

Contribution to the knowledge of rupicolous plant communities in the limestone areas of North Africa

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Abstract

The rupicolous plant communities of the Moroccan Rif and Atlas Mountains and the Algerian Djurjura Mountains have been studied in this contribution. The structure and floristic composition of these plant communities are described according to the phytosociological methodology. The following seven new syntaxa are described: *Saxifraga tricrenatae*-*Poetum ligulatae* and *Saxifraga globuliferae*-*Seslerietum argenteae* from the Western Rif; *Drabo hispanicae*-*Pterocephaletum kunkeliani* from the Eastern Rif; *Saxifraga globuliferae*-*Geranietum cataractari* from the Middle Atlas; *Arabido alpinae*-*Festucetum atlanticae* from the High Atlas; *Centaureo benoistii*-*Galietum ephedroides* from the Saharan Atlas and *Poo alpinae*-*Saxifragetum numidicae* from the Djurjura mountainous region.

New data referring to the chorology and floristic composition of the other previously described syntaxons are also provided.

Key words: rupicolous plant communities, Morocco (Atlas Mountains, Rif), Algeria (Djurjura), vegetation, phytosociology.

INTRODUCTION

The first global vision regarding the rupicolous communities of the Magreb was provided by QUÉZEL (1952, 1957). In these works, the major rupicolous formations of the high mountain vegetation of the Great Eastern, Central and Western Atlas, and the Middle Atlas, are described. More recently, and without going into excessive detail as regards the studies made, it is worth mentioning that DEIL (1994) studied the rupicolous communities present on both sides of the Straits of Gibraltar, DEIL & HAMMOUMI (1994) the Bokkoya Massif in the Eastern Rif, DEIL (1996) the rock seep communities in the whole of Morocco referable to the class *Adiantetetea*, GÉHU & BIONDI (1998) the maritime rupicolous communities with macaronesian affinities, MÉDAIL & QUÉZEL (1999) the rupicolous communities of the Anti-Atlas with *Dracaena* and DEIL (2006) has recently studied

Ptilostemon rock communities in the Central Rif Mountains. We must also remember that DEIL & GALÁN DE MERA (1996) have elaborated a synthesis on the limestone plant communities in Morocco.

However, over extensive areas of mountainous terrain, such as the Western Rif or the Djurjura in the (Algerian) Kabylie, their study has, at best, been fragmentary. And the principal massifs of the Atlas also reveal an only partial knowledge of the middle altitude rupicolous vegetation, since the greater part of the botanical exploration of this range has been carried out at the high mountain level. The question, therefore, is whether or not the rupicolous plant communities are in fact well known.

While carrying out our field work, we explored in particular the mid-elevation mountain areas, and little-studied areas of the Rif, the Middle Atlas and the Djurjura, and to a lesser extent the Great Atlas and Anti-Atlas.

MATERIALS AND METHODS

Throughout the process of our botanical explorations of Morocco and Algeria, a number of relevés in accordance with the phytosociological methodology of BRAUN-BLANQUET (1977), MUELLER-DUMBOIS & ELLENBERG (1974) and DIERSCHKE (1994) were elaborated. In these relevés the slope is given in degrees, not as 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 and 2007) and JAHANDIEZ & MAIRE (1931) for the rest of the country; and QUÉZEL & SANTA (1962) for Algeria.

RESULTS

Numerous associations, hitherto not recognized, have been detected and are described in the following section.

Saxifraga tricrenatae–*Poetum ligulatae*, assoc. nova

This association (Table 1) is characterized by the presence of rupicoles (saxicoles) some of which are of a very restricted range: *Saxifraga tricrenata* is an endemic to the central-West Rif (MATEOS, 2003) and is a taxon (described by Font Quer in his *Iter Maroccanum*, 1928: 156, see GONZÁLEZ BUENO, 1988) which was ignored by VARGAS (2003); *Arenaria grandiflora* subsp. *gomarica* is endemic to the western Rif, known at present from the Jbels: Lexhaab or Lakraa, Tissouka, Tasnot and Arhoud, ROMO & BORATYŃSKI (2007b) and SÁEZ *et al.* (2002); *Globularia liouvillei* subsp. *greuteri* is an endemic plant of Jbel Lakraa, recently described by MATEOS & VALDÉS (2006); and *Potentilla caulescens* subsp. *achhalii* is an endemic plant from the Middle Atlas and Rif mountains (ROMO, 2003). All these taxa highlight the great richness of endemic species from these rupicolous communities of the Western Rif (ROMO, 1995).

It colonizes the limestone cliffs of a supra-montane level, preferably with a northern or eastern orientation, at between 1600 and 2000 m. It can be found in the domain of the *Abies maroccana* woodlands

(BENABID, 1982). It colonizes the areas which receive a head-on influence of the humid air masses from the Mediterranean sea, in zones of condensation and of a high precipitation (QUÉZEL, 2000).

In its well formed state, it can be found from Jbel Tissouka to Jbel Lakraa or Adrar Lexhab. It is fairly uniform throughout this area (Fig. 1).

This new association should be included in the *Violon Saxifragae* Quézel 1952 alliance.

As typus relevé of the association, number three of Table 1 has been taken.

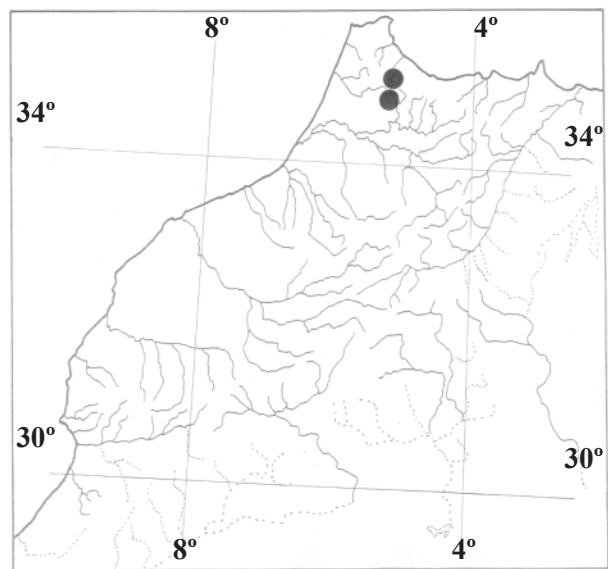


Figure 1. Distribution of *Saxifraga tricrenatae*–*Poetum ligulatae*.

