

*1-*Leontodonto longirostris-Vulpietum bromoidis *ass. nova hoc loco (Appendix I, Table I:* typus *relevé 126)*

This association is dominated by *V. bromoides* and co-dominated by *Leontodon longirostris*. It occupies sandy soils derived from granite substrata or alluvial humid soils, supporting crops at intervals of less than 5 years and extensive grazing (sheep). It occurs on the climatic domain of *Sanguisorbo agrimonoidis-Querco suberis S.* and *Arbuto unedonis-Querco pyrenaicae S.* in the Lusitanian-Extremadurean subprovince. When unconsolidated sandy soils have a fine texture on low altitudinal territories of the Tagus and Guadiana basins, some characteristic *taxa* of *Malcolmietalia* occur that allow us to distinguish a new subassociation, the ***vulpietosum membranaceae* subass. nova hoc loco** (Appendix I, Table I, *typus* relevé 138). The Iberian endemism *Rumex hispanicus* is one of the diagnostic species of this subassociation. These communities do not correspond with any of the Natura 2000 network natural habitats.

Holco annui-Brachypodietum distachyi *ass. nova hoc loco (Appendix I, Table II:* typus *relevé 76)*

B. distachyon is the dominant species and the main diagnostic species in this association. It is distributed in thin soils (leptosols), derived from schist, with a shallow sandy or sandy loam texture, with low acidity, in the lower to upper mesomediterranean and upper thermomediterranean thermotypes on the territory of *Pyro bourgaeanae-Querco rotundifoliae S.* It also occupies very reliquial potential areas of *Sanguisorbo agrimonoidis-Querco suberis S.*, in the Lusitanian-Extremadurean subprovince. The variant with *P. bulbosa* occurs more frequently on the clearings of *Cistus ladanifer* communities, on compact soils rich in gravel. These communities support extensive grazing (sheep), though their pastoral interest is low. They do not correspond with any of the Natura 2000 network natural habitats.

3-Holco annui-Micropyretum tenellae ass. nova hoc loco (Table III of the appendix I, *typus* relevé 104)

This association concerns grasslands dominated by *Micropyrum tenellum* that occupies extensive areas of *rañas* and very rocky sandy soils, as a substitution stage of *Sanguisorbo agrimonioidis-Querco suberis S.* in the Beirense Meridional and Alentejano districts of the Lusitan-Extremadurean subprovince. Its ocurrence is related to very oligotrophic soils without extensive grazing. It does not correspond with any of the Natura 2000 network natural habitats.

4-Micropyro tenellae-Anthoxanthetum aristati ass. nova hoc loco (Table IV of the appendix I, *typus* relevé 10)

Anthoxanthum aristatum and *Microprum tenellum* dominate this association, whereas *Ornithogalum broteroi* and *Ornithogalum conccinum* are the main diagnostic species. It occupies interstices with sand and gravel between rock granite and schist outcrops. The texture can range from fine to coarse sand in the clearings of *Cistus ladanifer* or *Cytisus* spp.

Table I. Synoptic table of *Helianthemion guttati* associations and their variants. Diagnostic species with significant fidelity are marked (p <0.05 *).

Community type	1	2	3	4	5	6	7	8	9	10
Number of relevés	9	7	8	10	11	11	6	11	24	10
Characteristics and differentials of associations										
Vulpia bromoides	V*	V*	I	.	I	II	.	I	II	.
Leontodon longirostris	III	V	IV	IV	III	I	II	I	I	.
Ornithopus compressus	II	V	IV	III	III	I	.	I	II	I
Vulpia membranacea	.	V*	.	.	.	.	.	.	.	.
Rumex hispanicus	.	V*	.	.	.	.	.	.	.	.
Brassica barreleri	.	V*	.	.	.	.	.	.	.	.
Plantago bellardii	.	.	V	II	II	I	.	I	I	.
Trifolium cherleri	.	.	II*	I	I	.	.	.	.	.
Brachypodium distachyon	.	.	I	V*	V*	.	.	.	.	.
Holcus annuus	III	.	.	V	III	V	III	V	.	I
Anthoxanthum aristatum	III	II	I	.	I	V	.	I	IV	IV
Ornithogalum pyrenaicum	.	.	.	.	.	II*	.	.	.	.
Paronychia cymosa	.	.	.	I		I	V*	I	.	.
Micropyrum tenellum	.	.	.	.		III	IV	V*	IV	V
Sedum album	.	.	.	.	.	.	.	.	III	IV*
Ornithogalum broteroi	.	.	.	.	.	.	.	.	III*	I
Ornithogalum conccinum	.	.	.	.	.	.	.	.	II	III*
Arnoseris minima	.	.	.	.	.	.	.	.	III	III
Briza maxima	II	III	I	III	V	III	IV	V	I	I
Tolpis barbata	II	II	IV	III	II	V	IV	II	I	I
Tuberaria guttata	II	III	V	IV	IV	I	III	IV	II	II
Hypochoeris glabra	I	II	I	I	I	.	.	I	III	III
Aira caryophyllea	.	.	I	II	II	II	II	III	I	.
Logfia minima	.	.	I	I	I	.	II	I	III	II
Ornithopus pinnatus	.	II	II	.	I	I	I	I	I	.
Teesdalia nudicaulis	.	I	I	.	I	I	IV	I	I	.
Hymenocarpus lotoides	.	I	II	III	I	.	.	I	I	.
Jasione montana	.	.	.	II	II	III	IV	III	I	.
Lathyrus angulatus	II	I	.	I	I	.	.	I	.	I
Airopsis tenella	.	.	.	I	I	I	I	I	.	.
Psirulus incurvus	.	.	.	I	.	I	I	I	.	.
Rumex gallicus	II	I	.	.	.	II	.	I	.	.
Molineriella laevis	II	III	I	.	.	II	.	.	.	.
Trifolium campestre	.	.	I	II	.	III	.	.	.	.
Coronilla dura	.	.	I	II	.	.	.	.	.	.
Silene portensis	.	.	.	I	I	.	.	I	.	.
Trifolium bocconei	.	.	III	.	.	.	.	.	.	.
Trifolium striatum	.	.	.	I	.	.	.	.	.	.
Characteristics of *Poetea bulbosae*										
Poa bulbosa	.	.	III	I	V	I	.	I	I	V
Erodium bothrys	.	.	.		I	.	.	.	I	I
Romulea bulbocodium	.	.	.		I	.	.	I	.	II
Trifolium subterraneum	.	.	I		I	.	.	.	.	.
Gynandriris sysirinchium	.	.	.	II	I	.	.	.	.	.
Parentucellia latifolia	.	.	.		I	.	.	.	.	.
Bellis annua	.	.	.		I	.	.	.	.	.
Others with higher frequency than 10%										
Plantago coronopus	II	V	V	I	I	.	II	II	I	I
Rumex angiocarpus	I	III	.	.	I	II	.	I	I	I
Vulpia myurus	I	I	I	I	II	I	.	.	I	I
Agrostis castellana	II	.	.	I	.	IV	II	.	I	I
Chamamaelum mixtum	II	IV	I	.	.	I	.	.	I	.
Crepis capillaris	II	I	.	I	.	II	.	I	I	.
Sesamoides purpurascens	.	.	I	I	I	I	II	II	I	.
Andryala integrifolia	I	I	.	I	.	I	.	I	.	.
Gaudinia fragilis	I	I	I	I	I	I	.	.	.	.
Logfia gallica	I	I	I	.	I	.	I	I	.	.

