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Contribution to the knowledge of the Moroccan mountain vegetation

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Abstract
Different types of plant communities, till now undetected in Morocco, are here described using the phytosociological method. The following new subassociations and associations are proposed: *Anthyllido polycephalae-Stachydetum fontqueri* subass. *quercetosum rotundifoliae* is a machia from the Northern Rif Mountains; *Genisto anglicae-Ericetum ciliaris* subsass. *pinguiculetosum lusitanicae* is a heathland from the Bou Hassim range in the Western Rif; *Cephalario maroccanae-Inuletum maletii* is a megaphorbic community from the Middle Atlas; *Bellis caerulescendis-Heracletum sphondyllii* is a megaphorbic community from the High Atlas; *Arenario armerinae-Sideritetum matris-filiae* is a high mountain grassland from the Tichchoukt range in the Middle Atlas.

New data are given for the syntaxa already described but with the distribution, variability and ecology not well known. This is the case of the following associations: *Polysticho setiferi-Prunetum lusitanicae*, a riverine woodland from the W Rif Mountains; *Primulo acaulis-Betuletum celtibericae*, a birch woodland from the C Rif and *Astragaletum numidico-maroccani* a high mediterranean mountain plant community from the Western Rif.

As a conclusion, the vegetation of the peculiar habitats that occur in reduced areas is only partially known.

Key words: Atlas Mountains; Morocco; phytosociology; plant communities; Rif Mountains; vegetation.

Resumen
Contribución al conocimiento de la vegetación de las montañas marroquíes.- Se describe con la metodología fitosociológica diferentes tipos de comunidades vegetales, no detectadas hasta el presente en Marruecos. Se proponen las siguientes nuevas asociaciones y subasociaciones: *Anthyllido polycephalae-Stachydetum fontqueri* subass. *quercetosum rotundifoliae* corresponde a una maquia de las montañas septentrionales del Rif; *Genisto anglicae-Ericetum ciliaris* subsass. *pinguiculetosum lusitanicae* es un brezal del macizo de Bou Hassim en el Rif occidental; *Cephalario maroccanae-Inuletum maletii* es una formación de megaforbios del Atlas Medio; *Bellis caerulescendis-Heracletum sphondyllii* es una formación de megaforbios del Gran Atlas; *Arenario armerinae-Sideritetum matris-filiae* es un pastizal de alta montaña mediterránea del macizo de Tichchoukt en el Atlas Medio.

Se aportan nuevos datos para otros sintáxones ya descritos pero con la distribución, variabilidad y ecología poco conocidas. Este es el caso de las asociaciones siguientes: *Polysticho setiferi-Prunetum lusitanicae*, bosquecillo ripario de las montañas del Rif occidental y central; *Primulo acaulis-Betuletum celtibericae*, corresponde a un bosque de abedules del Rif central, y *Astragaletum numidico-maroccani* es una comunidad de caméfitos de alta montaña mediterránea conocida hasta el presente del Rif occidental.

Como conclusión se puede aseverar que la vegetación de los hábitats que ocupan áreas reducidas en las montañas marroquíes es conocida de forma parcial.

Palabras clave: comunidades de plantas; fitosociología; Marruecos; montañas del Atlas; montañas del Rif; vegetación.

INTRODUCTION

The decline of phytosociological studies, as insinuated by Fennane (2003), in Morocco, is in direct contrast with the progress being made in the field of vascular plant study. That this is the case is clearly demonstrated by recent works of a synthetic nature dealing with the native NW African flora. Some of these cover the whole territory (Fennane *et al.*, 1999; 2005; 2007), while others deal with extensive territories (Valdés *et al*., 2002).

This progress in our knowledge of the flora should lead to a new "age of prosperity" for studies in the field of plant communities. With this in light, we have been able to order and detail more of our field data and have consequently diagnosed the floristic elements conserved in the collected material. The critical taxa of our relevés are supported by herbarium sheets that can be consulted in herbarium BC. All this is fruit of several expeditions made in the Maghreb (North West Africa) from 1985 up to the present day. The field data were annotated following the Braun-Blanquet phytosociological method (Braun-Blanquet, 1977). The block corresponding to rupicolous communities made up part of a recent publication (Romo, 2008).

Within Morocco, the Straights area (Galán de Mera, 1993; Deil, 1994, 1997) and the Central Rif (Deil, 1984) have received more attention from the phytosociological point of view, and these regions have been studied quite thoroughly. In contrast, vegetation studies have been less intense in the Western Rif, Eastern Rif and in certain habitats of the Atlas mountains.

MATERIALS AND METHODS

Throughout the process of our botanical explorations of Morocco, a number of relevés in accordance with the phytosociological methodology (Braun-Blanquet, 1977; Mueller-Dombois & Ellenberg, 1974; Dierschke, 1994) were elaborated. In these relevés the data of the studied stations are reordered in the standard way, and the slope is given in degrees, not as a percentage.

For the nomenclature of the plants we have referred to the works of Valdés *et al*. (2002) for Northern Morocco, Fennane *et al*. (1999; 2007) and Jahandiez & Maire (1931) for the rest of the country. The names of the syntaxa agree with the international code of Phytosociological Nomenclature (Weber *et al*., 2000).

RESULTS

Several associations, some of them already described and others hitherto not recognized, have been detected and are described in the following section. For each one of them their structure, floristic composition, ecology and distribution is described, along with their syntaxonomy, relation with other associations and evolution. The syntaxonomic synopsis of the syntaxa mentioned in the text is compiled in Appendix 1.

Anthyllido polycephalae-Stachydetum fontqueri Quézel, Barbero, Benabid, Loisel & Rivas Martínez 1988 subassoc. *quercetosum rotundifoliae* subassoc. nova

This subassociation (Table 1) is a dense scrub dominated by various shrubs or by shrub-size trees. Among species characteristic of this association it is worth making special mention of some endemic species of limited distribution: *Stachys fontqueri, Origanum grosii, Hedera maderensis* subsp. *iberica, Digitalis laciniata, Lithodora maroccana* (Fennane & Ibn Tattou, 1998). *Stachys fontqueri* is an endemic plant of the West Rif Area; *Origanum grosii* is an endemic also, referred from W Rif and C Rif and Targuist, where it is rare; the same applies to *Digitalis laciniata*, referred from W Rif, Targuist and Imzzourène; *Lithodora maroccana* and *Hedera maderensis* subsp. *iberica* have a wider distribution. The subassociation is characterized by the presence of *Quercus rotundifolia, Hedera maderensis* subsp. *iberica, Rubia peregrina, Smilax aspera* and *Pistacia lentiscus.*

This type of maquis is found in the *Quercus rotundifolia* domain. It colonizes principally the south-facing slopes, to a lesser degree the western ones, and somewhat rarely east-facing expositions, at between 1,000 and 1,400 m. In the Rif mountain areas where it develops it comes under the influence of maritime winds loaded with humidity proceeding from the Atlantic Ocean and Mediterranean Sea (Fig. 1).