Saxifraga globuliferae–*Seslerietum argenteae*, assoc. nova

Among the species characteristic of this association, the presence of the following mountain species (orophytes) should be mentioned: *Erinus alpinus*, *Sesleria argentea* subsp. *gomarica* and *Festuca rifana* (Table 2).

This association is typical of the limestone cliffs with a northern orientation, situated between 1400 and 1600 m, and exceptionally to 1700 m. As from this altitude, this community is substituted by the *Saxifraga tricrenatae*–*Poetum ligulatae*.

It occurs in the *Quercus rotundifolia* domain and in the areas where this domain meets the *Abies maroccana* domain.

Table 1. *Saxifraga tricrenatae*–*Poetum ligulatae*. Origin of the relevés: 1-5 Morocco, Western Rif, above Chefchouane, Jbel Assillenh, Tissin-Lel valley, Tissouka massif, 35° 11' N 5° 15' W; 6-13 Morocco, Western Rif, Jbel Lakraa or Adrar Lexhab, 35° 09' N 5° 08' W.

	Number of relevé												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Aspect	N	N	N	E	E	NE	W	NE	NE	NW	E	N	N
Slope	90	90	90	90	90	90	90	90	90	90	90	90	90
Cover	25	30	30	40	40	35	40	40	40	40	35	40	40
Altitude (x10)	160	165	165	174	164	180	186	185	187	187	190	188	188
Studied surface (m ²)	15	20	30	20	20	15	20	20	20	20	30	20	20
Characteristics of the association and of the superior units													
<i>Saxifraga tricrenata</i>	2.3	2.3	3.3	2.2	3.3	.	2.4	2.2	3.4	2.3	.	2.3	2.3
<i>Arenaria grandiflora</i> subsp. <i>gomarica</i>	1.1	.	.	.	.	+	1.2	1.1	.	1.2	.	1.2	1.1
<i>Erinus alpinus</i>	.	2.1	2.3	+	.	2.2	.	1.2	.	1.2	1.1	.	.
<i>Asplenium ceterach</i>	1.1	1.1	.	1.1	.	.	.	.	.	.	.	.	.
<i>Crepis albida</i>	.	.	.	1.1	.	+	.	.	+	+	+	.	.
<i>Centranthus nevadensis</i> subsp. <i>nevadensis</i>	.	.	.	1.1	.	.	.	.	.	.	1.1	.	.
<i>Potentilla caulescens</i> subsp. <i>achhalii</i>	.	.	.	.	.	2.3	.	1.2	.	.	.	.	.
<i>Leontodon tingitanus</i>	1.1	1.1	.	1.1	.	.	.	.	.	.	.	.	.
<i>Cystopteris fragilis</i>	.	.	.	.	.	.	.	.	+	+	.	.	.
<i>Globularia liouvillei</i> subsp. <i>greuteri</i>	.	.	.	.	.	+	+	.	.	.	.	.	.
<i>Rhamnus pumila</i>	.	.	.	.	.	1.2	.	.	.	2.3	1.3	1.2	.
<i>Draba hispanica</i> subsp. <i>hispanica</i>	.	.	.	.	.	1.1	.	.	.	+	1.1	.	.
<i>Asplenium trichomanes</i> subsp. <i>quadrivalens</i>	.	.	.	1.1	.	.	.	.	.	.	.	.	.
<i>Silene andryalifolia</i>	1.1	.	2.2	.	.	.	.	.	.	.	.	.	.
<i>Sedum dasyphyllum</i>	1.1	+	+	1.1	.	.	.	.	.	.	.	.	.
<i>Sedum mucizonia</i> subsp. <i>mucizonia</i>	+	.	+	+	.	.	.	.	.	.	.	.	.
<i>Chaenorhinum villosum</i> subsp. <i>granatense</i>	.	.	1.1	+	+	.	.	.	.	.	.	.	.
<i>Prunus prostrata</i>	.	.	.	.	.	.	.	.	+	.	.	.	.
<i>Linaria tristis</i> subsp. <i>pectinata</i>	.	.	.	.	+	+	.	+	.	.	.	.	.

Table 1. Cont.

	Number of relevé												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<i>Arabis alpina</i>	1.1	.	.	.	.	.	.	.	.	.	.	.	.
<i>Cerastium gibraltarium</i>	.	.	.	+
Acompanying taxa													
<i>Poa ligulata</i> subsp. <i>pau</i>	2.2	2.2	2.1	2.2	.	.	.	1.1	.	.	.	.	1.1
<i>Avenula gervasii</i> subsp. <i>arundana</i>	+	1.1	.	.	.	.	.	.	.	.	.	.	.
<i>Festuca hystrix</i>	+	.	+2	.	.	.	+	.
<i>Pimpinella villosa</i>	+	+	1.1
<i>Sanguisorba rupicola</i>	.	+	+
<i>Galium album</i>	.	.	+	.	+
<i>Scabiosa turolensis</i> subsp. <i>maroccana</i>	+	+	.	.	.
<i>Minuartia hybrida</i>	.	+
<i>Taraxacum obovatum</i>	.	.	+
<i>Alyssum serpyllifolium</i>	.	.	+	+	.
<i>Alyssum spinosum</i>	+	.
<i>Carex hallerana</i>	.	.	+
<i>Asperula laevigata</i>	.	.	+
<i>Berberis hispanica</i>	+2
<i>Dianthus sylvestris</i> subsp. <i>longicaulis</i>	2.2	.	.	.	.	.	.	.
<i>Eryngium mohamedanii</i>	+
<i>Ononis aragonensis</i>	+
<i>Iberis gros-miquelii</i>	+	.