(*Continued*)

Table I. (*continued*)

Community type	1	2	3	4	5	6	7	8	9	10
Number of relevés	9	7	8	10	11	11	6	11	24	10
Plantago lagopus	I	I	I	.	II	I	.	.	.	.
Spergula arvensis	II	I	.	.	.	I	.	.	I	I
Avena barbata	II	III	II	II	III	.	.	.	.	.
Bromus hordeaceus	II	I	.	I	.	I	.	.	.	.
Cynosurus echinatus	I	I	.	.	.	III	.	I	.	.
Vulpia geniculata	I	.	II	I	I	.	.	I	.	.
Agrostis pourretii	I	.	.	.	.	I	.	.	I	.
Agrostis truncatula	.	.	.	.	.	.	I	I	I	.
Allium pruinatum	.	.	.	.	I	.	.	I	.	.
Allium sphaerocephalon	.	.	.	.	.	I	.	I	.	I
Centaurium erythraea	.	.	.	.	I	.	.	I	.	.
Coleostephus myconis	I	.	.	.	I	.	.	I	.	.
Crucianella angustifolia	I	.	.	.	I	.	.	I	.	.
Euphorbia exigua	.	.	I	I	I	.	.	I	.	.
Herniaria glabrescens	.	.	I	.	I	.	.	.	I	.
Hypochoeris radicata	II	.	.	.	.	.	I	.	I	.
Lolium rigidum	.	I	.	I	.	I	.	.	.	.
Muscari commosum	.	.	.	.	I	I	.	I	.	.
Ornithopus sativus	.	.	I	.	I	.	.	.	I	.
Raphanus raphanistrum	.	II	.	.	.	.	.	I	I	.
Sherardia arvensis	II	I	.	.	I	.	.	.	.	.
Silene gallica	I	II	.	.	.	I	.	.	.	.
Spergularia purpurea	.	II	.	.	.	.	.	.	I	I
Stachys arvensis	II	II	.	.	II	.	.	.	.	.
Trifolium arvense	.	.	I	I	I	I	.	.	.	.
Umbilicus rupestris	.	.	.	.	.	.	.	I	I	I
Vulpia ciliata	.	II	II	II	.	.	.	.	.	.
Vulpia muralis	.	.	.	I	II	I	.	.	I	.

Note: 1 – *Leontodonto longirostris-Vulpietum bromoidis* ass. nova; 2 – *Leontodonto longirostris-Vulpietum bromoidis* ass. nova *vulpietosum membranaceae* subass. nova; 3 – *Trifolio cherleri-Plantagintetum bellardii*; 4 – *Holco annui-Brachypodietum distachyi* ass. nova; 5 – *Holco annui-Brachypodietum distachyi* ass. nova var. with *Poa bulbosa*; 6 – *Holco setiglumis-Anthoxanthetum aristati* (Rivas Goday, 1964; Vicente Orellana & Galán de Mera, 2008); 7 – *Paronychio cymosae-Pterocephaletum diandri*; 8 – *Holco anuui-Micropyretum tenellae* ass. nova; 9 – *Micropyro tenellae-Anthoxanthetum aristati* ass. nova; 10 – *Micropyro tenellae-Anthoxanthetum aristati* ass. nova var. with *Poa bulbosa*

Species in two columns: *Arrhenatherum baeticum* 8: I, 9: I; *Bromus madritensis* 2: I, 4: I; *Carlina racemosa* 7: I, 9: *Chamaemelhum nobile* 3:I, 7: II; *Chamamaelum fuscatum* 1: I; 5: I; *Conopodium marianum* 5: II, 9: I; *Corrigiola litoralis* 2:II, 9: I; *Cynodon dactylon* 5: I; 9: I; *Dactylis hispanica* 4: I; 7: I; *Dipcadi serotinum* 4: I; 9: I; *Echium plantagineum* 1: II; 5: I; *Erodium cicutarium* 8: I, 9: I; *Evax pygmaea* 3: I, 4: I; *Hedypnois cretica* 2: II; 9: I; *Hyacinthoides hispanica* 1: II; 8: I; *llecebrum verticillatum* 6: IV, 9: I; *Juncus capitatus* 6: II; 7: I; *Lotus hispidus* 1: I, 4: I; *Lupinus luteus* 2: I, 6: I; *Raphanus microcarpum* 1: II, 2: I; *Sanguisorba verrucosa* 4: I; 7: I; *Sedum brevifolium* 8: I, 9: I; *Sedum hirsutum* 8: I, 9: I; *Senecio minutus* 8: I, 9: I; *Trifolium stellatum* 3: III, 4: I.

