

Article

Contribution to the Knowledge of Rocky Plant Communities of the Southwest Iberian Peninsula

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Abstract: The rocky habitats of southern Portugal are ecosystems with extreme xericity conditions, associated with special abiotic strains. In these unstable ecological conditions, a considerable diversity of plant communities occurs. The objective of this study, carried out in the Algarve and Monchique, and the Mariánica Range biogeographical sectors, is to compare chasmo-chomophytic communities of the southwestern Iberian Peninsula, using a phytosociological approach (Braun–Blanquet methodology) and numerical analysis (hierarchical cluster analysis). From these results, two new communities were identified, *Sanguisorbo rupicolae-Dianthetum crassipedis* and *Antirrhinetum onubensis*, as a result of floristic and biogeographical differences from other associations already described within the alliances *Rumici indurati-Dianthion lusitani* and *Calendulo lusitanicae-Antirrhinion linkiani*, both included in the *Phagnalo saxatilis-Rumicetea indurate* class.

Keywords: phytosociology; numerical analysis; *Phagnalo saxatilis-Rumicetea indurate* class; southern Portugal; *Dianthus crassipes*; *Antirrhinum onubensis*

1. Introduction

Habitats are very important natural or semi-natural places that need to be continuously studied to preserve them and their inhabitants, especially the plant endemic species that characterize them [1,2]. In fact, different habitats in the world are threatened by different types of pressures and threats [3–10]. Among the wide spectrum of habitats, we focus on plant communities that develop on rocky habitats, which are often associated with crests, cliffs, lithosols, rocky soils or rock outcrops. In these edaphoxerophilous biotopes that appear to be evidence of extreme xericity conditions, namely great edaphic drought as a result of the soil’s reduced capacity for water retention [5,11]. In fact, this environment offers the ideal conditions for a highly specialized type of vegetation: the chasmo-chomophytic communities, which encompass rupicolous vegetation that colonizes earthy broad crevices, rocky soils and lithosols (chomophytes) or narrow rocky fissures (chasmophytes).

The perennial chasmo-chomophytic communities of the southwestern Iberian Peninsula are included in the *Phagnalo saxatilis-Rumicetea indurati* vegetation class [12,13]. The

Phagnalo saxatilis-Rumicetalia indurati is the only order of this class and is further divided into six alliances in the Iberian Peninsula [13]. Because of the substrata nature given to the descriptions of the chasmo-chomophytic communities within the *Phagnalo saxatilis-Rumicetalia indurati* order, such as schist or greywackes, limestone and dolomite, Costa et al. [12] recognized the presence of two alliances in southern Portugal: *Rumici indurati-Dianthion lusitani*, which is ascribed to the communities developing on fissures of siliceous rocks of the West Iberian Mediterranean and Oroiberian territories, whereas the communities growing in the Dividing Portuguese Sector and Arrábida range (central and western Portugal), typically associated with limestone and dolomitic substrates, are classified within the *Calendulo lusitanicae-Antirrhinion linkiani* class.

The present paper aims to provide new knowledge of the chasmo-chomophytic communities of the southwestern Iberian Peninsula, included in the *Phagnalo saxatilis-Rumicetalia indurati* class. The phytosociological and syntaxonomical vegetation analysis of the chasmo-chomophytic communities dominated by *Dianthus crassipes* (*Rumici indurati-Dianthion lusitani* alliance) and *Antirrhinum onubensis* (*Calendulo lusitanicae-Antirrhinion linkiani* alliance) allow us to distinguish two new communities: *Sanguisorbo rupicolae-Dianthetum crassipedis* and *Antirrhinetum onubensis*.

2. Materials and Methods

2.1. Study Area

Located in the southwest of the Iberian Peninsula, the study area covers two distinct units: the first, in the southern part of the Algarve and Monchique biogeographical sector, encompasses the sub-littoral lower altitude reliefs of Algarve limestone—Barrocal algarvio (maximum 480 m high), where there is frequent presence of basic rocky outcrops. The second includes the schist, greywacke and quartzite cliffs of the low-altitude range (with an altitude of less than 400 m) of the lower Guadiana valley, in the southwestern part of the Mariánica Range Sector. According to the most recent study of Peninsula Iberica bioclimatic characterization by Rivas-Martínez et al. [14], the study area is classified as mediterranean pluviseasonal oceanic, dry to subhumid thermomediterranean bioclimate.