These winds as they enter the mountainous region condense and form fog banks which are frequent in the upper Rif elevations nearer the coast. This maquis colonizes the southern slopes of the ranges affected by these fogs, but only in those where a strong contrast exists between both sides, since the sunnier conditions of the south-facing slopes are not compensated for by the humidity of the fog.

Table 1. *Anthyllido polycephalae-Stachydetum fontqueri* subassoc. *quercetosum rotundifoliae*. Provenance of relevés: 1-2 Morocco, Rif Occidental, Jbel Assillenh, towards Tazaout, 35º 13' N 5º 04' W, between 1,150-1,160 m; 3-4 Morocco, Rif Occidental, Jbel Tissouka, above Chefchaouene, 35º 10' N 5º 13' W, between 1,380-1,400 m; 5-6 Morocco, Rif Occidental, Jbel Tissouka, above Mechkralla, 35º 09' N 5º 14' W, between 1,390-1,400 m; 7 Morocco, Rif Occidental, Jbel Tissouka, above Haj S. Bouker, 35º 09' N 5º 13' W, between 1,390-1,400 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Aspect	S	S	W	S	E	E	W
Slope	15	10	10	40	25	25	15
Cover	100	100	100	100	100	100	100
Vegetation height (m)	1-1.5	1-1.5	1-1.5	1.5-2	1-1.5	1.5-2	1.5-2
Altitude (x10)	115	116	138	139	140	139	139
Studied surface (m^2)	60	40	50	70	60	50	60
Characteristics of the subassociation							
Quercus rotundifolia	2.3	2.2	4.4	2.2	4.4	4.4	3.4
Hedera maderensis subsp. *iberica*	.	.	+	.	1.1	1.1	.
Rubia peregrina	.	.	+	1.1	1.1	1.1	.
Smilax aspera	.	.	+	.	.	+	.
Characteristics of the association and of the superior units							
Stachys fontqueri	2.2	2.2	2.1	2.2	2.2	2.2	1.1
Origanum grosii	1.1	1.1	2.1	2.3	2.3	2.3	+
Ptilostemon riphaeus subsp. *riphaeus*	.	.	.	.	.	+	+
Cistus albidus	1.1	.	2.1	2.3	2.3	2.3	.
Digitalis laciniata subsp. *riphaea*	.	.	+	.	+	.	.
Lithodora maroccana	.	.	.	.	.	+	1.1
Ononis aragonensis	.	.	.	.	.	.	2.2
Avenula gervaisii subsp. *arundana*	.	.	.	+	.	.	.
Pistacia lentiscus	.	.	1.1	.	.	+	.
Characteristics of the *Quercetea ilicis*							
Daphne gnidium	1.1	.	1.1	.	1.1	1.1	1.1
Juniperus oxycedrus subsp. *oxycedrus*	+	.	.	.	1.1	.	3.3
Juniperus phoenicea	.	.	+	2.2	.	.	.
Euphorbia characias subsp. *characias*	.	.	+	+	+	+	.
Companions							
Rubus ulmifolius	.	.	+	+	+	+	.
Brachypodium retusum	1.1	.	1.1	1.1	1.1	.	.
Euphorbia nicaensis	.	.	+	.	.	.	1.1
Viola suavis	+	+	.	.	.	.	.
Melica minuta	+	.	+	.	.	+	.
Piptatherum paradoxum	.	.	+	.	+	.	.
Aristolochia paucinervis	.	.	.	.	+	+	.
Chamaerops humilis	+	+	.	.	.	.	.

Species annotated in a single relevé: *Anagallis arvensis* 1 (+); *Carduus pycnocephalus* 4 (+); *Dactylis glomerata* susbp. *hispanica* 3 (+); *Pimpinella tragium* 3 (+).

The typical *Anthyllido polycephalae-Stachydetum fontqueri* (Table 2) was described from Jbel Kelti, above Tamalout and from the southern slopes of Talassentane (Quézel *et al.*, 1988).

This subassociation at present is known from Jbel Tissouka and Jbel Tazaout. The two massifs constitute the highest mountains in the W Rif dorsal. The newly-described subassociation should be included in the alliance *Pseudoscabioso-Origanion grosii* Quézel, Barbero, Benabid, Loisel & Rivas-Martínez 1988 (Quézel *et al.*, 1988).

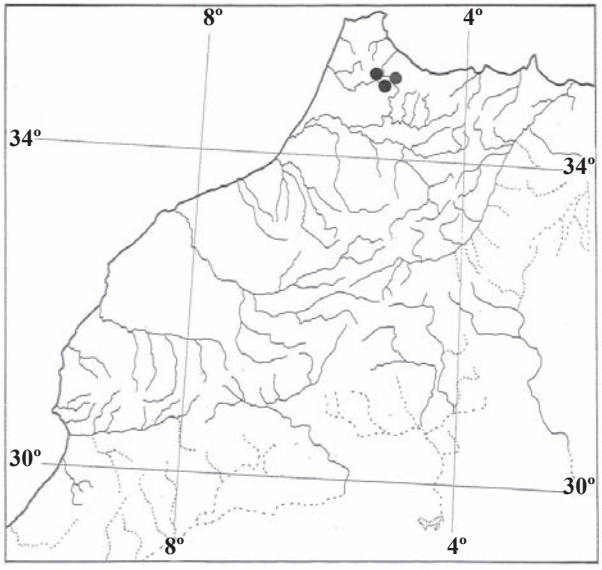

Figure 1. Distribution of *Anthyllido polycephalae-Stachydetum fontqueri* subassoc. *quercetosum rotundifoliae.*

As the holotypus, relevé 3 of Table 1 has been chosen.

On deeper soils and those with a less-pronounced slope, this association can evolve toward *Paeonio maroccanae-Quercetum rotundifoliae* Barbero, Quézel & Rivas-Martínez 1981, which in the W Rif is found between 800 and 1,400 (1,500) m. This forest community, though more typical of south-facing aspects, is also found on north-facing ones. The usual case is the presence of this maquis as constituting a permanent community on sunny expositions between 1,000 and 1,400 (1,500) m. On shady slopes it is substituted by formations of *Paeonio maroccanae-Quercetum canariensis* Barbero, Quézel & Rivas-Martínez 1981, between (1,200) 1,300 and 1,500 m. On higher ground this maquis disappears as from 1,500 m on the shady, and 1,800-1,900 m on the sunny sides. Above these altitudinal limits communities of *Paeonio maroccanae-Abietetum maroccanae* Barbero, Quézel & Rivas-Martínez 1981 can be found.