Species in one column: *Aegilops triuncialis* 4: I; *Agrostis curtisii* 9: I; *Armeria transmontana* 8: I; *Arrhenatherum* album 7: I; *Arrhenatherum elatius* 7: I; *Briza minor* 5: I; *Bromus diandrus* 1: I; *Bromus lanceolatus* 5: II; *Bromus rigidus* 2: III; *Chaetopogon fasciculatus* 6: III; *Chamaemelum discoideum* 8: I; *Cytisus striatus* 8: I; *Filago pyramidata* 6: I; *Galium spurium* 4: I; *Holcus lanatus* 5: I; *Holcus mollis* 7: I; *Hypericum linarifolium* 7: I; *Jasione sessiflora* 9: I; *Juncus bufonius* 1: I; *Leucanthemospis flaveola* 8: I; *Linaria spartea* 2: II; *Lotus castellanus* 5: I; *Misopates orontium* 4: I; *Ornithogalum ortophyllum* 9: I; *Ornithopus perpusillus* 8: I; *Petrorhagia nanteulii* 5: I; *Phalaris coerulescens* 1: I; *Plantago afra* 4: I; *Rumex acetosa* 9: I; *Serapias lingua* 4: I; *Silene coutinhoi* 4: I; *Silene scabriflora* 2: II; *Stipa capensis* 4: I; *Taeniatherum caput-medusae* 4: II; *Trifolium angustifolium* 3: III: *Trifolium scabrum* 3: I:*Vicia tenuifolia* 5: I.

Frequency classes: V: 80–100% of the relevés, IV: 60–80%, III: 40–60%, II: 20–40%, I: 10–20%.

communities, especially in the Carpetan-Leonese subprovince but less frequently in the Lusitan-Extremadurean subprovince. It occupies territories of *Arbuto-Querco pyrenaicae S.* and *Sanguisorbo agrimonoidis-Querco suberis S.* Therefore, the variant with *P. bulbosa* spreads on more compact soils with a high bryophyte frequency. The *Micropyro tenellae-Anthoxanthetum aristati* ass. nova hoc loco does not correspond with any of the Natura 2000 network natural habitats.

Trachynion distachyae *alliance*

Relevés of calcareous therophytic grasslands only configure the association *Velezio rigidae-Astericetum aquaticae* (Appendix I, Table V). This association corresponds with habitat 6220 (subtype 3) of the Natura 2000 network natural habitats. Its occurrence is related to extensive grazing (sheep and cow), though its pastoral interest is low. In the researched area, the most characteristic species are: *B. distachyon*, *Lomulosia simplex* and *Ononis pubescens*.

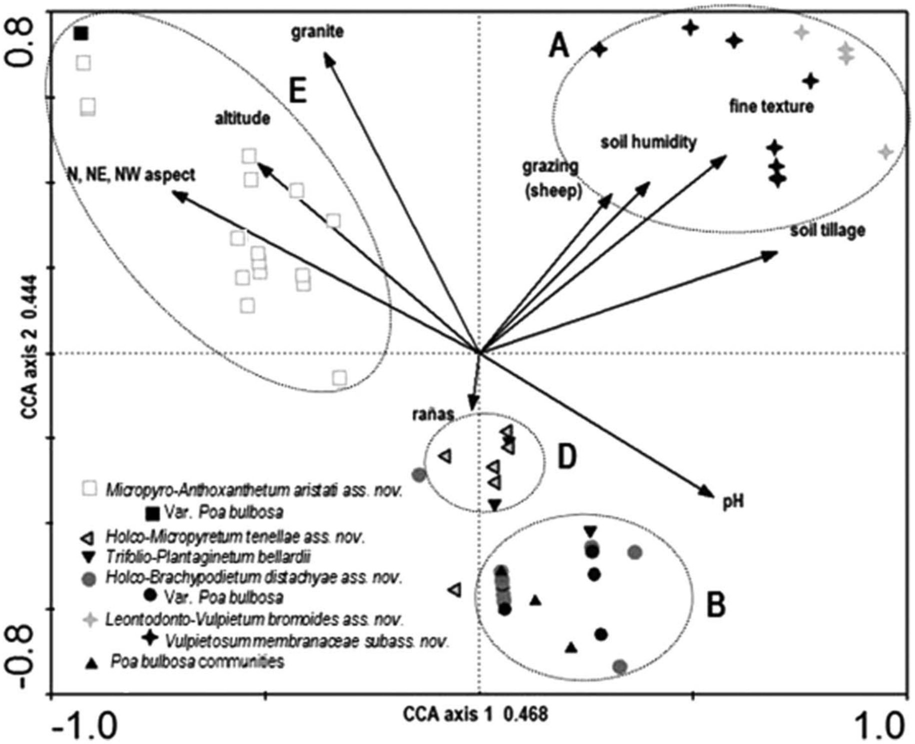


Figure 3. Canonical correspondence analysis (CCA). Biplot with samples and environmental and land use variables was selected using the Monte Carlo permutation test ($p < 0.05$). A, B, D and E: groups of modified TWINSPAN classification.

This habitat subtype occurs as a mosaic with communities of *Brachypodietalia phoenicoidis* or *Stipo giganteae-Agrostietea castellanae*. There are many other communities, subtypes and types of habitats that are associated or in contact with *B. distcahyon* communities. For example, when these communities are subjected to excessive grazing pressure or to some tillage, many nitrophilous species of *Stellarietea mediae* will appear in their floristic composition. Moreover, in the territory studied, when grazing pressure is moderate or when the soils are more compact, a transition to *Poetea bulbosae* communities will occur. In fact, *Velezio rigidae-Astericetum aquaticae* forms a mosaic with subtype 2 (*Poetalia bulbosae*), although the latter has a strict dependence on intense livestock grazing (San Miguel 2008). These annual basophilous grasslands also coexist as a mosaic with perennial habitats, mainly with habitat 6310 (Dehesas with evergreen *Quercus* spp.), habitat 9320 (*Olea* and *Ceratonia* forests) and habitat 9340 (*Quercus ilex* and *Quercus rotundifolia* forests). Therefore, habitat type 6220 is the last vegetation substitution stage of 9320 and 9340 habitats on base-rich soils.

Partitioning the variance of species composition

The units that were recognized above were grouped according to similar environmental and management strata. Centroides of these groups were submitted to a CCA. Seven variables were admitted in the forward selection by the Monte Carlo Permutation test ($p < 0.05$) on CCA ordination: alluvial, calcareous, granite, fine texture, (N, NE, NW) aspect and grazing (sheep). Correlations of these variables with axis 1 and axis 2 are presented in Table II. The first two axes of the CCA explain 25.5% of species variation that are explained in 56.9% of the environmental and land use variables.

In variation partitioning, the largest fractions were obtained through the pure effect of environmental variables (39.27%). On the other hand, pCCA of pure effect of land use variables explained only 5.05% of the total explained variance, while the joint effect of environmental and land use variables accounted for 0.01%. The total variation amount, explained by environmental and land use variation and their combined effects, is 44.33% (Figure 4).