2.2. Data Collection

Field research was carried out from 2011 to 2020. Phytosociological relevés were collected according to the Zurich–Montpellier phytosociological method [12,13,15–17], where we found two new distinct associations in the Algarve and Monchique, and Mariánica Range biogeographical sectors (Figure 1), based on the comparison of the phytosociological relevés, performed in Table 1. Following Biondi [18], each relevé is a floristically and ecologically homogeneous plant community that represents the plant association on the ground. Within this definition, for each relevé, all plants that are found in an area whose floristic, structural and ecological conditions are homogeneous, were identified and assigned a quantitative value or index for their coverage, using the conventional abundance–dominance scale of Braun–Blanquet.

Table 1. Cont.

Association No.	1	2	3	4	5	6	7	8
Alliance, Order and Class Characteristics								
<i>Erysimum linifolium</i> Rivas Goday & Bellot	.	.	III	.	.	.	.	.
<i>Antirrhinum graniticum</i> Rothm.	.	.	III	I	.	.	.	.
<i>Sedum hirsutum</i> All.	.	.	III	.	V	III	.	.
Companions								
<i>Lavandula luisieri</i> (Rozeira) Rivas Mart.	IV	.	.	.	.	.	.	.
<i>Genista polyanthos</i> R. Roem. Ex Willk.	IV	.	.	.	.	.	.	.
<i>Cistus ladanifer</i> L.	IV	.	.	.	.	.	.	.
<i>Rosmarinus officinalis</i> L.	III	.	.	.	.	.	.	.
<i>Scilla autumnalis</i> L.	III	.	.	.	.	.	.	.
<i>Phlomis purpurea</i> L.	III	.	.	.	.	.	.	.
<i>Cheilanthes maderensis</i> Lowe	III	.	.	.	.	.	.	.
<i>Quercus rotundifolia</i> Lam.	II	.	.	.	.	.	.	.
<i>Polypodium interjectum</i> Shivas	II	.	.	.	.	.	.	.
<i>Leucosium autumnale</i> L.	II	.	.	.	.	.	.	.
<i>Campanula lusitanica</i> L.	II	.	.	.	.	.	.	.
<i>Cheilanthes guanchica</i> Bolle	II	.	.	.	.	.	.	.
<i>Pistacia lentiscus</i> L.	II	.	.	.	.	.	.	.
<i>Olea europaea</i> var. <i>sylvestris</i> (Mill.) Rouy ex Hegi	II	.	.	.	.	.	.	.
<i>Cosentinia vellea</i> (Aiton) Todaro	II	.	.	.	.	.	.	.
<i>Centaurea melitensis</i> L.	II	.	.	.	.	.	.	.
<i>Thymus mastichina</i> (L.) L.	III	II	.	.	.	.	.	.
<i>Dactylis hispanica</i> subsp. <i>lusitanica</i> (Stebbins & Zohary) Rivas Mart. & Izco	III	.	.	.	.	.	III	.
<i>Sedum forsterianum</i> Sm.	III	.	.	.	.	.	.	I
<i>Rhamnus oleoides</i> L.	II	III	.	.	.	.	.	.
<i>Hyparrhenia sinaica</i> (Delile) Llaurodó ex G. López	II	.	.	.	.	.	III	.
<i>Helichrysum stoechas</i> (L.) Moench	II	.	.	.	.	.	III	.
<i>Rhamnus alaternus</i> L.	II	.	.	.	.	.	.	I
<i>Umbilicus rupestris</i> (Salisb.) Dandy	III	II	IV	IV	V	III	.	.
<i>Prasium majus</i> L.	.	IV	.	.	.	.	.	.
<i>Asplenium petrarchae</i> (Guérin) DC.	.	IV	.	.	.	.	.	.
<i>Genista hirsuta</i> subsp. <i>algarbiensis</i> (Brot.) Rivas Mart. et al.	.	III	.	.	.	.	.	.
<i>Aristolochia baetica</i> L.	.	III	.	.	.	.	.	.
<i>Asparagus albus</i> L.	.	III	.	.	.	.	.	.
<i>Juniperus turbinata</i> Guss.	.	II	.	.	.	.	.	.
<i>Valantia hispida</i> L.	.	II	.	.	.	.	.	.
<i>Theligonum cynocrambe</i> L.	.	II	.	.	.	.	.	.
<i>Pistacia terebinthus</i> L.	.	II	.	.	.	.	.	.
<i>Elaeoselinum tenuifolium</i> (Lag.) Lange in Willk. & Lange	.	II	.	.	.	.	.	.
<i>Ceratonia siliqua</i> L.	.	II	.	.	.	.	.	.
<i>Campanula erinus</i> L.	.	II	.	.	.	.	.	I
<i>Sedum sediforme</i> Jacq.) Pau	.	IV	.	.	.	.	.	II
<i>Asplenium billotii</i> F.W. Schultz	.	.	IV	.	I	.	.	.
<i>Melica minuta</i> L.	.	IV	.	.	.	.	III	III
<i>Polypodium cambricum</i> L.	.	III	.	.	I	.	.	I
<i>Galium glaucum</i> subsp. <i>australe</i> L.	.	.	V	.	.	.	.	.
<i>Cheilanthes hispanica</i> Mett.	.	.	II	.	.	.	.	.
<i>Sanguisorba minor</i> Scop.	.	.	II	.	.	.	.	.
<i>Lavandula pedunculata</i> (Mill.) Cav.	.	.	II	.	.	.	.	.
<i>Isatis platyloba</i> Link ex Steud.	.	.	II	.	.	.	.	.
<i>Lactuca serriola</i> L.	.	.	II	.	.	.	.	.
<i>Linaria saxatilis</i> (L.) Chaz.	.	.	II	.	.	.	.	.
<i>Sedum album</i> L.	.	.	II	.	.	.	III	III
<i>Sesamoides purpurascens</i> (L.) G. López	.	.	.	IV	.	.	.	.
<i>Linaria nivea</i> Boiss. & Reuter	.	.	.	III	.	.	.	.
<i>Arrhenatherum elatius</i> subsp. <i>elatius</i> (L.) P. Beauv. ex J. Presl & C. Presl	.	.	.	III	.	.	.	.
<i>Allium scorzonerifolium</i> Desf.	.	.	.	II	.	.	.	.
<i>Bufonia macropetala</i> Willk.	.	.	.	II	.	.	.	.
<i>Hieracium castellanum</i> Boiss. & Reut.	.	.	.	II	.	.	.	.