Polysticho setiferi-Prunetum lusitanicae Barbero, Quézel & Rivas-Martínez 1981

Dense riverine woodland (Table 3), dominated by *Prunus lusitanica* and different species of *Quercus*, which attain a modest size. Beneath the tree canopy an herbaceous stratum with shade loving woodland species is developed. The following species stand out: *Athyrium filix-femina, Blechnum spicant, Paeonia coriacea* var. *maroccana* and *Hedera maderensis* subsp. *iberica*.

This river woodland, located in the wetter zones of the mid mountain level, in the deciduous forest domain, meets with favourable conditions between 1,100 and 1,400 m. It extends along the entire dorsal western Rif from Bou Hassim and Jbel Kelti to Jbel Tiziren and the Central Rif (Deil, 1984). Beyond this mountain and towards the East the climate becomes more markedly continental and these riverine woodlands disappear (Fig. 2). These localities increase the distribution

Table 2. Comparative table of the two subassociations: (A), *Anthyllido polycephalae-Stachydetum fontqueri* subassoc. typicum (résumé of 8 relevés) from Quézel *et al.* (1988); (B), *Anthyllido polycephalae-Stachydetum fontqueri* subassoc. *quercetosum rotundifoliae* (résumé of 7 relevés) from this paper.

Characteristics of the subassociation	**A**	**B**
Quercus rotundifolia	-	7
Hedera maderensis subsp. *iberica*	-	3
Rubia peregrina	-	4
Smilax aspera	-	2
Pistacia lentiscus	-	2
Characteristics of the association		
Stachys fontqueri	8	7
Anthyllis polycephala	3	-
Characteristics of alliance		
Salvia interrupta subsp. *paui*	2	-
Pseudosacbiosa grosii	6	-
Origanum grosii	4	7
Ptilostemum riphaeum	2	2
Characteristics of order and class		
Ulex parviflorus	5	-
Cistus albidus	5	5
Satureja graeca	5	-
Helianthemum cinereum subsp. *rotundifolium*	3	-
Aphyllanthes monspeliensis	3	-
Cerastium gibraltaricum	2	-
Ononis aragonensis	-	1
Avenula gervaisii subsp. *arundana*	-	1
Characteristics of *Quercetea ilicis*		
Buxus balearica	3	-
Juniperus oxycedrus	2	3
Juniperus phoenicea	2	2
Daphne gnidium	1	5
Euphorbia characias	1	4

Table 3. *Polysticho setiferi-Prunetum lusitanicae*. Provenance of relevés: 1-2 Morocco, Rif Occidental, Bou Hassim, above Boubiyene, 35º 15' N 5º 25' W, between 1,180-1,200 m; 3-4 Morocco, Rif Occidental, Bou Hassim, above El Maouzkir, 35º 14' N 5º 25' W, between 1,190-1,210 m; 5-7 Morocco, Rif Occidental, Jbel Kelti, above Tamolout, between, 35º 21' N 5º 18' W, 1,300-1,360 m; 8 Morocco, Rif Cental, Jbel Tizirene, above Bab Barret, 35º 01' N 4º 55' W, 1,500 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Aspect	W	W	NW	E	N	N	NW	E
Slope	5	0	0	0	30	20	25	30
Tree hight (m)	6	6	6	6	5.5	5.5	6	6
Cover	100	100	100	100	100	100	100	100
Altitude (x10)	118	120	121	119	130	130	136	150
Studied surface (m^2)	90	120	100	120	100	100	100	100
Characteristics of the association and of the superior units								
Prunus lusitanica	5.5	5.5	2.3	3.4	5.5	4.5	1.2	3.4
Paeonia coriacea var. *maroccana*	.	.	.	+	2.2	2.2	3.3	+
Quercus canariensis	.	.	.	.	2.3	.	3.4	.
Acer opalus subsp. *granatense*	.	.	.	.	+	1.1	2.2	2.2
Alnus glutinosa	.	+	+.1	.	.	.	.	.
Daphne laureola subsp. *latifolia*	.	.	.	.	1.2	1.1	1.1	.
Ilex aquifolium	.	+.1	1.1	1.1	.	.	.	.
Athyrium filix-femina	.	.	.	2.2	+	.	+	.
Blechnum spicant	.	.	1.1	2.3	.	.	.	.
Digitalis mauretanica	.	.	.	.	+	.	+	1.1
Frangula alnus subsp. *alnus*	.	+.1	+	+	.	+	.	.
Hedera maderensis subsp. *iberica*	+.1	1.2	+.1	.	.	.	.	.
Helleborus foetidus	.	.	.	.	+	1.1	.	.
Osmunda regalis	.	.	2.4	1.1	.	.	.	.
Salix atrocinerea	.	.	.	.	.	+	+	1.1
Satureja vulgaris subsp. *arundana*	.	.	.	.	+	.	.	.
Viola munbyana	.	.	.	.	.	.	.	+
Lonicera peryclimenum subsp. *hispanica*.		.	+	1.1	.	.	.	.
Companions								
Euphorbia characias	.	.	.	.	1.1	1.1	2.1	.
Arbutus unedo	.	.	+	1.1	.	.	.	.
Asplenium adiantum-nigrum	.	1.1	+	.	.	.	.	.
Cistus populifolius	+	.	+	.	.	.	.	.
Quercus rotundifolia	.	.	.	.	+	.	+	.

Species annotated in a single relevé: *Cynosurus echinatus* 5 (+); *Festuca arundinacea* subsp. *atlantigena* 7 (+); *Galium album* 5 (+); *Ptilostemon riphaeus* 7 (+); *Quercus canariensis* x *Q. pyrenaica* 7 (2.3); *Valantia hispida* 2 (+); *Viburnum tinus* 3 (+.1).

of this association, which was described from the northern slopes of the Tidighine range and Bab Besen (Barbero *et al.,* 1981: 409).

This association is included in the alliance *Violo munbyanae-Cedrion atlanticae* Barbero, Quézel & Rivas-Martínez 1981.

The destruction of these woods generates dense bramble thickets which, if in turn disturbed, give way to hygronitrofilous grassland, rich in banal, nitrophilous plants.

***Primulo acaulis-Betuletum celtibericae* Barbero, Quézel & Rivas-Martínez 1981**
= *Polysticho setiferi-Prunetum lusitanicae* subassoc. *betuletosum* Deil 1984

The birch woods are low-density woodlands that only possess a tree layer which is generally monospecific, along with an herbaceous layer dominated by frondose plants with large tender leaves (Table 4).