The variance accounted for environmental and land use variables combined is much smaller than pure environmental and land use influence. This means that the two sets of variables are largely independent in explaining floristic composition, and each set of variables is largely explained by specific aspects of species composition variation. Therefore, the low variance accounted for by the pure effect of land use variables suggests that *H. guttati* communities do not support high anthropogenic pressure.

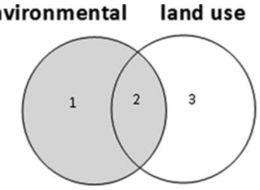
The pCCA biplots allow us to visualize the main environmental gradients underlying floristic composition. The pCCA biplots representing pure environmental and pure land use components (Figure 5) reveal that pCCA axis 1 of the pure environmental component is positively correlated with calcareous substrata, showing a gradient from basic to acid soils. Those substrata are not extensively grazed, but they are submitted to frequent soil tillage and crops.

Discussion

Few studies have been published on the influence of ecological gradients and land use on floristic patterns of therophytic grasslands in Continental Portugal. In *Helianthemion guttati* grasslands, our study allowed us to identify five main floristic groups that were related to 11 community types, of which five did not have any phytosociological correspondence. Thus, based on diagnostic species and ecological gradients, four new associations and one new subassociation were proposed and described. Ordination revealed that the main environmental factors are related to altitude, pH, granite, fine soil texture, soil humidity, *rañas*, and N, NE, NW aspect variables. In fact, the differentiation between the various associations described can be explained by both ecological and biogeographical factors. Thus, the *Holco annui-Brachypodietum distachyi* ass. nova hoc loco has more affinity with mesomediterranean and upper thermomediterranean thermotypes in the Lusitan-Extremadurean subprovince, in compact soils with low acidity. Otherwise, on more acid soils in this territory, the *Trifolio-Plantaginetum bellardii* association occurs. In the same subprovince, we can find the *Leontodonto longirostris-Vulpietum bromoidis* ass. nova hoc loco but only in mesomediterranean thermotype, in moist, very fine textured soil, especially in alluvial terraces. Moreover, limited to Beirense Meridional and Alentejano districts, in very rocky dry sandy soils, and again only in mesomediterranean thermotype, the *Holco annui-Micropyretum tenellae* ass. nova hoc loco develops, which does not spread in the Carpetan-Leonese subprovince. However, at higher elevations and with rainfall the *Micropyro tenellae-Anthoxanthetum aristati* ass. nova hoc loco extends to this subprovince, mainly in N, NE, NW slopes.

Table II. Correlations of preditor variables with axis 1 and axis 2.

Variables	Axis 1	Axis 2
Environmental		
fine texture	−0.0772	−0.1296
alluvial	−0.1231	−0.1063
calcareous	0.9150	0.3734
granite	−0.6175	0.6533
N, NE, NW aspect	−0.4599	0.7412
Land use		
grazing	−0.1905	−0.1586



Number	Contribution to total variance (%)	Source of Explained Variance
1	39.27	Pure environmental
2	5.05	Pure land use
3	0.01	Shared environmental + land use
∑	44.33	Total explained

Figure 4. Results of variance partitioning. The contribution of each set of selected variables ($p < 0.05$) was obtained by partial canonical correspondence analysis (pCCA).

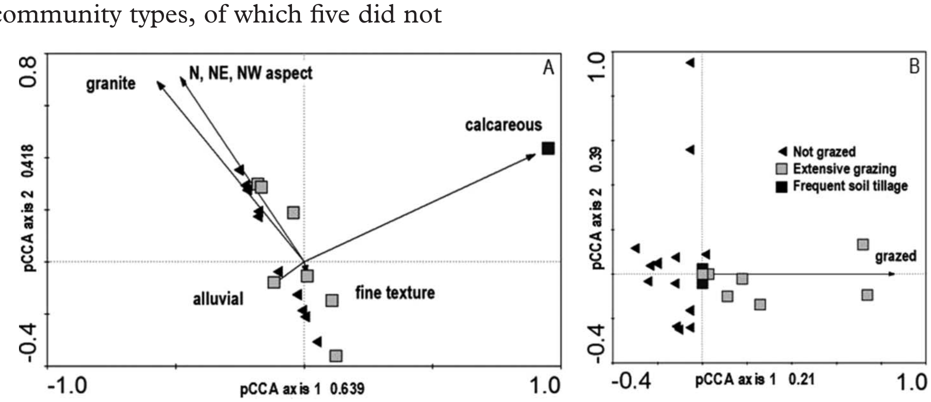


Figure 5. Ordination biplots based on partial CCA (pCCA) of floristic composition representing pure environmental (A) and pure land use (B) components.

Some other communities of *Helianthemion guttati* have been described before in the studied territory, but they were not surveyed. These communities were: *Airo praecocis-Radioletum linoidis* Rivas Goday 1958; *Anthoxantho aristati-Micropyretum patentis* Belmonte & Sanchez-Mata in Sanchez-Mata 1989; *Lupino rothmaleri-Ornithopetum isthmocarpae* Rivas Goday 1958 and *Periballio minutae-Airopsietum tenellae* Rivas Goday 1958.

Airo praecocis-Radioletum linoidis is an association that occupies sandy–loamy soils in mountain areas which are in transition to communities of *Isoeto-Nanojuncetea*. *Ornithopus perpusillus*, a characteristic differential of mountain areas, is dominated by *Radiola linoides* with *Aira praecox* and *Airopsis tenella* as companion species (Rivas Goday 1964).

Anthoxantho aristati-Micropyretum patentis, dominated by *Micropyrum patens,* spreads across the Carpetan-Leonese subprovince in superficial siliceous soils (Belmonte López 1986).

Lupino rothmaleri-Ornithopetum isthmocarpae, an association that occupies siliceous sandy soils derived from granites, includes *Lupinus hispanicus* and *Ornithopus isthmocarpus* in the combination characteristic species.

Periballio minutae-Airopsietum tenellae is an association of small therophytes (dominated by *Airopsis tenella* and *Molineriella minuta*) with low abundance, occupying sandy soils (Rivas Goday 1964).

None of the associations mentioned above corresponds to any of the new syntaxa proposed, neither from a floristic nor an ecological point of view.