Table 1. Cont.

Association No.	1	2	3	4	5	6	7	8
<i>Leucanthemopsis pallida</i> (Mill.) Heywood	.	.	.	I	.	.	.	.
<i>Asplenium septentrionale</i> (L.) Hoffm.	.	.	.	I	.	.	.	.
<i>Agrostis truncatula</i> Parl.	.	.	.	I	.	.	.	.
<i>Koeleria crassipes</i> Lange	.	.	.	I	.	.	.	.
<i>Jasione sessiliflora</i> Boiss. & Reut.	.	.	.	III	.	IV	.	.
<i>Biscutella valentina</i> (Loefl. ex L.) Heywood	.	.	.	III	.	.	.	IV
<i>Lactuca viminea</i> subsp. <i>chondrilliflora</i> Boreau	.	.	.	II	.	.	.	II
<i>Scrophularia canina</i> L.	.	.	.	II	.	.	II	.
<i>Polypodium vulgare</i> L.	.	.	.	I	.	III	.	.
<i>Sedum brevifolium</i> DC.	.	.	.	I	V	III	.	.
<i>Arrhenatherum elatius</i> subsp. <i>sardoum</i> (Em.Schmid) Gamisans	V	.	.	.
<i>Hypochaeris radicata</i> L.	V	.	.	.
<i>Armeria x francoi</i> J.C. Costa Capelo	IV	.	.	.
<i>Rumex acetosella</i> subsp. <i>angiocarpus</i> (Murb.) Murb.	II	.	.	.
<i>Pteridium aquilinum</i> L.	II	.	.	.
<i>Quercus pyrenaica</i> Willd.	I	.	.	.
<i>Calluna vulgaris</i> (L.) Huds.	I	.	.	.
<i>Micropyrum tenellum</i> (L.) Link.	I	.	.	.
<i>Festuca indigesta</i> Lag. x Lange	V	.	.
<i>Digitalis purpurea</i> L.	IV	.	.
<i>Juniperus communis</i> subsp. <i>alpina</i> (Suter) Celakn	IV	.	.
<i>Agrostis delicatula</i> Pourr. ex Lapeyr.	III	.	.
<i>Murbeckiella boryi</i> (Boiss.) Rothm.	III	.	.
<i>Phalacrocarpum oppositifolium</i> (Brot.) Willk.	III	.	.
<i>Micromeria juliana</i> (L.) Rchb.	IV	.
<i>Urginea maritima</i> (L.) Baker	III	.
<i>Carex hallerana</i> Asso	II	.
<i>Thymus sylvestris</i> Hoffmans. & Link	II	.
<i>Linaria supina</i> (L.) Mill.	III	I
<i>Piptatherum miliaceum</i> (L.) Coss.	III	I
<i>Melica magnolii</i> (Gren. & Godr.) K. Richt.	II	III
<i>Sanguisorba verrucosa</i> (Link ex G. Don) Ces	IV
<i>Galium lucidum</i> subsp. <i>fruticescens</i> All.	IV
<i>Silene gracilis</i> DC.	III
<i>Ceterach officinarum</i> DC.	III
<i>Geranium purpureum</i> Vill.	III
<i>Bituminaria bituminosa</i> (L.) C.H. Stirt	II
<i>Coincya johnstonii</i> (Samp.) Greuter & Burdet	II
<i>Scabiosa columbaria</i> subsp. <i>affinis</i> (Gren. & Godr.) Nyman	II
<i>Crambe hispanica</i> L.	II
<i>Lagurus ovatus</i> L.	II
<i>Anthyllis vulneraria</i> subsp. <i>maura</i> (G. Beck) Lindb.	II
<i>Hyparrhenia hirta</i> (L.) Stapf in Prain	II
<i>Allium paniculatum</i> L.	II
<i>Asplenium trichomanes</i> subsp. <i>quadrialeans</i> D.E. Mey	I
<i>Asplenium ruta-muraria</i> L.	I
<i>Selaginella denticulata</i> (L.) Link	I
<i>Hedera maderensis</i> subsp. <i>iberica</i> Mc Allister	I
<i>Brachypodium distachyon</i> (L.) Beauv.	I
<i>Blackstonia perfoliata</i> (L.) Huds.	I
<i>Avena barbata</i> Pott ex Link	I
<i>Crepis taraxacifolia</i> Thuill.	I
<i>Arrhenatherum album</i> (Vahl) W.D. Clayton	I
<i>Torilis nodosa</i> (L.) Gaertn.	I
<i>Sideritis hirsuta</i> L.	I
<i>Hyacinthoides hispanica</i> (Mill.) Rothm.	I
<i>Cheirolophus sempervirens</i> (L.) Pomel	I
<i>Iberis microcarpa</i> (Franco & P. Silva) Rivas Mart.	I
<i>Clinopodium vulgare</i> L.	I