It colonizes the montane limestone cliffs of the Western Rif, where it occurs from the Jbel Lakraa in the east to Jbel Tissouka, further west (Fig. 2).

Owing to its floristic composition, it should be referred to the *Violon saxifragae* Quézel 1952 alliance. Despite being species-poor, it contains numerous endemics such as *Sesleria argentea*

subsp. *gomarica*, a taxon found in a limited area of the limestone mountains of the Ghomara and the neighbourhood of Xauen (ROMO, 1987) and which, surprisingly, does not appear in ROMERO-ZARCO (2002). Apart from *Sesleria argentea* subsp. *gomarica*, *Erinus alpinus* and *Festuca fontqueri* are also lacking in areas of higher elevation.

Table 2. *Saxifraga globuliferae*-*Seslerietum argenteae*. Origin of the relevés: Morocco, Western Rif (1-2 Jbel Lakraa, 35° 09' N 5° 09' W; 3-4 Jbel Tissouka, Sfiha Telj, 35° 10' N 5° 13' W).

	Number of relevé			
	1	2	3	4
Aspect	N	N	N	N
Slope	80	85	80	85
Cover	15	15	20	20
Altitude (x10)	155	160	142	149
Studied surface (m ²)	20	15	20	20
Characteristics of the association and of the superior units				
<i>Arabis alpina</i>	1.2	1.2	+	1.2
<i>Cystopteris fragilis</i>	1.3	1.3	.	1.1
<i>Erinus alpinus</i>	.	.	+	+
<i>Festuca rifana</i>	.	.	1.1	.
<i>Saxifraga globulifera</i>	3.4	3.4	3.3	2.3
<i>Sesleria argentea</i> subsp. <i>gomarica</i>	.	.	3.3	2.2
<i>Sedum dasyphyllum</i>	.	+	+	+
Acompanying taxa				
<i>Abies maroccana</i>	.	.	+	.
<i>Avenula marginata</i> subsp. <i>albinervis</i>	.	.	+	+
<i>Cynosurus echinatus</i>	+	.	.	+
<i>Geranium molle</i>	.	.	+	+
<i>Ribes uva-crispa</i>	+	.	.	+
<i>Satureja vulgaris</i> subsp. <i>arundana</i>	.	.	+	+
<i>Sedum album</i>	+	+	.	.
<i>Solidago virgaurea</i>	.	.	+	+

Number 3 of Table 2 has been taken as a typus relevé.

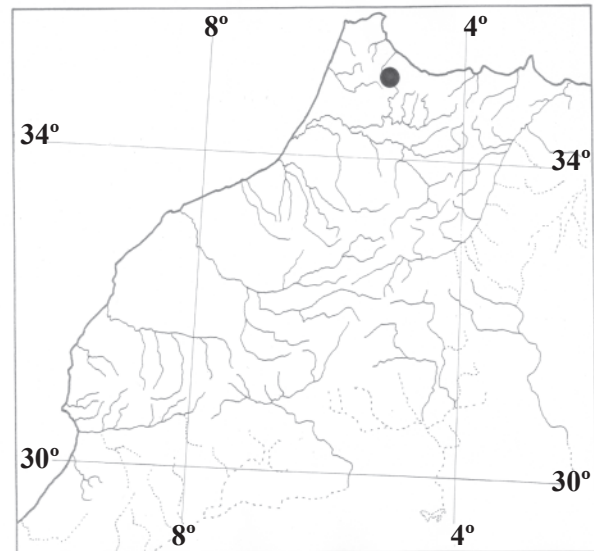


Figure 2. Distribution of *Saxifraga globuliferae*-*Seslerietum argenteae*.

***Draba hispanicae*-*Pterocephaletum kunkeliani*, assoc. nova**

Among the species characteristic of this association (Table 3), apart from some significant endemics such as *Pterocephalus kunkelianus*, an eastern Rif endemic, vicariant of *Pterocephalus depressus*, a species widespread in the High Atlas, ROMO *et al.* (1999), the following species stand out: *Silene patula* subsp. *patula* and *Draba hispanica* subsp. *hispanica*. Other taxa which reach the eastern limit of their range in the Rif include: *Paronychia maroccana*, *Erinus alpinus* and *Arenaria armerina*.

This association is typical of the shaded limestone cliffs, with a northern orientation. It occurs in the higher montane level, falling within the limits of the oromediterranean zone, from 1800 to 1980 m, in the domain of *Quercus rotundifolia* woodlands.

It colonizes the limestone cliffs of the Azrou Akechar massif. This massif is one of the highest in the Eastern Rif and is isolated from the other massifs of a similar elevation. Apart from its solitary aspect, the presence of calcareous substrates in an area where this type of substrate is rare should be noted. The great calcareous massifs are to be found in the Western Rif, whereas the Central and Eastern Rif are dominated by siliceous rocks (Fig. 3).

Table 3. *Drabo hispanicae-Pterocephaletum kunkeliani*. Origin of the relevés: 1-4 Morocco, Eastern Rif, Jbel Azrou Akechar, above Tizi Ousli, 34° 47' N 3° 51' W.

	Number of relevé			
	1	2	3	4
Aspect	N	N	N	N
Slope	90	90	90	90
Cover	40	45	40	40
Altitude (x10)	195	194	194	193
Studied surface (m ²)	20	20	20	20
Characteristics of the association and of the superior units				
<i>Saxifraga globulifera</i>	1.2	1.2	2.3	1.2
<i>Pterocephalus kunkelianus</i>	2.2	2.3	1.2	2.2
<i>Silene patula</i> subsp. <i>patula</i>	2.3	2.3	1.2	2.3
<i>Draba hispanica</i> subsp. <i>hispanica</i>	+	1.1	+	+
<i>Arenaria armerina</i>	.	1.2	1.1	1.1
<i>Paronychia maroccana</i>	.	+	+	+
<i>Crepis albida</i>	.	+	+	+
<i>Erinus alpinus</i>	1.1	.	.	+
<i>Hypochoeris laevigata</i>	.	+	+	+
Acompanying taxa				
<i>Asperula aristata</i>	+	+	1.1	.
<i>Dianthus brachyanthus</i>	+	+	.	+
<i>Leontodon eriopodus</i>	+	+	.	+
<i>Biscutella atlantica</i>	+	.	+	+
<i>Chrysanthemum demnatense</i>	+	+	.	.