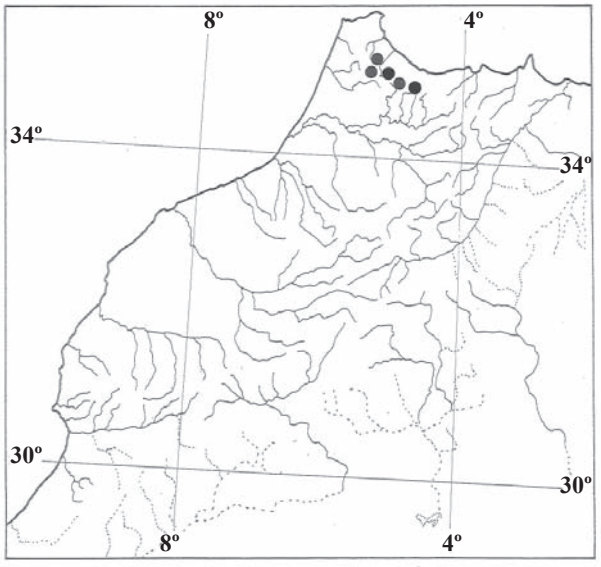

Figure 2. Distribution of *Polysticho setiferi-Prunetum lusitanicae.*

These woods cover limited areas of north-facing slope in the dorsal central Rif mountains, where they can be found in the wetter zones, albeit within areas possessing a markedly continental climate.

Up to now, only a few stations in the Jbel Dadoh have been located, and these occur within the cedar woodland domain. This new station must be added to those of the description in the Jbel Tidighin, Ketama and Bab Besen (Barbero *et al*., 1981) and Deil (1984) (Fig. 3).

These birch woods can be considered as relict communities, being found here at the southern limit of their distribution. The destruction of these communities leads to the colonization of their habitat by plants characteristic of nitrophilous herbaceous communities and also to bracken (*Pteridium aquilinum*) infestation.

It must be included in the order *Querco-Cedretalia atlanticae* Barbero, Loisel & Quézel, 1974 and *Violo munbyanae-Cedrion atlanticae* Barbero, Quézel & Rivas-Martínez 1981 alliance.

Genisto anglicae-Ericetum ciliaris Quézel, Barbero, Benabid, Loisel, & Rivas-Martínez 1988 subsassoc. *pinguiculetosum lusitanicae* subassoc. nova

Heathland dominated by small chamaephytes: *Genista ancistrocarpa, Erica ciliaris* and *Potentilla erecta*, and hemicryptophytes: *Carex sp. pl*., *Potentilla erecta, Osmunda regalis* (Table 5).

Table 4. *Primulo acaulis-Betuletum celtibericae.* Provenance of the relevés: 1-2 Morocco, Rif Central, Jbel Daddoh (Dedokh), vers Tizi-n Tigrout, 34º 55' N 4º 38' E, between 1,480-1,490 m; 3-4 Morocco, Rif Central, Jbel Daddoh (Dedokh), above Ketama, 34º 55' N 4º 37' W, between 1,480-1,500 m.

Number of relevé	**1**	**2**	**3**	**4**
Aspect	N	N	N	N
Slope	10	15	15	15
Cover	50	70	70	70
Altitude (x10)	148	149	148	150
Studied surface (m^2)	100	90	100	100
Characteristics of the association and of the superior units				
Betula pendula subsp. *fontqueri*	2.3	2.3	3.3	2.2
Primula acaulis subsp. *atlantica*	2.3	3.3	2.3	2.3
Mycelis muralis	2.1	1.1	1.1	1.1
Poa nemoralis	1.1	2.2	1.1	1.1
Sanicula europaea	1.1	1.1	+	1.1
Salix atrocinerea	2.2	+	.	.
Myosotis decumbens subsp. *rifana*	.	1.1	.	+
Galium rotundifolium	2.3	1.1	+	+
Geum sylvaticum	+.1	+	+	+
Digitalis mauretanica	.	1.1	+	+
Companions				
Aira cupaniana	1.1	+	.	+
Cedrus atlantica	.	+	.	+
Prunella vulgaris	.	+	.	.
Pteridium aquilinum	+	1.1	+	+
Ranunculus repens	1.1	2.2	+	1.1

These constitute among the most clearly represented groups of vegetation showing an Atlantic affinity of those in the Mediterranean landscape observed here.

Within this community numerous hygrophilous species appear, among them *Pinguicula lusitanica* and *Oenanthe maroccana*, these being rare in the territory as a whole. This association colonizes the edges of permanent watercourses, such as the small streams in the Bou Hassim massif. This receives the full impact of the Atlantic oceanic influence. Its north- and south-facing aspects aid the condensation of moisture-laden winds which blow towards the east. Within the massif, the high precipitation favours the presence of springs and permanent streams, well-supplied even in the height of summer. This community colonizes the permanently moist soils of an acidic nature on level or slightly sloping ground. It enters into contact with *Alnus glutinosa* in the general domain of *Quercus canariensis* woodland.

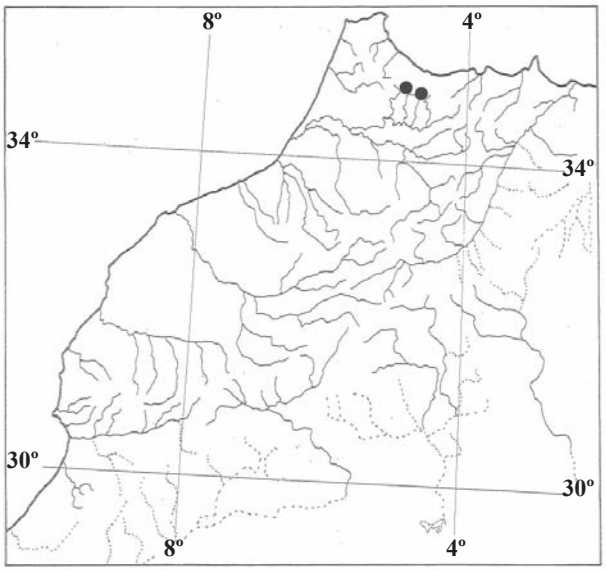

Figure 3. Distribution of *Primulo acaulis-Betuletum celtibericae.*

It can be found from 1,200 m up to 1,400 m, in *Quercus canariensis* woodland domain, in gully bottoms containing streams, and oriented in a north to north-easterly direction. In these, it colonizes the stream edges in the montane zone of the W Rif, where it is known from the Bou Hassim massif (Fig. 4).

Floristically poor due to its relictic nature in the limits of its area, it appears that this community can be included within the sub-Iberian alliance *Genistion micrantho-anglicae* Rivas-Martínez 1979.