Association: No. 1 *Sanguisorbo rupicolae-Dianthetum crassipedis* (Table 2 of this paper, 8 relevés; clusters 1–8); No. 2 *Antirrhinetum onubensis* (Table 3 of this paper, 8 relevés; 9–16); No. 3 *Phagnalo saxatilis-Rumicetum indurati* Rivas-Martínez ex F. Navarro & C. Valle in Ruiz 1986 ([20]: Table 12, 5 relevés; clusters 17–21); No. 4 *Digitali thapsi-Dianthetum lusitani* Rivas-Martínez ex V. Fuente 1986 ([21]: Table 12, 10 relevés; clusters 22–31); No. 5 *Silene acutifoliae-Dianthetum lusitani* Vicente & Galán 2008 ([22]: Table 3, 9 relevés; clusters 32–40); No. 6 *Sileno montistellensis-Dianthetum lusitani* Rivas-Martínez 1981 corr. Ladero, Rivas-Martínez, Amor, M.T. Santos & Alonso 1999 ([23]: Table 6, 4 relevés; clusters 41–44); No. 7 *Phagnalo saxatilis-Dianthetum barbati* C. Lopes, Pinto-Gomes, Lousã & Ladero 2012 ([24]: Table 20, 6 relevés; clusters 45–51); No. 8 *Sileno longiciliae-Antirrhinetum linkiani* Ladero, C. Valle, M.T. Santos, Amor, Espírito Santo, Lousã & J.C. Costa 1991 ([25]: Table 1, 13 relevés clusters 52–64). The highlighted cells indicate the characteristic species of each association.

Table 2. Sanguisorbo rupicolae-Dianthetum crassipedis ass. nova hoc. loco (Rumici indurati-Dianthion lusitani, Phagnalo saxatilis-Rumicetalia indurati and Phagnalo saxatilis-Rumicetea indurati).