This new syntaxon, in spite of its being poor in species, should be included in the *Violon saxifragae* Quézel 1952 alliance.

As a typus relevé, number 1 of Table 3 has been taken.

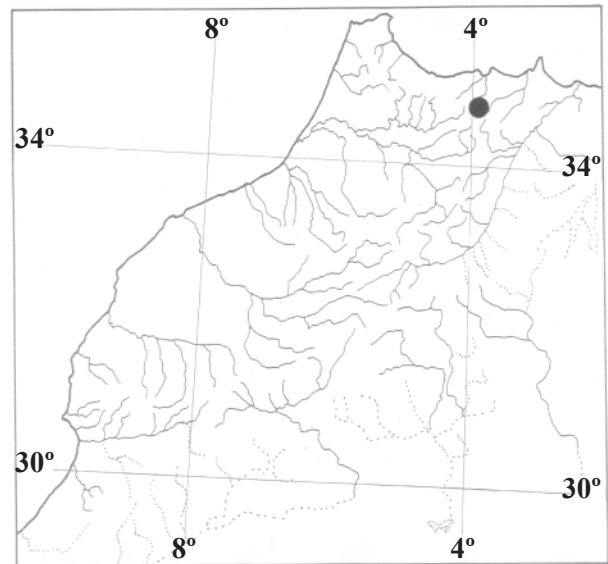


Figure 3. Distribution of *Drabo hispanicae-Pterocephaletum kunkeliani*.

***Saxifraga globuliferae-Geranium cataractari*, assoc. nova**

This association (Table 4) is characterized by the presence of, among other species, the following rupicoles: *Saxifraga globulifera* var. *spatulata*, *Biscutella frutescens*, *Silene patula* subsp. *patula*, *Sarcocapnos crassifolia*, *Draba hispanica* and *Linaria tristis* subsp. *marginata*.

Geranium cataractanum subsp. *pitardii* is an endemic rupicolous plant from limestone cliffs of the Middle Atlas, which has also been reported from the High Atlas, Jbel Ayachi at 3100 m, by GUITTONNEAU (1975). However, as FONT QUER (1931) stated, the characters on which the subspecies is based are variable, such that the recognition of this endemic entity requires further study.

It colonizes the limestone cliffs with a northern orientation, from between (1500) 1600 and 2000 m. It is found in the domain of *Cedrus atlantica* woodland and in the limits of the *Quercus rotundifolia* woodlands domain where this meets the *Cedrus atlantica* domain.

It colonizes the areas which receive a direct influence from the humid Atlantic winds. It is to be found in zones of high rainfall and atmospheric condensation.

This association grows on montane zones of the Middle Atlas, where it is known from Jbel Hebri

Table 4. *Saxifraga globuliferae-Geranium cataractari*. Origin of the relevés: 1-10 Morocco, Middle Atlas, towards Azrou, consolidated limestones close to Timahdite, 98 km to the south of Meknès, between 1820-1860 m., 36° 93' N 8° 22' W; 11-15 Morocco, Middle Atlas, Jbel Tazzeke, cliffs of Bab Bou Idir, to Bab Bou-Idir, 34° 02' N 4° 08' W.

	Number of relevé														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Aspect	N	N	NE	NW	W	N	N	N	N	NE	N	N	N	N	N
Slope	90	90	90	90	90	90	90	90	90	90	85	90	90	90	90
Cover	30	30	35	35	35	30	35	30	30	30	40	30	30	30	30
Altitude (x10)	184	184	183	184	185	184	182	184	184	184	180	181	182	181	181
Studied surface (m ²)	35	35	40	20	30	10	15	20	20	20	20	20	40	30	50
Characteristics of the association and of the superior units															
<i>Saxifraga globulifera</i>	. 3.4	. 3.3	. 2.3	. 2.2	. 3.2	. 2.2	. 3.2	. 2.2	. 2.2	. 2.2	. 4.4	. 4.4	. 4.4	. 4.4	. 3.4
<i>Geranium cataractarum</i> subsp. <i>pitardii</i>	. .	. .	. +	. +	. .	. +	. +	. +	. +	. .	. 1.1	. 2.1	. 1.1	. 1.1	. 1.1
<i>Arabis alpina</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. 1.1	. 1.1	. 1.1	. 1.1	. .
<i>Biscutella</i> <i>frutescens</i>	1.1	. .	3.4	1.1	2.1	2.2	2.2	2.2	2.2	2.2	. .	. .	. .	. .	. .
<i>Silene patula</i> subsp. <i>patula</i>	1.1	. .	2.1	1.1	. .	1.1	1.1	1.1	1.1	. .	. .	. .	. .	. .	. .
<i>Sarcocapnos</i> <i>crassifolia</i>	2.1	2.2	. .	2.1	4.4	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
<i>Linaria tristis</i> subsp. <i>marginata</i>	+ +	+ +	2.1	1.1	1.1	. .	. .	. .	. .	1.1	. .	1.1	. .	. .	. .
<i>Pimpinella</i> <i>tragium</i>	1.1	. .	+ +	+ +	1.1	+ +	+ +	+ +	+ +	. .	. .	. .	. .	. .	. .
<i>Draba hispanica</i>	. +	. .	. .	. .	. .	. .	. .	. .	. .	1.1	. .	. .	. .	. .	. .
<i>Cerastium</i> <i>gibraltarium</i>	+ .	. .	. .	+ .	. .	. .	. .	. .	. .	. .	. .	1.1	. .	+ .	. .
<i>Centranthus nevadensis</i> subsp. <i>nevadensis</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ +	+ +	+ +	. .
<i>Geranium lucidum</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ +	+ +	+ +	. .
<i>Petrorhagia illyrica</i> subsp. <i>angustifolia</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ +	2.2
<i>Rupicapnos africana</i> subsp. <i>mairei</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ .	. .	+ .	. .
<i>Bunium alpinum</i> subsp. <i>atlanticum</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ .	. .	+ .
<i>Rhamnus pumila</i>	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	+ +	+ +	. .	2.2

Table 4. Cont.