Although *Helianthemion guttati* communities did not match any of the Natura 2000 network natural habitats, we consider the variant of *Holco annui-Brachypodietum distachyi* ass. nova hoc loco with *P. bulbosa* included in subtype 2 of the 6220 habitat, since *P. bulbosa* is abundant.

Relevés of basic soils corresponded phytosociologically to *Velezio-Astericetum aquaticae* and also to 6220 habitat (subtype 3) of the Natura 2000 network. Its ocurrence in the studied territory was not very frequent and it was subjected to moderate agricultural practices as well as grazing with sheep and cows.

Variation partitioning revealed that only a small fraction of variation can be explained by land use factors, and that environmental components had an important role in the floristic composition patterns of the studied grasslands. However, a moderate amount of unexplained variance was obtained, which is a common finding in ordination models (Økland 1999), possibly because of unmeasured non-spatial explanatory variables. Other explanations could be the lack of record of environmental variables on a small scale (Rosenzweigh 1997) and/or the dispersal strategies of plants.

The associations more closely linked to extensive grazing were *Leontodonto-Vulpietum bromoidis* ass. nova hoc loco, *Holco-Brachypodietum distachyi* ass. nova hoc loco and *Trifolio-Plantaginetum bellardii*, suggesting that slightly extensive grazing on these communities would not significantly affect their floristic patterns. In addition, low periodicity soil tillage did not seem to significantly affect their floristic patterns either. This seems to confirm that these traditional activities, when performed in moderation, contribute to the maintenance of plant diversity, by decreasing the competitive dominant species (Collins et al. 1998; Olff & Ritchie 1998).

According to Dutoit et al. (2005), Hodgson et al. (2005), Römermann et al. (2005) and San Miguel (2008), we must take into account that in habitat type 6220, floristic patterns will suffer loss of biodiversity if there is an intensification of either agricultural or pastoral activities or alternatively their abandonment. Abandonment of traditional management activities would lead to natural plant succession, resulting in the substitution of these communities by perennial grasslands or shrub communities. On the other hand, maintaining and managing a landscape mosaic may be sustainable, where *T. distachyae* communities may occupy patches adjacent to croplands, playing their environmental role (San Miguel 2008).

Climate change, if resulting in a slight temperature increase within the summer drought period, may expand habitat type 6220 community areas (Mannetje 2006). The strategies identified by Grime (1974, 1977, 1979, 2002) and Grime et al. (1988) and tested by Madon and Médail (1997) could justify the expansion expected for these communities.

Syntaxonomical typology

New syntaxa were named according to the International Code of Phytosociological Nomenclature (ICPN), 3rd edition (Weber et al. 2000).

Helianthemetea guttati (Br.-Bl. *in* Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963
(=*Tuberarietea guttatae* (Br.-Bl. *in* Br.-Bl., Roussine & Nègre 1952) Rivas Goday & Rivas-Martínez 1963 em. Rivas-Martinez 1978 nom. mut. propos.)
Helianthemetalia guttati Br.-Bl. *in* Br.-Bl., Molinier & Wagner 1940
(=*Tuberarietalia guttati* Br.-Bl. *in* Br.-Bl., Molinier & Wagner 1940 em. Rivas-Martinez 1978 nom. mut. propos.)
Helianthemion guttati Br.-Bl. *in* Br.-Bl., Molinier & Wagner 1940
(=*Tuberarion guttatae* Br.-Bl. *in* Br.-Bl., Molinier & Wagner 1940 nom. mut. propos.)
Helianthemenion guttati Rivas-Martínez 1978
(=*Tuberarienion guttatae* Rivas-Martínez 1978 nom. mut. propos.)

Holco annui-Brachypodietum distachyi ass. nova hoc loco
var. with *Poa bulbosa*
Leontodonto longirostris-Vulpietum bromoidis ass. nova hoc loco
vulpietosum membranaceae subass. nova hoc loco
Lupino rothmaleri-Ornithopetum isthmocarpae Rivas Goday 1958
Trifolio cherleri-Plantaginetum bellardii Rivas Goday 1958
Evacenion carpetanae Pérez Prieto & X. Font. 2005
Airo praecocis-Radioletum linoidis Rivas Goday 1958
Anthoxantho aristati-Micropyretum patentis Belmonte & Sanchez-Mata in Sanchez-Mata 1989
Holco setiglumis-Anthoxanthetum aristati Rivas Goday 1958
Holco annui-Micropyretum tenellae ass. nova hoc loco
Micropyro tenellae-Anthoxanthetum aristati ass. nov. hoc loco
var. with *Poa bulbosa*
Paronychio cymosae-Pterocephaletum diandri Rivas Goday 1958 corr. Rivas-Martínez 1978
Periballio minutae-Airopsietum tenellae Rivas Goday 1958
Trachynietalia distachyae Rivas-Martínez 1978
(=*Brachypodietalia distachyi* Rivas-Martínez 1978 nom. mut. propos.)
Trachynion distachyae Rivas-Martínez 1978
(=*Brachypodion distachyi* Rivas-Martínez 1978 nom. mut. propos.)
Velezio rigidae-Asteriscetum aquaticae Rivas Goday 1964

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Appendix I: Phytosociological tables

Table I. *Leontodonto longirostris-Vulpietum bromoidis* ass. nova hoc loco; 10–16: *vulpietosum membranaceae* subass. nova hoc loco (*Helianthemetea guttati, Helianthemetalia guttati, Helianthemion guttati, Helianthemenion guttati*).