Relevé No.	1	2	3	4	5	6	7	8 *	PRESENCES
Surface (m ²)	20	30	25	10	25	35	25	30	
Altitude (m)	160	210	210	270	185	135	215	220	
Cover Rate (%)	70	50	70	50	35	35	55	70	
Orientation	NE	E	O	O	NE	O	NO	O	
Slope (%)	35	60	80	50	25	65	35	80	
Average Height (m)	0.4	0.3	0.4	0.35	0.4	0.3	0.4	0.4	
No. of Species	11	6	9	10	6	8	8	12	
Association Characteristics of Association and Higher Units									
<i>Dianthus crassipes</i>	4	3	4	3	2	2	3	4	V
<i>Sanguisorba rupicola</i>	+	-	-	1	-	+	+	+	IV
Alliance and Higher Ranks Characteristics									
<i>Phagnalon saxatile</i>	-	+	+	1	+	-	-	+	IV
<i>Rumex induratus</i>	-	-	-	-	+	+	+	+	III
Companions									
<i>Lavandula luisieri</i>	-	1	-	+	+	+	-	r	IV
<i>Genista polyanthos</i>	r	-	r	-	-	+	r	r	IV
<i>Cistus ladanifer</i>	+	+	+	-	-	-	+	-	III
<i>Rosmarinus officinalis</i>	-	-	+	-	-	+	-	+	II
<i>Dactylis hispanica</i> subsp. <i>lusitanica</i>	+	-	-	+	+	-	-	-	II
<i>Umbilicus rupestris</i>	-	-	+	-	-	-	+	+	II
<i>Scilla autumnalis</i>	1	-	+	-	-	-	+	-	II
<i>Phlomis purpurea</i>	-	-	+	+	-	-	-	-	II
<i>Thymus mastichina</i>	-	+	-	1	-	-	-	-	II
<i>Sedum forsterianum</i>	1	-	1	-	-	-	-	-	II
<i>Cheilanthes maderensis</i>	-	-	-	+	-	-	r	-	II

Other taxa—Companions: +*Quercus rotundifolia*, +*Rhamnus oleoides*, +*Polypodium interjectum*, +*Leucocjum autumnale* in 1; +*Campanula lusitanica* in 2; 1 *Cheilanthes guanchica*, r *Rhamnus alaternus* in 4; +*Helichrysum stoechas* in 5; +*Pistacia lentiscus*, +*Olea europaea* var. *sylvestris* in 6; +*Hyparrhenia sinaica*, +*Cosentinia vellea*, +*Asparagus albus*, +*Centaurea melitensis* in 8. **Location of the relevés:** 1—Monte da Ribeira (near Cachopo; lat 37°17'45.23" N, long 7°44'54.44" W); 2—Pão Duro (near Vaqueiros; lat 37°23'08.67" N, long 7°44'54.94" W); 3—Madeiras (lat 37°20'02.44" N, long 7°43'38.15" W); 4—Tavilhão (near Ameixial; lat 37°22'31.81" N, long 8°00'00.15" W); 5—Azinhosa (near Relvais; lat 37°18'14.40" N, long 7°44'24.49" W); 6—Galego (lat 37°20'17.16" N, long 7°43'26.65" W); 7—Plenganas (near Vaqueiros; lat 37°24'15.03" N, long 7°44'16.45" W); 8 (* holotypus)—Madeiras (lat 37°20'06.03" N, long 7°43'38.82" W).

Table 3. Antirrhinetum onubensis ass. nova hoc. loco (Calendulo lusitanicae-Antirrhinion linkiani, Phagnalo saxatilis-Rumicetalia indurati and Phagnalo saxatilis-Rumicetea indurati).

Relevé No.	1	2	3	4	5	6 *	7	8	PRESENCES
Surface (m ²)	15	10	20	15	10	20	15	15	
Altitude (m)	235	245	380	250	240	245	260	250	
Cover rate (%)	30	20	20	30	35	30	35	30	
Orientation	NO	S	S	N	SO	N	O	S	
Slope (%)	70	80	30	40	60	80	50	60	
Average Height (m)	0.5	0.4	0.4	0.5	0.5	0.5	0.4	0.5	
No. of Species	8	6	9	7	5	10	6	9	
Association Characteristic									
<i>Antirrhinum onubensis</i>	3	2	2	3	3	3	3	3	V
Alliance and Higher Rank Characteristics									
<i>Sedum mucizonia</i>	-	-	+	1	1	+	+	1	IV
<i>Phagnalon saxatile</i>	-	-	-	-	-	r	+	+	II
<i>Sanguisorba rupicola</i>	-	+	-	-	-	-	-	-	I
Companions									
<i>Melica minuta</i>	+	+	+	-	-	+	-	+	IV
<i>Asplenium petrarchae</i>	-	+	-	+	r	+	-	+	IV
<i>Sedum sediforme</i>	-	-	+	+	1	-	-	+	III
<i>Prasium majus</i>	+	+	+	+	-	-	-	-	III
<i>Genista hirsuta</i> subsp. <i>algarbiensis</i>	+	-	-	-	+	+	-	+	III
<i>Asplenium ceterach</i>	+	-	-	-	-	+	+	-	II
<i>Aristolochia baetica</i>	-	-	+	+	-	+	-	-	II

Table 3. Cont.