	Number of relevé														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Crepis albida</i>	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.
<i>Pritzelago alpina</i> subsp. <i>font-queri</i>	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
<i>Chaenorrhinum</i> <i>villosum</i> subsp. <i>granatense</i>	1.1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Prunus prostrata</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Acompanying taxa															
<i>Galium mollugo</i>	1.1	+	.	.	1.1	1.1	1.1	1.1	1.1	1.1	.	.	.	.	.
<i>Sanguisorba rupicola</i>	.	.	1.1	.	.	.	+	.	.	.	.	.	.	.	.
<i>Ribes uva-crispa</i>	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.
<i>Dactylis glomearta</i> subsp. <i>hispanica</i>	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.
<i>Bupleurum spinosum</i>	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rhamnus lycioides</i> subsp. <i>velutina</i>	.	+	.	.	1.1	.	.	.	.	.	.	.	.	.	.
<i>Plantago mauritanica</i>	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
<i>Umbilicus gaditanus</i>	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.
<i>Poa ligulata</i>	.	.	.	.	.	.	.	.	.	.	.	+	+	.	2.1
<i>Cynosurus elegans</i>	.	+	.	.	.	.	.	.	.	.	.	+	+	.	.

Species present in a single relevé: *Chrysanthemum demnatense* (+, 1); *Cynosurus elegans* (+, 2); *Thymelaea virgata* (+, 3); *Satureja alpina* subsp. *meridionalis* (+, 3); *Sinapis incana* (+, 4); *Sisymbrium orientale* (+, 4); *Alyssum montanum* s.l. (+, 4); *Thymus zygis* (+, 7); *Euphorbia characias* (+, 7); *Microlonchus duriaei* (+, 7); *Teucrium polium* s.l. (+, 7); *Poa bulbosa* (+, 8); *Moehringia pentandra* (2.2, 11); *Lamium flexuosum* (1.1, 11); *Alyssum serpyllifolium* (+, 11); *Anthemis pedunculata* subsp. *pedunculata* (+, 11); *Stachys circinata* (+, 11); *Bromus benekenii* (+, 11); *Tamus communis* (+, 11); *Galium lucidum* (+, 12); *Ferula communis* (+, 12); *Festuca ovina* s.l. (+, 14); *Silene colorata* (+, 15); *Hieracium* cf. *pseudopilosella* (+, 15); *Scandix australis* (+, 15).

and Jbel Tazzeke to the North, to Jbel Irhoud, further South (Fig. 4). In the latter massif, this being a more meridional locality, the species diversity grows poorer.

This new association should be included in the *Coeno-Sarcocapnion* Deil & Galán de Mera 1996 alliance.

In the Jbel Ayachi, it is substituted by *Biscutellatum frutescentis ayachicum* Quézel (1953), typical of

the shaded cliffs with a northern orientation, and situated between 2300 and 3200 m in the high mountain area of Jbel Ayachi in the Great Eastern Atlas. These are floristically very different, and in our association all the high mountain Mediterranean plants are lacking and, instead, numerous species of the middle mountain level can be found.

As a typus relevé of this association, number 3 of the Table 4 has been taken.

QUÉZEL (1957) described a close association: *Pitardietum caerulescentis*, from the Bou Naceur massif, characteristic of the zones of higher elevation of this Middle Atlas massif, where it is found in the limestone cliffs from 1800 to 2300 m. In contrast, this new association occurs at a lower altitude, where high mountain Mediterranean plants are lacking, and where other species which are indicative of a higher degree of oceanic influence than occurs in Bou Naceur massif are present.

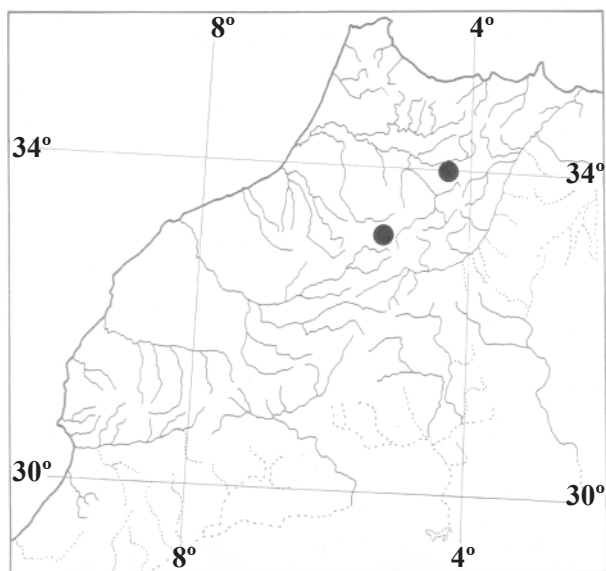


Figure 4. Distribution of *Saxifraga globuliferae*-*Geranium cataractari*.

Anthyllidetum warnieri, Quézel 1952

Despite the limited number of species characteristic of this association (Table 5), these are plants of a very reduced distribution. Among them the following species stand out: *Campanula schotteri*, *Aliella iminouakense* and *Carum iminouakense*, all of these being taxa known at present only from the Imi-n-Ouakka gorge and its surroundings.

This association is typical of the fissures and ledges of the limestone cliffs with a northern orientation, from between 1700 and 1900 m, these being somewhat ruderalized by the nitrogen-enriched droppings of the birds that colonize the rocks. It is found in the dominion of *Juniperus thurifera* subsp.

africana woodlands (ROMO & BORATYŃSKI, 2005, 2007a).