No. of relevés	1111111111111111
	3332223224443334
	2138670954217893
No. of reference	1234567891111111
	0123456
Altitude (m)	3331223372333333
	5566661138115556
	9901114445559991
Area (m2)	4444444444444444
No. of species	9898191912111111
	5 0 3223948
Characteristic combination	
Vulpia bromoides	5555555532244433
Leontodon longirostris	21..1....1212212
Ornithopus compressus	....2..2112111.1
Anthoxanthum aristatum	23+....1..2....+
Briza maxima	......++2...+11.
Molineriella laevis	....22....r+...+
Tolpis barbata	.+2+.........+1.
Tuberaria guttata	......22....+11.
Lathyrus angulatus	....111......+..
Hypochoeris glabra	+........1.....+
Rumex gallicus	....+1...2......
Logfia gallica	...+.....1......
Ornithopus pinnatus	..........32....
Silene scabriflora	..............+.+
Vulpia myurus	........2......+
Teesdalia coronopifolia	.......1........
Crucianella angustifolia	........1.......
Hymenocarpus lotoides	.........1......
Teesdalia nudicaulis	..............1.
Differential species of subass.	
Vulpia membranacea	3332244
Brassica barreleri	.........211+++2
Rumex hispanicus	.........211+1++
Other species	
Plantago coronopus	+...+....221++1+
Avena barbata	1+.+.....1..+++.
Chamaemelum mixtum	...2....++..++++
Holcus annuus	+++2..+.........
Raphanus raphanistrum	....2+...+++....
Bromus hordeaceus	..++..+......+..
Crepis capillaris	......+++....+..
Rumex angiocarpus	2........+++....
Stachys arvensis	....++...+...+..
Agrostis castellana	......++2.......
Bromus diandrus	1...++..........
Bromus rigidus	.............++.+
Silene gallica	........++..+...
Spergula arvensis	....+2.....+....
Sherardia arvensis	.+....+......+..
Andryala integrifolia	........+1......
Cynosurus echinatus	........2...+...
Corrigiola litoralis	...........1..+.
Echium plantagineum	....11..........
Gaudinia fragilis	..+............+
Hedypnois cretica	.........+...+..
Hyacinthoides hispanica	......++........
Hypochoeris radicata	+..+............
Linaria spartea	..............+.1
Plantago lagopus	........++......
Spergularia purpurea	.........+.....+
Celtica gigantea	.+............+.
Vulpia ciliata	.........2.....+

Species with 1 occurence: *Coleostephus myconis* 3: +; *Phalaris coerulescens* 3: +; *Vulpia geniculata* 3: +; *Agrostis pourretii* 4: 2; *Chamaemelum fuscatum* 6: 1; *Juncus bufonius* 6: +; *Lotus hispidus* 6: +; *Bromus madritensis* 10: +; *Lolium rigidum* 16: +; *Lupinus luteus* 10: +.
Localities: 1, 2, 11 to 15 – Escalos de Baixo; 3 – Nisa; 4 – N. Sra dos Remédios; 5, 6 – S. Miguel D' Acha; 7, 8 – Cafede; 9 – Portalegre; 10 – Arez; 16 – Alcains.

Table II. *Holco annui-Brachypodietum distachyi* ass. nova hoc loco; var. with *Poa bulbosa* (13–24) (*Helianthemetea guttati, Helianthemetalia guttati, Helianthemion guttati, Helianthemenion guttati*).

No. of relevés	655775775556666667776567
	978219464231065323704675
No. of reference	123456789111111111122222
	012345678901234
	121323132222112222112112
Altitude (m)	888560392111446688639436
	026546547333114450156114
Area (m^2)	444444444444444444444444
No. of species	118111119699117122119111
	12 05442 34 14122 412
Characteristic combination	
Brachypodium distachyon	445555445544443555443545
Leontodon longirostris	121..+11....1+...1+.1++2
Tuberaria guttata	21.11..1....++.12+.2.1.+
Hymenocarpus lotoides	....1.11...21+.1+++.1.+.
Briza maxima	1.21.2+....+1..11.+....+
Holcus annuus	..+11112....+..1+11.....
Plantago bellardii	22.+.+.2.....1..1.2..1.2
Tolpis barbata	++.112+1........21.....+
Ornithopus compressus	.1..11.1.....2..+11..11.
Aira caryophyllea	r+.....1.......+++.2...+
Trifolium campestre	......+.1.+..1..1+..+.+.
Jasione montana	.....++.......1+1..2....
Vulpia myurus	+...+........+..1..2.+..
Coronilla dura	1.....12....+....+......
Vulpia muralis	......+.......21......+1
Teesdalia coronopifolia	............+1.....+.1..
Hypochoeris glabra	........1......11.......
Lathyrus angulatus	.+..............+1......
Logfia minima	.....+...............+..
Trifolium cherleri	.2................1.....
Airopsis tenella	+.......................
Psirulus incurvus	+.......................
Paronychia cymosa	.+......................
Trifolium striatum	....+...................
Silene portensis	.................+......
Teesdalia nudicaulis	...........+............
Rumex gallicus	.........+..............
Differential species of var. with *Poa bulbosa*	
Poa bulbosa	244332122222
Gynandriris sysirinchium	......+1.+..1.........+2
Other species	
Avena barbata	+..1+...1..+.1.r++..1+..
Taeniatherum caput-medusae	....+...+.1.1...++...+..
Trifolium stellatum	.......1.....++2.1...2+.
Bromus lanceolatus	.........2+.2..+.....+..
Vulpia ciliata	.+..1......1....+..+....
Plantago afra	.2.........1.2...1.....2
Stipa capensis	.........+.+..21..+.....
Aegilops triuncialis	...1..2...........1...+.
Plantago lagopus	...............2++1.....
Vulpia geniculata	.......1........+.......
Centaurium erythraea	..........++............
Coleostephus myconis	...+...+................
Galium spurium	.1..................+...
Gaudinia fragilis	....++..................
Hypochoeris radicata	..............++........
Misopates orontium	....+..+................
Parentucellia latifolia	........+.........+.....
Sanguisorba verrucosa	..............++........
Sesamoides purpurascens	.....2..........1..+....
Stachys arvensis	............1....+......

Species with 1 occurence: *Bromus madritensis* 2: 2; *Crucianella angustifolia* 2: +; *Trifolium arvense* 2: +; *Crepis capillaris* 3: +; *Euphorbia exigua* 3: 2; *Silene coutinhoi* 3: 2; *Agrostis castellana* 4: +; *Lolium rigidum* 5: +; *Andryala integrifolia* 6: +; *Chamaemelum mixtum* 6: +; *Bromus hordeaceus* 7: +; *Serapias lingua* 9: +; *Ornithopus sativus* 12: +; *Plantago coronopus* 12: +; *Rumex angiocarpus* 12: +; *Allium pruinatum* 14: +; *Sherardia arvensis* 14: +; *Herniaria scabrida* 16: +; *Dactylis hispanica* 17: 3; *Erodium bothrys* 17:1; *Muscari commosum* 18: 2; *Romulea bulbocodium* 18.1; *Bellis annua* 20:1; *Dipcadi serotinum* 21: +; *Trifolium subterraneum* 22:2; *Silene scabriflora* 23: +; *Paronychia argentea* 24:2.
Localities: 1 – Vila Velha de Ródão; 2 – Toulões; 3, 20 – Castelo Branco (Ponsul); 4 – Mendares; 5, 18 – Monforte da Beira; 6 – Nisa; 7, 23 – Aljustrel; 8 – Perais; 9 – Castro Verde; 10 to 12, 21 – Rosmaninhal; 13, 14, 22 – Cegonhas; 15, 16, 24 – Almodôvar; 17 – Arez; 19 – N. Sra dos Remédios.