<i>Rhamnus oleoides</i>	+	-	-	-	-	1	-	-	II
<i>Asparagus albus</i>	-	-	+	-	-	+	-	-	II
<i>Polypodium cambricum</i>	-	-	-	-	-	+	+	-	II

Other taxa—Companions: 1 *Juniperus turbinata*, +*Valantia hispida* in 1; +*Theligionum cynocrambe* in 2; +*Campanula erinus*, +*Umbilicus rupestris* in 3; +*Thymus mastichina* in 4; +*Pistacia terebinthus* in 7; +*Elaeoselinum tenuifolium*; +*Cerantonia siliqua* in 8. **Location of the relevés:** 1—Barrocal da Tôr (near Tôr; lat 37°10′24.9″ N, long 8°02′26.9″ W); 2—Cerro da Cabeça (near Moncarapacho; lat 37°06′33.9″ N, long 7°46′54.8″ W); 3—Rocha da Pena (near Salir); 4—Malhada Velha (near Loulé; lat 37°10′20.4″ N, long 8°00′37.0″ W); 5—Varejota (near Parragil; lat 37°10′19.3″ N, long 8°04′50.3″ W); 6 (*holotypus)—Barrocal da Tôr (near Tôr; lat 37°10′25.3″ N, long 8°02′39.4″ W); 7—Malhada Velha (near Loulé; 37°10′18.7″ N 8°00′44.2″ W); 8—Varejota (near Parragil; 37°10′16.8″ N 8°04′47.6″ W).

2.3. Nomenclature

Syntaxonomical typologies followed Rivas-Martínez [13,26,27], Costa et al. [12] and Mucina et al. [28]. Plant identification follows Coutinho [29], Franco [30], Franco and Rocha Afonso [31], Castroviejo [32] and Valdés et al. [33]. Taxonomic nomenclature was updated using Iberian lists elaborated by Rivas-Martínez et al. [27], Sequeira et al. [34] and Costa et al. [12]. The biogeographical and bioclimatological information was collected according to Rivas-Martínez et al. [14,19], and substratum affinity information was collected from the literature: Quinto-Canas [35], Meireles [36], Orellana and Galán de Mera [22] and Lopes [24]. The phytosociological name of the new vegetation unit is given according to the International Code of Phytosociological Nomenclature [37].

2.4. Data Analysis

For statistical data processing of the samples, we first generated a data matrix that included 64 relevés and 135 species from our field sampling (Tables 1 and 2; association 1; Figure 2, clusters 1–8; Table 3, association 2; Figure 2, clusters 9–16) and relevés taken from the literature [20–23,25,35,36]. The matrix was subjected to the unweighted pair-group method using arithmetic averages (UPGMA), with Bray–Curtis distance, to produce the dissimilarity measure, using the software Primer 6 [38,39].