It colonizes the cliffs of limestone rocks at the middle-mountain level of the Great Central Atlas, where to date it is known only from the Imi-n-Ouakka Gorges (Fig. 5).

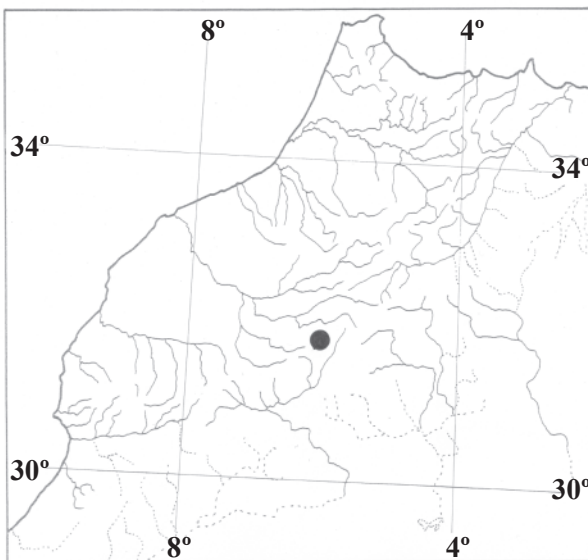


Figure 5. Distribution of *Anthyllidetum warnieri*.

Arabido alpinae-Festucetum atlanticae, assoc. nova

This association (Table 6) is characterized by the presence of, among other species, the following rupicoles: *Aliella helichrysoides*, *Aliella platyphylla* and *Festuca atlantica*.

Two distinct variants can be recognised.

The variant with *Aliella platyphylla* colonizes the porphyric cliffs with a northern orientation, from between 2600 and 3100 m. It is found at the oromediterranean level, where it covers the areas which receive a direct influence from the humid Atlantic winds, in zones of high mountain conditions.

In contrast the southern facing cliffs, cracks, fissures and skeletal soils of the rock outcrops on granite rocks, from 2600 to 3100 m, are dominated by the variant of *Aliella helichrysoides*.

This association grows on high altitude zones of the High Atlas, where it is known from Ousdim and Plateau de Tichka to the west to Jbel Angour and Oukaïmeden, further east (Fig. 6).

Table 5. *Anthyllidetum warnieri*. Origin of the relevés: 1-7 Morocco, High Atlas, Imi-n-Ouaka Gorges, between Jbel Azegza and Jbel Alimane, 1800-1860 m, 31° 37' N 6° 44' W.

	Number of relevé						
	1	2	3	4	5	6	7
Aspect	S	N	N	NE	NW	N	N
Slope	80	85	70	80	90	90	90
Cover	15	20	15	15	30	20	20
Altitude (x10)	182	182	186	182	184	184	180
Studied surface (m ²)	10	15	12	15	12	12	15
Characteristics of the association and of the superior units							
<i>Campanula schotteri</i>	.	1.2	.	+	.	1.2	1.1
<i>Aliella iminouakense</i>	1.1	2.3	1.1	.	1.1	2.2	1.2
<i>Globularia nainii</i>	2.3	.	2.2	1.2	1.1	2.2	.
<i>Polygala rupestris</i>	.	.	1.1	.	.	1.2	.
<i>Anthyllis warnieri</i>	.	1.2	1.1	.	1.2.	.	1.1
<i>Asperula aristata</i>	.	.	.	.	.	.	2.2
<i>Festuca ovina s. l.</i>	.	1.1	1.1	+	+	.	+
<i>Saxifraga globulifera</i>	.	.	.	.	.	.	+
<i>Fumana ericoides</i> subsp. <i>montana</i>	.	1.1	.	.	1.1	.	.
<i>Sedum dasyphyllum</i>	.	.	.	.	+	+	.
<i>Putoria brevifolia</i>	1.2	.	.	.	.	.	.
<i>Carum iminouakense</i>	1.1	.	.	.	.	.	.
<i>Hieracium amplexicaule</i>	.	.	.	1.1	.	+	.
<i>Centranthus battandieri</i>	.	+	.	1.1	.	.	.
Acompanying taxa							
<i>Anarrhinum fruticosum</i>	.	.	.	+	.	.	.
<i>Galium ephedroides</i>	.	1.1	1.1	.	.	.	.
<i>Paronychia kapela</i> subsp. <i>serpyllifolia</i>	.	.	.	+	.	.	.
<i>Ephedra nebrodensis</i>	.	.	.	.	.	+	.
<i>Bupleurum spinosum</i>	.	.	.	.	.	+	.
<i>Pimpinella tragiium</i> subsp. <i>litophila</i>	.	.	.	+	.	.	.
<i>Bromus tectorum</i>	.	.	+	.	.	.	.

Table 6. *Arabido alpinae-Festucetum atlanticae*. Origin of the relevés: 1-3 Morocco, Jbel Oukaïmeden, 31° 11' N 7° 52' W; 4-6: Morocco, Jbel Angour, 31° 12' N 7° 50' W.

	Number of relevé					
	1	2	3	4	5	6
Aspect	S	S	S	NE	N	NE
Slope	90	90	90	90	80	85
Cover	15	20	15	30	20	15
Altitude (x10)	295	298	300	300	299	300
Studied surface (m ²)	10	10	10	15	12	10
Characteristics of the association and of the superior units						
<i>Aliella helichrysoides</i>	1.2	2.2	1.2	.	.	.
<i>Aliella platyphylla</i>	.	.	.	2.2	1.2	+
<i>Arenaria pungens</i>	1.1	2.2	1.2	.	.	.
<i>Festuca atlantica</i>	+	1.1	+	1.1	.	.
<i>Arabis alpina</i>	+	.	.	1.1	1.2	.
<i>Festuca dyris</i>	1.1	.	.	.	.	.
<i>Minuartia stereoneura</i>	.	+	2.1	.	.	.
<i>Herniaria regnieri</i>	.	.	.	.	.	+
<i>Hieracium amplexicaule</i>	.	.	.	.	+	.
<i>Draba hispanica</i>	.	.	.	.	.	+
Acompanying taxa						
<i>Erinacea anthyllis</i>	.	+	.	.	.	.
<i>Sideritis incana</i>	.	.	1.1	.	.	.
<i>Bellis caerulescens</i>	.	.	.	2.1	+	.