It is closely related to the *Genisto anglicae-Ericetum ciliaris* subassoc. *typicum* described from the Tanger Region (Tangerois), from the surroundings of boggy ground in the Southern part of the El Araix woodlands and Khemis Sahel, between 130 and 360 m. As has been noted by Loidi *et al.* (2007) these Moroccan heaths occupy a very reduced extension and they contain several endemic taxa, which could be the result of an ancient establishment of this vegetation type. Time

Table 5. *Genisto anglicae-Ericetum ciliaris* subsass. *pinguiculetosum lusitanicae*. Provenance of relevés: 1-3 Morocco, Mountains of W Rif, Bou Hassim, above Boubiyene, 35º 15' N 5º 26' W, between 1,190-1,300 m; 4-5 Morocco, Mountains of W Rif, Bou Hassim, above El Maouzkir, 35º 14' N 5º 24' W, between 1,300-1,360 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**
Aspect	N	NE	N	N	N
Slope	5	5	5	5	5
Cover	100	100	100	100	100
Altitude (x10)	121	119	130	130	136
Studied surface (m^2)	20	16	20	20	20
Characteristics of the subassociation					
Blechnum spicant	1.1	2.2	.	2.3	2.2
Pinguicula lusitanica	.	.	1.1	+	.
Oenanthe maroccana	.	.	1.1	1.1	.
Characteristics of the association and of the superior units					
Erica ciliaris	2.3	1.2	1.2	4.5	2.3
Genista ancistrocarpa	2.3	+	.	+	.
Potentilla erecta	2.2	2.2	1.1	2.2	1.1
Calluna vulgaris	.	.	.	+	.
Danthonia decumbens	.	.	.	+	.
Lythrum junceum	1.1	.	.	.	.
Anagallis tenella	.	.	1.2	.	.
Companions					
Osmunda regalis	.	1.1	.	2.2	1.1
Alnus glutinosa	1.1	.	+	.	.
Lotus hispidus	1.1	.	.	.	.
Carex distans	.	2.2	.	1.1	1.1
Pteridium aquilinum	.	.	1.1	+	.
Carex demissa	.	.	2.3	.	+
Carex flaca subsp. *serrulata*	.	.	.	+	.

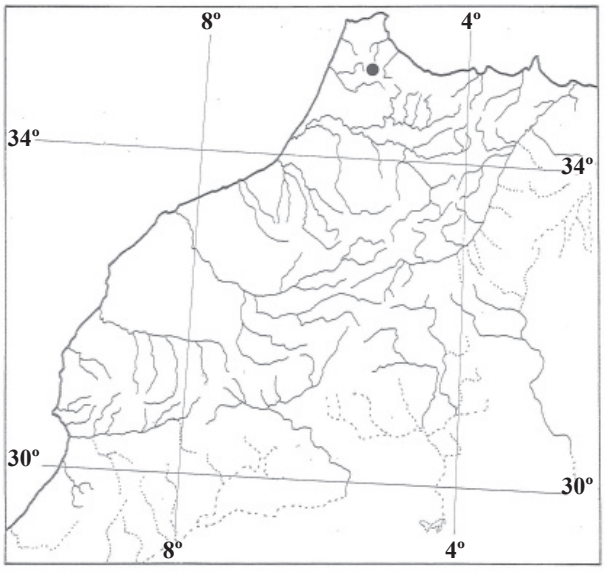

Figure 4. Distribution of *Genisto anglicae-Ericetum ciliaris* subsassoc. *pinguiculetosum lusitanicae*.

and isolation have probably enhanced speciation in these rainy areas and where the presence of wet soils has favoured this process.

The difference between both subassociations can be recognized in the adjoining table (Table 6). This new syntaxa is recognized by the lack of *Anagallis crassifolia, Erica scoparia* and *Halimium halimifolium*. That is, it becomes poor in floristic elements of the lower-lying land, and yet is enriched by plants more characteristic of the mountains.

As holotypus of this new syntaxon, relevé 3 of Table 5 is selected.

Cephalario maroccanae-Inuletum maletii assoc. nova

This plant community is characterized by the presence of some endemic taxa, such as *Inula maletii, Cephalaria maroccana* and *Paeonia coriacea* var. *maroccana* (Table 7). In it, the megaphorbic species, plants of a high and dense habit, stand out. Such is the case of *Cephalaria maroccana,* capable of attaining over 1.5 m height, or *Inula maletii,* which reaches 1m. The habit of these plants, together with their high degree of cover, imparts a frondose and robust appearance to this association, reminding one of the megaphorbic plant communities of more northern latitudes.

Cephalaria maroccana is endemic to the High Atlas and the Central Middle Atlas (near Daya-t-Hachlaf and Azrou, Fennane & Ibn Tattou, 1998).

Table 6. Comparative table of the two subassociations: (A), *Genisto anglicae-Ericetum ciliaris* subassoc. *typicum* (résumé of 5 relevés) from Quézel *et al*. (1988); (B), *Genisto anglicae-Ericetum ciliaris* subassoc. *pinguiculetosum lusitanicae* (résumé of 6 relevés).

Characteristics of subassociation	**A**	**B**
Pinguicula lusitanica	-	2
Oenanthe maroccana	-	2
Danthonia decumbens	-	1
Characteristics of association		
Erica ciliaris	6	5
Genista ancistrocarpa	5	2
Potentilla erecta	6	5
Osmunda regalis	3	3
Anagallis crassifolia	2	-
Characteristics of alliance		
Blechnum spicant	-	4
Pinguicula lusitanica	-	2
Calluna vulgaris	2	1
Erica scoparia	4	-
Agrostis setacea	2	-
Halimium halimifolium	1	-
Companions		
Pteridiumm aquilinum	2	3
Schoenus nigricans	4	-
Inula viscosa	4	-
Cistus salvifolius	3	-
Myrtus communis	2	-
Isoetes hystrix	2	-
Myosostis sicula	2	-
Eleocharis multicaulis	2	-
Carex distans	2	3
Agrostis stolonifera	2	-
Sphagnum sp.	2	-
Alnus glutinosa	-	2
Carex flava	-	2
Carex flacca subsp. *serrulata*	-	1
Lythrum junceum	-	1
Anagallis tenella	-	1

Inula maletii is restricted to the mountainous zones of the Middle Atlas (Fennane & Ibn Tattou, 1998). *Paeonia coriacea* var. *maroccana* is widely present in the Rif and the Middle Atlas (Romo, 1992).

This community develops in the cedar woodland clearings, on north-facing aspects with a fairly gentle relief. In these clearings it colonizes the humus-rich soils in which the tussocks or necks of perennial plants leave small gaps which in turn are colonized by the annual plants.

At present the association is known only from the Michliffene massif in the Middle Atlas (Fig. 5).