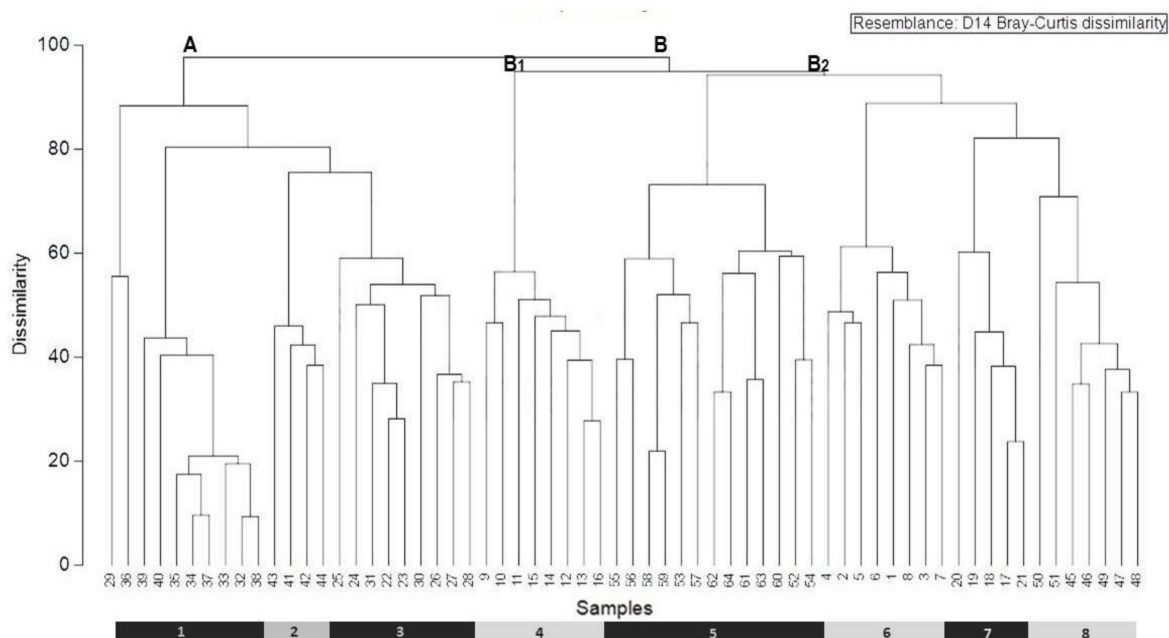


Figure 2. Classification analysis (UPGMA clustering dendrogram (with Bray–Curtis distance) on chasmo-chomophytic associations from the Southwestern Iberian Peninsula (included in both *Rumici indurati-Dianthion lusitani* and *Calendulo lusitanicae-Antirrhinion linkiani* alliances): 1—*Silene acutifoliae-Dianthetum lusitani* (32–40); 2—*Sileno montistellensis-Dianthetum lusitani* (41–44); 3—*Digitali thapsi-Dianthetum lusitani* (22–31); 4—*Antirrhinetum onubensis* (9–16); 5—*Sileno longiciliae-Antirrhinetum linkiani* (52–64); 6—*Sanguisorbo rupicola-Dianthetum crassipedis* (1–8); 7—*Phagnalo saxatilis-Rumicetum indurati* (17–21); 8—*Phagnalo saxatilis-Dianthetum barbati* (45–51).

The transformation of Braun–Blanquet’s abundance–dominance values follows Van der Maarel [40]. This transformation is required as a solution for converting the non-numerical values into numerical scale and in this form used as input data for numerical analysis, with the following equivalence: $r = 1$, $+$ = 2, 1 = 3, 2 = 4, 3 = 5, 4 = 6 and 5 = 7.

3. Results and Discussion

3.1. Classification of Southwestern Iberian Peninsula Chasmo–Chomophytic Communities

The dendrogram and the synoptic table reveal a clear separation between all phytosociological chasmo-chomophytic communities of the Southwestern Iberian Peninsula, included in both alliances: *Rumici indurati-Dianthion lusitani* and *Calendulo lusitanicae-Antirrhinion linkiani*. The cluster analysis (Figure 2) produces two main groups of associations (group A and group B), which represent eight community types: *Sanguisorbo rupicolae-Dianthetum crassipedis* (clusters 1–8), *Antirrhinetum onubensis* (9–16), *Phagnalo saxatilis-Rumicetum indurati* (clusters 17–21), *Digitali thapsi-Dianthetum lusitani* (clusters 22–31), *Silene acutifoliae-Dianthetum lusitani* (clusters 32–40), *Sileno montistellensis-Dianthetum lusitani* (clusters 41–44), *Phagnalo saxatilis-Dianthetum barbati* (clusters 45–51) and *Sileno longiciliae-Antirrhinetum linkiani* (clusters 52–64).

Group A has a high dissimilarity in relation to the other associations and includes relevés dominated by *Dianthus lusitanus*. The *Digitali thapsi-Dianthetum lusitani* is an association co-dominated by *Dianthus lusitanus* and *Digitalis thapsi* which occur in the mesomediterranean to supramediterranean bioclimatic stages of the Lusitania and Extremadura, Carpetana and León, and Oroiberian Subprovinces, on rocky fissures of schist, quartzite and granite [21]. The *Silene acutifoliae-Dianthetum lusitani* occur mostly on quartzitic outcrops in the mesomediterranean belt of the São Mamede mountains (São Mamede Sierran District, Oretana Range and Tajo Sector), well characterized by the presence of *Silene acutifolia* [22]. The *Sileno montistellensis-Dianthetum lusitani* is found in submediterranean areas, with the supramediterranean to oromediterranean themotype, on granitic fissures of the Estrela mountain biogeographical territory, and is characterized by the presence of *Silene x montistellensis* (hybrid between *Silene acutifolia* and *Silene foetida*) [36].