Table III. *Holco annui-Micropyretum tenellae* ass. nova hoc loco *(Helianthemetea guttati, Helianthemetalia guttati, Helianthemion guttati, Evacenion carpetanae)*.

No. of relevés	00111111111
	33000000000
	67792340658
No. of reference	12345678911
	01
Altitude (m)	22121112111
	15860085888
	55936690990
Area (m^2)	44664444444
No. Of species	11519718111
	11 2 6 301
Characteristic combination	
Micropyrum tenellum	43534455554
Briza maxima	1+1+2111+11
Holcus annuus	.111112211.
Tuberaria guttata	..211+2.221
Jasione montana	+1....+.221
Aira caryophyllea	11.1..+.1..
Tolpis barbata	......11+.1
Teesdalia coronopifolia	......+.1+.
Airopsis tenella	..1...1....
Lathyrus angulatus	++.........
Ornithopus compressus	.+......2..
Ornithopus pinnatus	........+.+
Paronychia cymosa	......+...1
Teesdalia nudicaulis	++.........
Anthoxanthum aristatum	1..........
Crucianella angustifolia	+..........
Hymenocarpus lotoides	....+......
Hypochoeris glabra	.......+...
Leontodon longirostris	...1.......
Logfia gallica	1
Logfia minima	....+......
Psirulus incurvus	........1..
Plantago bellardii	1
Rumex gallicus	......+....
Silene portensis	...2.......
Vulpia bromoides	......+....
Other species	
Sesamoides purpurascens	......2.222
Chamaemelum nobile	......+.1+.
Plantago coronopus	......+.++.
Rumex angiocarpus	...+.....+.

Species with 1 ocurrence: *Arrhenatherum album* 1: +; *Muscari commosum* 1: +; *Sanguisorba verrucosa* 1: +; *Andryala integrifolia* 2: +; *Cynosurus echinatus* 2: +; *Hypericum linarifolium* 2: +; *Allium sphaerocephalon* 4: +; *Poa bulbosa* 4: 2; *Romulea bulbocodium* 4: +; *Umbilicus rupestris* 4: +; *Agrostis truncatula* 5: +; *Allium pruinatum* 5: +; *Dactylis hispanica* 5: 1; *Carlina racemosa* 6: +; *Centaurium erythraea* 6: +; *Lupinus luteus* 6: 1; *Euphorbia exigua* 7: +; *Coleostephus myconis* 8: +; *Crepis capillaris* 8: +; *Raphanus raphanistrum* 8: +; *Vulpia geniculata* 9: +; *Juncus capitatus* 10: r.
Localities: 1, 2 – Taberna Seca; 3, 5 to 7, 9, 10 – Vila Velha de Ródão; 4 – Idanha-a-Velha; 8 – Nisa; 11 – N. Sra dos Remédios.

Table IV. *Micropyro tenellae-Anthoxanthetum aristati* ass. nova hoc loco; var. with *Poa bulbosa* (17–25) *(Helianthemetea guttati, Helianthemetalia guttati, Helianthemion guttati, Evacenion carpetanae)*.

No. of relevés	0000000000000000110000000010000
	2020221100300012111121299310103
	8314320121089790564376978305862
No. of reference	1234567891111111111222222222233
	0123456789012345678901
Altitude (m)	3323232233322233113337271916769
	1161666611666611113311611419194
	4414101144211155116644140105451
	00 0 0
Area (m^2)	2222222222222222222222222222222
No. of species	1978891118965776991118717191871
	2 101 033 1 3 3 1
Characteristic combination	
Micropyrum tenellum	4.3.2521123322121+2222441421344
Anthoxanthum aristatum	245442452544452.22441..4+245.51
Sedum album	13222221221.......121.22.......
Hypochoeris glabra	.....2.....+1+..1+..+...122+..1
Ornithogalum conccinum	+...+.........2212..+2+..+.+...
Ornithogalum broteroi	.222.21+...221........2........
Ornithopus compressus	.1.++.++.......2...++......r+..
Tuberaria guttata	.+.2...+..........+2.2..+.2.2..
Teesdalia coronopifolia	+1.........r2+......+.1...+...1
Briza maxima	......2+.++........+.......+.+.
Teesdalia nudicaulis	.2.+..+++2.....................
Tolpis barbata	......+++.1....................
Senecio minutus	+.....+.............+....1....2
Leontodon longirostris	..............22..............+
Vulpia bromoides	....+.....+...............2....
Vulpia myurus	.+.......................1.+...
Jasione montana	2.....+........................
Aira caryophyllea	........+......................
Ornithopus pinnatus	........+......................
Lathyrus angulatus	....................+..........
Plantago bellardii	..............2................
Vulpia muralis	.+.............................
Differential of var. with *Poa bulbosa*	
Poa bulbosa	1.........1..+..553343221..+...
Romulea bulbocodium	................22++...........
Other species	
Arnoseris minima	22.....+2.......++..+..112112+2
Logfia minima	+.......+.......++...2.+2222..r
Arrhenatherum baeticum	....++++..2.......11...........
Umbilicus rupestris	..+........+.+....++.......+...
Rumex angiocarpus	.+.+....2+...............2.....
Spergula arvensis	+..............2.....+.2....+..
Leucanthemospis flaveola	.........................2.+++.
Spergularia purpurea	..............12...+...+.......
Agrostis castellana	+...................+.........2
Armeria transmontana	...........................+.2+
Erodium cicutarium	.......................+.+....+
Jasione crispa	.....................+.....2+..
Plantago coronopus	...+....2..............2.......
Sedum brevifolium	.....................2.+...+...
Conopodium marianum	...........................2+..
Dipcadi serotinum	..................+1...........
Erodium bothrys	..........+.........1..........
Hyacinthoides hispanica	..2......................1.....
Hypochoeris radicata	....2.........+................
Jasione sessiflora	....
Ornithopus perpusillus	.........................+2....
Rumex acetosa	................++.............
Sedum hirsutum	.....2................1........
Sesamoides purpurascens	..+........................+...