Table 7. *Cephalario maroccanae-Inuletum maletii*. Provenance of relevés: 1-10 Morocco, Middle Atlas, Michliffene, 33º 24' N 5 º05' W, between 1,820-1,890 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Aspect	N	N	NE	NW	N	N	N-NW
Slope	30	28	32	35	30	30	35
Cover	80	90	35	35	35	90	95
Altitude (x10)	189	184	183	184	185	185	187
Studied surface (m^2)	85	35	40	20	30	80	90
Characteristics of the association and of the superior units							
Cephalaria maroccana	4.5	4.5	3.4	3.3	4.5	3.4	4.5
Inula maletii	2.3	2.3	2.2	1.2	2.3	2.3	2.3
Geum atlanticum	.	.	.	.	.	+	1.2
Paeonia coriacea var. *maroccana*	.	.	1.1	1.1	1.2	1.2	1.2
Crepis vesicaria	1.1	.	2.1	1.1	1.1	1.1	1.1
Saponaria glutinosa	.	+	+.1	.	.	1.2	1.1
Armeria alliacea	.	+	.	.	.	.	1.1
Delphinium obcordatum			+	1.2			
Companions							
Quercus rotundifolia	1.2	+	.	.	+	.	1.1
Cedrus atlantica	.	.	+.1	1.2	+	.	+
Poa bulbosa	1.1	.	1.1	.	+	1.1	1.1
Bromus hordeaceus	1.2	2.2	1.1	2.2	.	1.2	1.2
Dianthus sylvestris	+	.	+	.	.	+	+
Cynosurus echinatus	+	+	.	.	1.1	1.2	+
Rosa canina	.	.	1.1	1.1	.	.	1.1
Galium lucidum	.	+	+	1.1	.	.	1.1
Petrorhagia prolifera	.	1.1	1.1	1.2	1.1	.	1.1
Vicia sp.	.	+	.	.	.	.	+
Satureja vulgaris			+	+			1.1
Poa pratensis				1.1			+
Catananche coerulea							+
Alyssum alyssoides		+				+	.
Xeranthemum inapertum	1.1	1.1		1.1		+	.
Helianthemum apenninum	1.2		1.1			.	1.1
Jurinaea humilis	1.2						
Mantisalca salmantica		+					
Onosma fastigiata var. *maroccana*				+			
Crataegus laciniata						.	+
Arenaria serpylllifolia		+					+
Echinaria capitata							+
Arenaria leptoclados							+
Cerastium sp.					+		
Dactylis glomerata subsp. *hispanica*		+	1.1				
Crucianella angustifolia		+					
Elymus repens		+					
Erysimum incanum							+
Linaria sp.		+	+				
Hieracium sp.							+
Rosa spinosissima			+				
Thlaspi perfoliatum					+		
Caucalis platycarpos		+					+

This zone is distinct due to its receiving humidity-laden air masses, which deposit copious snow in winter and abundant precipitations in autumn and spring. The only ski-station that exists at present in the Middle Atlas is found close by, and serves as proof of these climatic conditions.

The assigning of a phytosociological alliance in which to nest this new syntaxon is not an easy matter, due to the poor representation of structural taxa present in the more boreal megaphorb communities, and in contrast the presence of numerous species of a Mediterranean character.

The natural evolution of these megaphobic communities is towards forest formations. Dendrotaxons such as *Quercus rotundifolia* and *Cedrus atlantica* act as witnesses to this, indicating an evolution towards more or less pure forest stands of *Cedrus atlantica.*

As holotypus of this new syntaxon, relevé 6 of Table 7 is selected.

***Bellis caerulescendis-Heracletum sphondyllii* assoc. nova**

This megaforbic community is made up of herbaceous plants of considerable size, with tender, frondose leaves. Among these, representatives of the genera: *Heracleum, Alchemilla, Ranunculus* and *Polygonum* stand out (Table 8).

It colonizes the permanent watercourses of the High Atlas. It is found near springs and mountain streams in shady aspects, preferably on abrupt slopes with a north-facing aspect and in gullies excavated by the water courses, close to cliffs, between 2,400 and 2,800 m (Fig. 6).

Overgrazing and the strong pressure of ski slope installations can cause an alarming reduction of these megaphorbic communities.

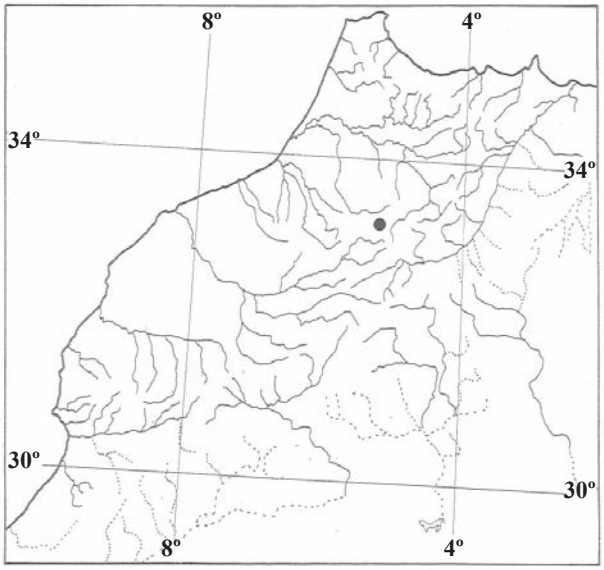

Figure 5. Distribution of *Cephalario maroccanae-Inuletum maletii.*

Table 8. *Bellis caerulescendis-Heracletum sphondyllii*. Provenance of relevés: 1-5 Morocco, High Atlas, Oukaïmedene area, southern slopes of Adrar Angour, 31º 11' N 7º 50º W, between 2,650-2,710 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**
Aspect	SW	S	-	-	-
Slope	10	5	-	-	-
Cover	100	100	100	100	100
Altitude (x10)	270	268	265	271	270
Studied surface (m^2)	25	20	30	25	25
Characteristics of the association and of the superior units					
Aconitum vulparia subsp. *neapolitanum*	1.2	.	4.4	2.3	4.4
Alchemilla atlantica	+	.	.	.	+
Bellis caerulescens	.	.	1.1	+	1.1
Carex ovalis subsp. *atlasica*	+	+	.	.	.
Heracleum sphondylium var. *suaveolens*	3.4	2.3	3.3	3.3	2.2
Polygonum bistorta	1.1	2.2	2.3	2.3	.
Ranunculus dyris	3.3	5.5	5.5	5.5	4.4
Companions					
Bromus hordeaceus	.	.	+	.	.
Cystopteris fragilis	+	+	.	.	.
Dactylorrhiza elata	.	+	+	.	.
Festuca rubra	1.1	1.1	.	.	1.1
Isatis tinctoria subsp. *tinctoria*	1.1	.	1.1	1.1	1.1
Poa trivialis	1.1	1.1	.	.	.