The cluster analysis also shows a group of relevés clearly separated from the rest, which are included in the cluster group B, divided into two subgroups. The relevé cluster subgroup B1 corresponds to the association *Antirrhinetum onubensis*, which is proposed here as a new association, largely confined to the limestones of Algarve District (Algarve and Monchique Sector). The subgroup B2 comprises samples ascribed to both silicicolous and calcicolous associations included in the alliances *Rumici indurati-Dianthion lusitani* (such as *Phagnalo saxatilis-Rumicetum indurati* and *Sanguisorbo rupicolae-Dianthetum crassipedis*) and *Calendulo lusitanicae-Antirrhinion linkiani* (such as *Phagnalo saxatilis-Dianthetum barbati* and *Sileno longiciliae-Antirrhinetum linkiani*), respectively. The floristic similarities between these four associations are a result of the high presence of *Phagnalon saxatile* and *Sanguisorba rupicola* in its characteristic species set, both with indifferent soil preferences, and also, in the scope of companion species, the presence of *Dactylis hispanica* subsp. *lusitanica*, *Sedum forsterianum*, *Hyparrhenia sinaica*, *Helichrysum stoecha*, *Sedum sediforme*, *Melica minuta*, *Polypodium cambricum* and *Sedum album*. The *Phagnalo saxatilis-Rumicetum indurati* is dominated by *Phagnalon saxatile* and *Rumex induratus*, and is widely distributed throughout the thermomediterranean to supramediterranean areas of the West Iberian Mediterranean, and Coastal Lusitania and West Andalusia Provinces. The *Sanguisorbo rupicolae-Dianthetum crassipedis*, a new association physiognomically characterized by *Dianthus crassipes*, occurs in the thermomediterranean to mesomediterranean dry areas of the East Mariánica District (Mariánica Range Sector). The *Phagnalo saxatilis-Dianthetum barbati*, a calcicolous community characterized by the co-dominance of *Dianthus barbatus* and *Phagnalon saxatile*, is found in the northern part of the Divisório Portuguese Sector [24]. The *Sileno longiciliae-Antirrhinetum linkiani*, which has been described by Ladero et al. [25] in the limestones of the Divisório Portuguese Sector and Arrabida Sierran District (Ribatejo and Sado Sector), is characterized by the dominance of species from the *Calendulo*

2000 code: *6110 Rupicolous calcareous or basophilic grasslands of the *Alyso-Sedion albi*, from the Annex I habitat types of the Council Directive 92/43/EEC of 21 May 1992.

3.3. Syntaxonomical Scheme

PHAGNALO SAXATILIS-RUMICETEA INDURATI (Rivas Goday & Esteve 1972) Rivas-Martínez, Izco & Costa 1973

PHAGNALO SAXATILIS-RUMICETALIA INDURATI Rivas Goday & Esteve 1972

Rumici indurati-Dianthion lusitani Rivas-Martínez, Izco & Costa ex V. Fuente 1986

Phagnalo saxatilis-Rumicetum indurati Rivas-Martínez ex F. Navarro & C. Valle in Ruiz 1986

Digitali thapsi-Dianthetum lusitani Rivas-Martínez ex V. Fuente 1986

Silene acutifoliae-Dianthetum lusitani Vicente & Galán 2008

Sileno montistellensis-Dianthetum lusitani Rivas-Martínez 1981 corr. Ladero, Rivas-Martínez, Amor, M.T. Santos & Alonso 1999

Sanguisorbo rupicolae-Dianthetum crassipedis Quinto-Canas, Cano-Ortiz, Spampinato, del Río, M. Raposo, Piñar Fuentes & Pinto-Gomes ass. nova hoc loco

Calendulo lusitanicae-Antirrhinion linkiani Ladero, C. Valle, M.T. Santos, Amor, Espírito Santo, Lousã & J.C. Costa 1991

Phagnalo saxatilis-Dianthetum barbati C. Lopes, Pinto-Gomes, Lousã & Ladero 2012

Sileno longiciliae-Antirrhinetum linkiani Ladero, C. Valle, M.T. Santos, Amor, Espírito Santo, Lousã & J.C. Costa 1991

Antirrhinetum onubensis Quinto-Canas, Cano-Ortiz, Spampinato, del Río, M. Raposo, Piñar Fuentes & Pinto-Gomes ass. nova hoc loco

Author Contributions: Conceptualization, R.Q.C., M.R. and C.P.G.; methodology, C.P.G. and S.d.R.; software, R.Q.C., J.C.P.F. and M.R.; validation, C.P.G. and S.d.R.; formal analysis, R.Q.C., A.C.-O. and G.S.; investigation, R.Q.C., A.C.-O., G.S. and J.C.P.F.; resources, R.Q.C., A.C.-O., G.S. and J.C.P.F.; data curation, R.Q.C., A.C.-O., G.S. and C.P.G.; writing—original draft preparation, R.Q.C.; writing—review and editing, C.P.G., A.C.-O., S.d.R. and G.S.; visualization, J.C.P.F.; supervision, C.P.G. and S.d.R. All authors have read and agreed to the published version of the manuscript.

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