It colonizes the granite and porphyry cliffs of the high level of the High Atlas, and to date it is known only from localities ranging from the Oukaïmeden massif to the Jbel Ousdim.

QUÉZEL (1957) described a close association: *Saxifraga maireanae-Phagnaletum platyphyllae*, from the Toubkal, Bou-Ourioul and Tazerhart massifs, characteristic of the zones of lower

elevation of this High Atlas area, where it is found in the sandy and schistic cliffs from 1900 to 2600 m. In contrast, this new association occurs at a higher altitude, where Mediterranean mountain plants are lacking.

It should be included in the *Violon saxifragae* Quézel 1957 alliance.

Number 1 of the Table 6 has been taken as a *typus* relevé.

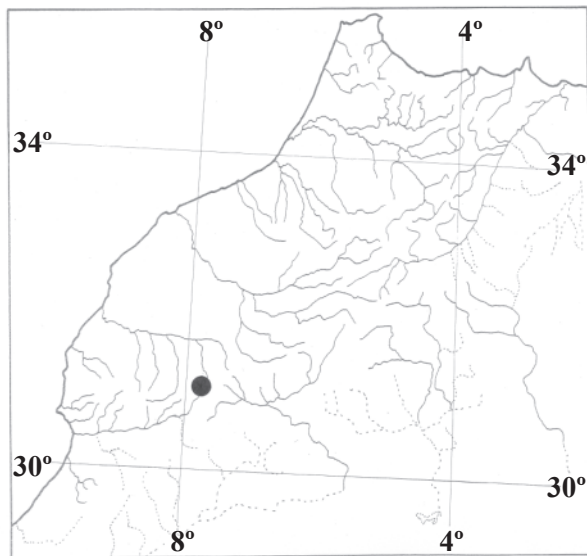


Figure 6. Distribution of *Arabido-Festucetum atlanticae*.

***Centaureo benoistii-Galietum ephedroidis*, assoc. nova**

Among the species characteristic of this association (Table 7), the following are worthy of special mention: *Centaurea benoistii*, *Galium ephedroides* and *Rhamnus atlantica*.

This association is typical of the limestone cliffs with a western or northern orientation, from 1300 to 1600 m. It is found in the dominion of *Adenocarpus bacqueri-Buxetum* (QUÉZEL & BARBERO, 1981), scrublands, see BARBERO *et al.* (1981). It colonizes the very continental areas which are subject to strong thermal oscillations and reduced rainfall.

It colonizes the limestone cliffs of the montane level of the Great Saharan Atlas, and extends from the Jbel Tazigzaout in the north to the Jbel Izouggarn, situated further south (Fig. 7).

This new association should be included within the alliance: *Bupleuro aiouensis-Globularion nainii* Quézel, Barbero, Benabid, Loisel & Rivas-Martínez, 1992.

As a *typus relevé*, number 2 of Table 7 has been taken.

According to QUÉZEL *et al.* (1994) it is replaced further south by *Lavandulo brevidens-Hertietum maroccanae*, between 1500 and 1600 m; which in turn and at a lower altitude (between 1200 and

1440 m), is replaced by *Convolvulo trabutiani-Genistetum capitellatae*.

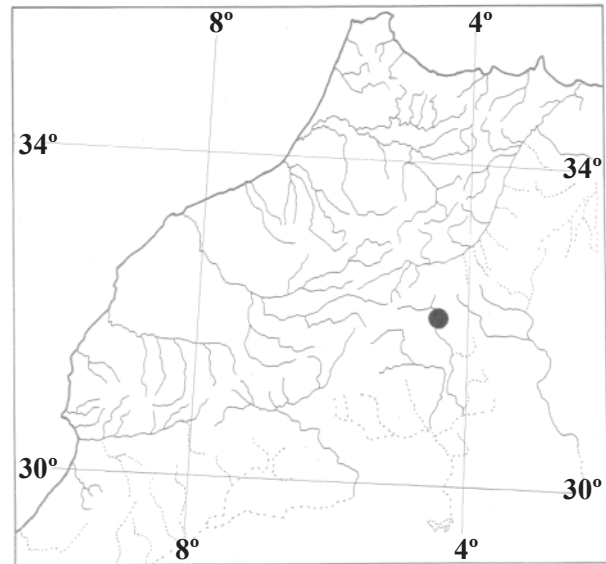


Figure 7. Distribution of *Centaureo benoistii-Galietum ephedroides*.

***Poo alpinae-Saxifragetum numidicae*, assoc. nova**

Among the characteristic species of this association (Table 8) it is worth mentioning the presence of numerous endemics typical of the Djurdjura massif: *Saxifraga numidica*, *Leontodon djurdjurae*, and *Poa alpina* subsp. *numidica*.

This association is typical of the shaded limestone cliffs, with a northern orientation, from 1400 to 1700 m. It is found in the domain of *Quercus rotundifolia* woodlands.

It colonizes the montane limestone cliffs of the Djurdjura massif, to the east of Algeria, and to date it is known only from the Jbel Heidzer.

The *Galio-Campanuletum jusiuriensis* has been described by Quézel, which substitutes this association higher up, from 1700 to 2300 m, WOJTERSKI (1985). This association has been included by QUÉZEL (1957: 103) into the *Potentillion caulescentis* alliance of the southern European mountains. To this same alliance the newly described association should be referred. This new syntaxon, despite been poorer in species, nonetheless contains numerous endemics which are lacking in areas of greater elevation.

As a *typus relevé*, number 5 of the Table 8 has been taken.