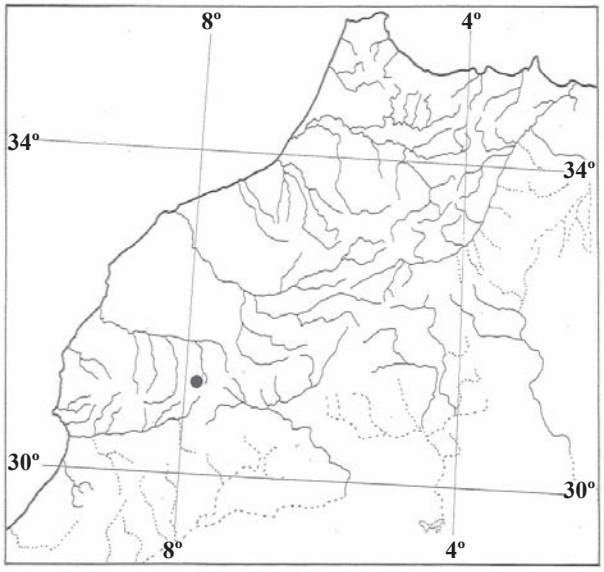

Figure 6. Distribution of *Bellis caerulescendis-Heracletum sphondyllii.*

It must be included in the alliance *Eryngion variifoliae* Quézel 1957. As holotypus of this new syntaxon, relevé 3 of Table 8 is selected.

Astragaletum numidico-maroccani Quézel, Barbero, Benabid, Loisel & Rivas-Martínez 1988

This plant community is made up, principally, of chamaephytes and, to a much lesser extent, of hemicriptophytes and therophytes (Table 9). Within the community certain endemic taxa, of very limited distribution, stand out: *Astragalus fontianus, A. meuselii* and *Allium pallescens*, the latter here surpassing the given altitudinal limit for the species, stated as 1,900 m by Mateos (2003).

This scrubland colonizes the crests and high plateaux above 2,000 m, on calcareous substrate. These areas are subject to a strong solifluxion as well as cryoturbation, owing to the high altitude. They are found in the supraforestal zone, above *Abies maroccana* woodlands, in areas with a high mountain Mediterranean climate.

It is known from between Talassentane and Lakraa, from where this syntaxon was described, and from the Jbel Lakraa (Adrar Lexhab) massif and its surrounding mountains, and possibly also from Jbel Taloussie (Fig. 7).

It is a permanent community that colonizes extreme areas of the Mediterranean high mountain environment. Its destruction leads to an increase of the annual plants and slightly nitrophilous hemicriptophytes.

Table 9. *Astragaletum numidico-maroccani*. Provenance of relevés: 1-3 Morocco, Rif Occidental, Jbel Lakraa or Adrar Lexhab, 35º 08' N 5º 09' W, between 2,080-2,140 m.

Number of relevé	1	2	3	4
Aspect	W	-	-	-
Slope	5	-	-	-
Cover	25	40	30	40
Altitude (x10)	210	214	208	210
Studied surface (m^2)	80	70	80	80
Characteristics of the association and of the superior units				
Astragalus meuselii	1.2	2.2	2.3	1.2
Alyssum spinosum	2.2	1.2	2.2	1.2
Arenaria armerina	1.1	+	1.1	+
Linaria tristis subsp. *pectinata*	1.1	.	+	+
Astragalus fontianus	.	+	+	+
Cynoglossum cheirifolium subsp. *heterocarpum*	.	+	+	+
Bupleurum spinosum	2.2	1.2	.	1.1
Companions				
Festuca hystrix	1.2	1.3	1.2	2.2
Allium pallens subsp. *pallens*	+	.	+	+
Bromus hordeaceus	+	.	+	.
Bromus sterilis	.	+	+	.
Sedum album	+	.	+	.
Sedum acre	+	+	.	+

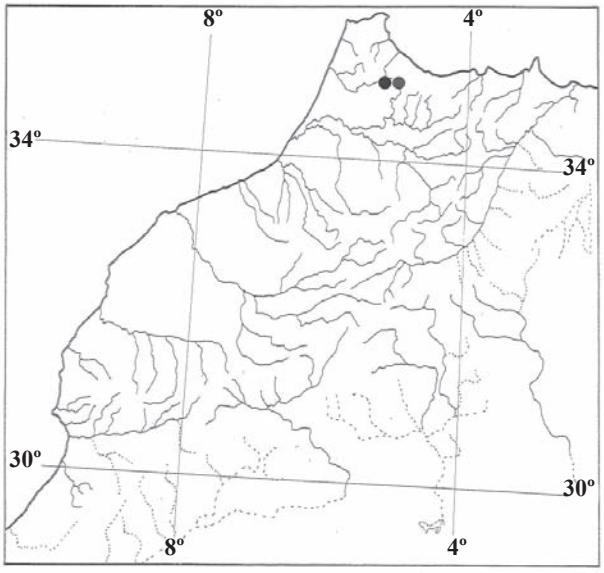

Figure 7. Distribution of *Astragaletum numidico-maroccani.*

Table 10. *Arenario armerinae-Sideritetum matris-filiae*. Provenance of relevés: 1-7 Morocco, Middle Atlas, Jbel Tichchoukt, near Lalal-Oum-el-Bent, 33º 23' N 4º 40' W, between 2,600-2,650 m.

Number of relevé	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Aspect	N	N	N	NW	S	N	N
Slope	15	30	10	15	20	15	15
Cover	40	40	45	45	30	35	40
Altidude (x10)	260	261	264	264	265	263	262
Studied surface (m^2)	80	80	60	70	50	80	70
Characteristics of the association and of the superior units							
Arenaria armerina	1.2	1.1	1.1	.	+	2.2	1.2
Bupleurum spinosum	2.3	1.1	2.3	2.2	1.1	2.3	2.2
Carduncellus atractyloides	1.2	2.2	2.2	1.1	.	+	1.1
Festuca hystrix	2.2	1.1	2.1	+	.	1.1	2.2
Helictotrichon jahandiezii	.	+	1.1	1.1	.	1.1	+
Jurinaea humilis	1.1	+	+	+	.	1.1	+
Sideritis matris-filiae	1.1	2.3	1.1	1.1	1.1	1.1	1.2
Thymus atlanticus	1.1	1.1	1.1	1.1	2.3	1.2	1.1
Alyssum atlanticum	.	.	.	.	+	.	.
Poa ligulata	1.1	1.1	1.1	+	1.1	.	1.1
Lactuca reviersii	.	.	.	.	+	.	.
Companions							
Asperula cynanchica	1.1	.	.	.	.	+	+
Helianthemum oelandicum subsp. *canum*	1.1	1.1	.	.	.	.	.
Juniperus communis subsp. *hemisphaerica*	.	.	.	.	.	+.1	.
Minuartia hibrida subsp. *hybrida*	.	.	.	.	+	.	.
Linum austriacum subsp. *mauritanicum*	.	.	.	.	+	.	.
Ononis cenisia	.	.	+	.	.	+	.
Pimpinella tragium	.	.	.	+	.	.	.
Sedum dasyphyllum	+	.	.	.	+	.	.
Satureja alpina subsp. *meridionalis*	.	.	+	.	.	.	.
Scorzonera pygmaea	.	.	.	1.2	.	.	.