Species with 1 ocurrence: *Arrhenatherum elatius* 6: 2; *Cytisus striatus* 6: 2; *Corrigiola litoralis* 11: +; *Illecebrum verticillatum* 19: +; *Raphanus raphanistrum* 20: r; *Ornithopus sativus* 30: +.
Localities: 1, 2, 4, 9, 10, 21 – Cafede; 3, 5, 7, 8, 12 to 14, 23, 34 – Idanha-a-Nova Dam; 4, 6, 11, 19, 20 – Nisa; 15, 16 – Escalos de Baixo; 17, 18, 22, 26 to 31 – Gardunha.

Table V. *Velezio rigidae-Astericetum aquaticae* Rivas Goday 1964 *(Helianthemetea guttati, Trachynietalia distachyae, Trachynion distachyae).*

No. of relevés	228999999
	991888888
	345123456
No. of reference	123456789
	112222222
Altitude (m)	990333333
	660222222
Area (m^2)	111111111
	222222222
No. Of species	871211117
	515326
Characteristic combination	
Brachypodium distachyon	554334215
Ononis pubescens	1.1222111
Atractylis cancellata	21..12542
Lomulosia simplex	1..12223+
Crupina vulgaris	..2212+1.
Linum strictum	..1+++++.
Astericus aquaticus	.r++...+.
Trifolium scabrum	.1+12+...
Euphorbia exigua	..++++...
Medicago minima	...11....
Trifolium stellatum	.+.+.....
Other species	
Aegilops geniculata	r2....22+
Raghadiolus stellatus	..+11.++.
Convolvulus arvensis	...+11...
Echinops strigosus	1...11...
Hedypnois cretica	..++...r.
Sherardia arvensis	..+++....
Tragopogon edulis	++......+
Aegilops triuncialis	......11.
Scorpiurus muricatus	......++.
Phalaris coerulescens	......++.
Anagallis arvensis	......1+.
Daucus crinitus	..++.....
Bromus lanceolatus	.......++
Stachys arvensis	..+....+.

Species with 1 ocurrence: *Taeniatherum caput-medusae* 1: +; *Daucus carota* 2: +; *Carlina corimbosa* 3: 1; *Medicago polymorpha* 3: 2; *Trifolium angustifolium* 3: +; *Trifolium lappaceum* 3: 2; *Carthamus lanatus* 4: +; *Gladiolus illyricus* 4: +; *Picris echioides* 4: +; *Plantago lagopus* 4: +; *Sanguisorba verrucosa* 4: +; *Teesdalia coronopifolia* 4: +; *Filago lutescens* 5: +; *Hordeum murinum* 5: 1; *Crucianella angustifolia* 6: +; *Nigella damascena* 6: 1; *Plantago afra* 6: +.
Localities: 1, 2 – Ouguela; 3 – Beringel; 4, 5 to 9 – Campo Maior.

Appendix II: Floristic appendix

An alphabetical list of abbreviated *taxa* present in the article and in the phytosociological tables is shown below.

Anthoxanthum aristatum: Anthoxanthum aristatum var. *aristatum*
Arrhenatherum baeticum: Arrhenatherum elatius subsp. *baeticum*
Arrhenatherum album: Arrhenatherum album var. *album*
Arrhenatherum elatius: Arrhenatherum elatius subsp. *elatius*
Asphodelus ramosus: Asphodelus ramosus subsp. *ramosus* var. *ramosus*
Astragalus pelecinus: Astragalus pelecinus subsp. *pelecinus*
Atractylis cancellata: Atractylis cancellata subsp. *cancellata*
Avena barbata: Avena barbata subsp. *barbata*
Avena lusitanica: Avena barbata subsp. *lusitanica*
Chamaemelum discoideum: Chamaemelum nobile var. *discoideum*
Chamaemelum nobile: Chamaemelum nobile var. *nobile*
Coronilla dura: Coronilla repanda subsp. *dura*
Crepis capillaris: Crepis capillaris var. *capillaris*
Crepis hanseleri: Crepis vesicaria subsp. *hanseleri*
Dactylis hispanica: Dactylis glomerata subsp. *hispanica*
Daucus maximus: Daucus carota subsp. *maximus*
Galium spurium: Galium aparine subsp. *spurium*
Gladiolus illyricus: Gladiolus illyricus subsp. *illyricus*
Herniaria glabrescens: Herniaria scabrida subsp. *sacabrida* var. *glabrescens*
Herniaria scabrida: Herniaria scabrida subsp. *sacabrida* var. *scabrida*
Holcus mollis: Holcus mollis subsp. *mollis*
Hordeum leporinum: Hordeum murinum subsp. *leporinum*
Jasione montana: Jasione montana var. *montana*
Leontodon longirostris: Leontodon taraxacoides subsp. *longirostris*
Leucanthemospis flaveola: Leucanthemospis flaveola subsp. *flaveola*
Lomelosia simplex: Lomelosia simplex subsp. *simplex*
Micropyrum tenellum: Micropyrum tenellum var. *tenellum*
Myosotis dubia: Myosotis discolor subsp. *dubia*
Narcissus bulbocodium: Narcissus bulbocodium subsp. *bulbocodium*
Narcissus pallidulus: Narcissus triandrus subsp. *pallidulus*
Ornithopus sativus: Ornithopus sativus subsp. *sativus*
Raphanus microcarpum: Raphanus raphanistrum subsp. *microcarpum*
Raphanus raphanistrum: Raphanus raphanistrum subsp. *raphanistrum*
Romulea bulbocodium: Romulea bulbocodium subsp. *bulbocodium*
Rumex acetosa: Rumex acetosa subsp. *acetosa*
Rumex angiocarpus: Rumex acetosella subsp. *angiocarpus*
Rumex gallicus: Rumex bucephalopharus subsp. *gallicus*
Rumex hispanicus: Rumex bucephalopharus subsp. *hispanicus*
Sanguisorba verrucosa: Sanguisorba minor subsp. *verrucosa*
Silene portensis: Silene portensis subsp. *portensis*
Silene scabriflora: Silene scabriflora subsp. *scabriflora*
Trifolium subterraneum: Trifolium subterraneum subsp. *subterraneum* var. *subterraneum*