Table 7. *Centaureo benoistii-Galietum ephedroidis*. Origin of the relevés: 1-4 Morocco, Great Saharan Atlas, Gorges du Ziz, below Aït Serhouchène, towards Rich, crystalline limestones, 1590-1620 m, 32° 16' N 5° 31' W.

	Number of relevé			
	1	2	3	4
Aspect	N	W	W	N
Slope	90	90	100	90
Cover	20	30	25	30
Altitude (x10)	159	160	162	160
Surface studied (m ²)	30	20	30	40
Characteristics of the association and of the superior units				
<i>Galium ephedroides</i>	2.3	1.1	1.1	2.1
<i>Centaurea benoistii</i>	1.1	1.1	2.1	1.1
<i>Rhamnus atlantica</i>	+	+	1.1	.
<i>Anarrhinum fruticosum (terr.)</i>	.	.	.	+
<i>Delphinium balansae</i>	.	.	.	+
<i>Lavandula tenuisecta</i>	.	.	.	+
Acompanying taxa				
<i>Stipa tenacissima</i>	+	+	1.1	.
<i>Capparis spinosa</i>	+	2.1	.	.
<i>Launea acanthoclada</i>	.	.	1.1	.
<i>Silene rouyana</i>	.	.	.	+
<i>Stipa parviflora</i>	.	.	.	+
<i>Pimpinella villosa</i>	.	.	.	+
<i>Avenula bromoides</i>	.	.	+	+

Syntaxonomic synopsis, following FENNANE (2003), and hierarchical relationships of the syntaxa cited in the text: Although many of the following associations are not mentioned in the text, all the syntaxa described in the study area for each phytosociological alliance have been included.

Class *Asplenietea trichomanis* (Braun-Blanquet in Meier & Braun-Blanquet 1934) Oberdorfer 1977

Potentilletalia caulescentis Braun-Blanquet in Braun-Blanquet & Jenny 1926

Potentillion caulescentis Braun-Blanquet in Braun-Blanquet & Jenny 1926

Poo alpinae-Saxifragetum numidicae Romo 2008

Violion saxifragae Quézel 1952

Anthyllidetum warnieri sensu Quézel 1952

Arabido alpinae-Festucetum atlanticae Romo 2008

Arenarietum dyris Quézel 1952

Arenarietum mairei Quézel 1952

Campanulo embergeri-Erodietum atlanticae Quézel 1957

Drabetum mariae-aliciae (Quézel 1952) Deil & Galán de Mera 1996

Drabetum oreadae (Maire 1924) Quézel 1957

Drabo hispanicae-Pterocephaletum kunkeliani Romo 2008

Erigeronto celerieri-Valerianetum

globulariifolii Quézel 1957

Gnaphalietum genevoisii Quézel 1952

Pitardietum coerulescentis Quézel 1957

Saxifragetum gaussemi Quézel 1952

Saxifragetum maireanae-Phagnaletum platyphyllae Quézel 1957

Saxifragetum mesatlantici Quézel 1957

Saxifrago globuliferae-Seslerietum argenteae Romo 2008

Saxifrago tricrenatae-Poetum ligulatae Romo 2008

Sileno dyris-Silenetum boryi Quézel 1957

Coeno-Sarcocapnetalia Deil & Galán de Mera 1996

Rupicapnion africanae Daumas, Quézel & Santa 1952

Rupicapnetum africanae Braun-Blanquet & Maire 1924

Rupicapnetum mairei Braun-Blanquet & Maire 1924

Rupicapnetum oranensis (Daumas, Quézel & Santa 1952) Deil & Galán de Mera 1996

Coeno-Sarcocapnion Deil & Galán de Mera 1996

Sarcocapnetum enneaphyllae Rivas Goday 1941

Sarcocapnetum (crassifoliae) speciosae Esteve

Table 8. *Poa alpinae-Saxifragetum numidicae*. Origin of the relevés: 1-7 Algeria, Djurjura massif, Jbel Heidzer, near Tala Guilef, between Yikjda and Tali Guilef, 36° 39' N 4° 05' E.

	Number of relevé						
	1	2	3	4	5	6	7
Aspect	N	N	N	N	N	N	N
Slope	90	90	90	90	85	90	80
Cover	20	25	20	20	25	25	20
Altitude (x10)	133	135	135	140	140	143	140
Studied surface (m ²)	20	15	10	15	25	20	20
Characteristics of the association and of the superior units							
<i>Saxifraga numidica</i>	1.1	+	.	+	1.1	1.1	+
<i>Leontodon djurjurae</i>	+	+	.	1.1	+	1.1	1.1
<i>Arabis alpina</i> subsp. <i>doumetii</i>	1.1	+	.	2.2	+	1.1	1.2
<i>Anthemis punctata</i>	+	1.1	1.1	+	1.1	1.1	+
<i>Ceterach officinarum</i>	+	+1	.	.	+	.	+
<i>Poa alpina</i> subsp. <i>numidica</i>	.	.	1.1	+	1.1	1.1	+
<i>Hornungia petraea</i>	.	.	.	+	.	.	.
<i>Sedum album</i>	.	.	.	+	.	.	.
Acompanying taxa							
<i>Arenaria leptoclados</i>	.	.	.	+	.	.	+
<i>Bromus mollis</i>	.	.	.	+	.	.	.
<i>Berberis hispanica</i>	.	.	.	+	+	.	.
<i>Cotoneaster racemiflora</i>	.	.	.	.	+	+	.
<i>Erysimum grandiflorum</i>	.	.	.	+	.	.	.
<i>Valeriana tuberosa</i>	.	.	+	.	.	.	.

& Fernández-Casas 1971

Sarcocapno crassifoliae-Erodietum tordylioidis Daumas, Quézel & Santa 1952

Sarcocapnetum atlanticae Quézel 1952

Saxifraga globuliferae-Geranium cataractari Romo 2008

Anarrhino fruticosi-Astragelalia armati Quézel & al. 1992

Bupleuro aiouensis-Globularion nainii Quézel

& al. 1992

Centaureo benoistii-Galietum ephedroides Romo 2008

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