It is included in the order *Erinacetalia anthyllidis* Quézel 1952, and the alliance *Diantho maroccani-Astragalion maroccani* Quézel, Barbero, Benabid, Loisel & Rivas Martínez 1988.

Arenario armerinae-Sideritetum matris-filiae assoc. nova

This is a high Mediterranean mountain plant community characterized by some endemics and other plants with a highly restricted distribution (Table 10).

Sideritis matris-filiae is an endemic basophilous plant from this range (Rejdali & Fennane, 2007) and from the Bou Nacer.

Helianthemum oelandicum subsp. *canum* is known from the High Atlas in the Jbel Ghat and Jbel Angour near Oukaimeden to Jbel Ayachi. It becomes rare in the Middle Atlas (Bou Iblane, Bou Nacer, Guelb-er-Rahal) and Tichchoukt Range (Fennane & Ibn Tattou, 1998).

Carduncellus atractyloides is known from the High Atlas (Rhate), and Tichchoukt Range in the Middle Atlas (Fenanne & Ibn Tattou, 1998).

Helictotrichon jahandiezii is an endemic plant of the Middle Atlas that reaches the ranges of Bou Iblane and Tichchoukt in the North Eastern Middle Atlas.

Lactuca reviersii is rare in the High Atlas and only known in the Middle Atlas beyond this range from Bou Iblane and Guelb-er-Rahal (Fennane & Ibn Tattou, 1998).

Juniperus communis subsp. *hemisphaerica* is rare in Morocco, otherwise from the Tichchoukt it is only referred from the massifs of Bou Iblane and Bou Nacer (Fennane & Ibn Tattou, 1998) in the Middle Atlas (Fig. 8).

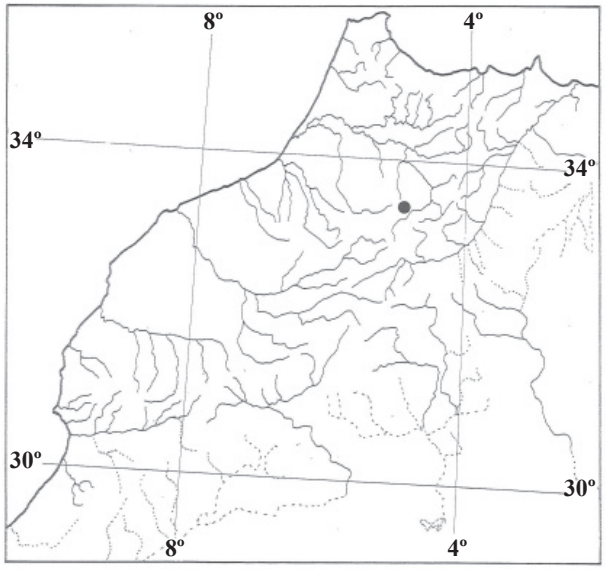

Figure 8. Distribution of *Arenario armerinae-Sideritetum matris-filiae.*

It colonizes rocky crests, where thin cryoturbated soils exist, from between 2600 and 2700 m above sea level. At present it is only known from the Tichchoukt massif, but it may well exist on the Bou Nacer Massif.

This new syntaxon must be referred to the alliance *Genistion pseudopilosae-Thymion comosi* Benabid 1988 included in the order *Erinacetalia anthyllidis* Quézel 1952, although its affinities with the alliance *Minuartio-Poion ligulatae* O. de Bolòs 1962 stand out. As holotypus of this new syntaxon, relevé 2 of Table 10 is selected.

CONCLUSIONS

In the present study of Moroccan mountain vegetation it becomes clear that the associations of some particular habitats usually occupying rather limited areas (as in the case of megaphorb communities, wet mountain flushes, bogs, mountain pastures, etc) are not known to the same extent as the forest and scrub communities. This is especially the case in the more isolated massifs which have long and difficult approaches, and the more remote uplands of complicated access and thus studied in a very general way from the botanical and phytosociological point of view, and practically unknown by these disciplines.

ACKNOWLEDGEMENTS

Along with this study I wish to remember the man who was our academic master, Professor Oriol de Bolòs. I will ever remain in debt to him for his initiating me into the fascinating world of the study of vegetation. Our gratitude to three anonymous reviewers, whose comments and indications permitted us to improve substantially this paper. Samuel Pyke has improved the English language.

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Appendix 1. Syntaxonomic synopsis of the syntaxa mentioned in the text.

QUERCO ROBORIS – FAGETEA SYLVATICAE Braun-Blanquet & Vlieger 1937
+ *Querco-Cedretalia atlanticae* Barbero, Loisel & Quézel 1974
Violo munbyanae-Cedrion atlanticae Barbero, Quézel & Rivas-Martínez 1981
Polysticho setiferi-Prunetum lusitanicae sensu Deil 1984
= *Polysticho-Prunetum* Barbero, Quézel & Rivas-Martínez 1981
Primulo acaulis-Betuletum celtibericae Barbero, Quézel & Rivas-Martínez 1981
= *Polysticho setiferi–Prunetum lusitanicae* subassoc. *betuletosum sensu* Deil 1984

CALLUNO VULGARIS – ULICETEA MINORIS Braun-Blanquet & Tüxen ex Klika & Hadac 1944
+ *Ulicetalia minoris* Quantin 1935
Genistion micrantho-anglicae Rivas-Martínez 1979
Genisto anglicae-Ericetum ciliaris Quézel, Barbero, Benabid, Loisel & Rivas-Martínez 1988 subassoc. *pinguiculetosum lusitanicae* Romo 2009

ONONIDO – ROSMARINETEA Braun-Blanquet in Braun-Blanquet, Roussine & Nègre 1952
+ *Rosmarinetalia officinalis* Braun-Blanquet ex Molinier 1934
Pseudoscabioso-Origanion grosii Quézel Barbero, Benabid, Loisel & Rivas Martínez. 1988.
Anthyllido polycephalae-Stachydetum fontqueri Quézel, Barbero, Benabid, Loisel & Rivas Martínez 1988 subassoc. *quercetosum rotundifoliae* Romo 2009
+ *Erinacetalia anthyllidis* Quézel 1952
Diantho maroccani-Astragalion maroccani Quézel, Barbero, Benabid, Loisel & Rivas Martínez 1988
Astragaletum numidico-maroccani Quézel, Barbero, Benabid, Loisel & Rivas-Martínez 1988
Genistion pseudopilosae-Thymion comosi Benabid 1988
Arenario armerinae-Sideritetum matris-filiae Romo 2009

BETULO PUBESCENTIS – ADENOSTYLETEA ALLIARIAE Braun-Blanquet & Tüxen ex Braun-Blanquet 1948
+ *Cirsietalia flavispinae* Quézel 1957
Eryngion variifoliae Quézel 1957
Cephalario maroccanae-Inuletum maletii Romo 2009
Bellis caerulescendis-Heracletum sphondyllii Romo 2009