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A contribution to the knowledge of the Moroccan Central Plateau plant communities

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Abstract

This work consists on a thorough phytosociological study and particularly the ecosystems of the Site of Biological and Ecological Interest (SBEI) of Kharouba, harboring some of the most beautiful *Tetraclinis* stands (*Tetraclinis articulata* (Vahl) Masters) at national level. This study allowed us to identify a new association called *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova. We present in this article its floristic and ecologic particularities.

Key words: Central Plateau, phytosociological study, *Tetraclinis* stands, SBEI of Kharouba.

Introduction

By its position between the Atlantic Ocean to the West and the Mediterranean Sea to the North, Morocco has got, compared to other Mediterranean countries, some original orographic, lithological, edaphic, climatic and original bioclimatic diversities. These unique characteristics offer Morocco its floristic richness, counting about 7000 taxa (species, subspecies and varieties) from which 950 are endemic (Benabid, 2000).

According to Fennane (2003), 36 classes, 61 orders, 87 alliances and 595 associations have been described in Morocco. However, this phytosociological classification remains incomplete. Various phytosociological, ecological and biogeographical values still require to be reviewed and clarified (Fennane, 2003).

The SBEI of Kharouba, located in the central part, offers some nice *Tetraclinis* stands (*Tetraclinis articulata* (Vahl) Masters) and still one of the most natural forests of the region, giving it an important floristic richness with over 143 taxa belonging to 54 families.

The phytosociological studies in the Central Plateau area revealed the presence of more than 9 associations (Fennane, 1988). However, to be carried out on a global scale in the Central Plateau region, this analysis need a more detailed and focused work.

In this perspective, a phytosociological study was conducted in 2014 at the Moroccan Central Plateau forest ecosystems, in particular at the SBEI of Kharouba to complete the previous studies, offering us the opportunity to find a new association.

Our objective is to determine the characteristics of this new association both floristically and biogeographically, and to compare it with the different associa-

tions previously described in the region.

Study area

The SBEI of Kharouba, with an area of 6,300 hectares, is a site of priority one (AFM, 1996). Located in the Moroccan Central Plateau, this area is characterized by its various reliefs, multitude expositions and different slopes. We note the abundance of Ordovician rocks represented by diverse schists including slate, sandstone and quartzite. Its soil is mostly skeletal. As for the climate, the average annual rainfall in the area varies between 450 mm and 600 mm and the average annual temperature ranges from 1 °C to 34 °C. The bioclimate is subhumid and semi-arid with temperate and cool variants (MCEF, 2002).

This SBEI is occupied by *Tetraclinis articulata* (Vahl) Masters widespread in low altitude and in warm zones, while the relatively humid environments are marked by the *Quercus rotundifolia* abundance.

Materials and Methods

The methodology approach recalls the following three concepts:

-The classical phytosociological approach, also called sigmatiste (International Station of Mediterranean and Alpine Geobotany Montpellier), was first developed by Braun-Blanquet (1932). It is based on the plant association concept. It is the most used methods in Morocco in order to describe plant structures (Barbero *et al.*, 1981; Benabid, 1982; Achhal, 1986; Aafi *et al.*, 1987, 2005; Aafi, 1995). This approach is based on the physiognomical features, height and cover of the diffe-

rent plant formations described and the ecological determinant factors (altitude, exposition, soil, slope and substrate). This method has been applied to evaluate the 150 floristic surveys allocated in the field.

-The numerical approach, supporting the first process, relies on the Factorial Correspondence Analysis (FCA) and association with the phytosociological sigmoidal interpretations. The FCA enable us to describe the distribution of surveys, species and the ecological descriptors, in their containing space graphic and to establish the plant communities type from a set of surveys that have common floristical and ecological affinities.

-The cartographic approach, requiring the use of supervised classification of high resolution satellite image (2.5 m) dating from 2008, was adopted for the plant communities spatialization.

Results and discussion

The numerical approach results

The eigenvalues table (Tab.1) shows that axis 1 eigenvalue exceeds 0.60; which is the minimum threshold required for easy groups' individualization (Benzecri, 1973).

Factorial Axes Interpretation

The interpretation of the factorial axis was executed through the absolute contribution (CTR) or the relative contributions (COR) expressing the opposition between two sets of points in each of its poles, positive and negative. In this case, strong contributions from species were taken into account, pointing out the correspondence between the floristic surveys and the species.

Based on the species ecological values with strong contributions, axis 1 can be interpreted as an altitude and exposition indicator, associated with a stressed degradation effect. On the positive side, we find species, which are located in low altitudes and warm expositions, such as: *Tetraclinis articulata*, *Rhus pentaphylla*, *Olea europaea* var. *oleaster*, *Pistacia lentiscus*, *Hyparrhenia hirta*, *Lamarckia aurea*. This group incorporates the floristic surveys: R57, R59, R71, R83, R90, R91, R92, R93, R94, R96, R99, R115.

On the negative side, we placed surveys that are usually located in fresh expositions and at higher altitude. Among the species with strong contributions, we

find *Quercus rotundifolia*, *Myrtus communis*, *Cistus salviifolius*, *Cistus albidus*, *Ononis natrix*, *Arisarum vulgare*, etc.. This group consists of floristic surveys: R3, R5, R22, R27, R28, R29, R31, R34, R39, R41, R43, R44.

Axis 2 highlights two species groups: the first group, based on the negative side, represents species such *Clematis cirrhosa*, *Smilax aspera*, *Nerium oleander*, *Tamarix africana* and *Vitex agnus-castus*. These are considered to be indicators for riparian areas and humid conditions of the station. This group includes the following floristic surveys: R1, R2, R3, R5, R22, R95, R115.

On positive side, the second group harbors mesophilic and thermophilic species such as *Lavandula dentata*, *Cistus albidus*, *Quercus rotundifolia*, *Tetraclinis articulata*, etc.. This group consists of floristic surveys: R31, R34, R39, R41, R43, R91, R92, R93, R96, R99.

The factorial plan graph analysis (Fig.1) reveals the individualization of a group consisting of the following surveys: R90, R91, R92, R93, R94 and R96. This group is characterized by the following species: *Rhus pentaphylla*, *Pistacia lentiscus*, *Tetraclinis articulata*, *Olea europaea* var. *oleaster*, *Ephedra fragilis*, *Lavandula multifida*, *Osyris lanceolata*, *Lamarckia aurea*, *Dipsacus sativus*, *Hyparrhenia hirta*, *Ammi majus*, *Notholaena vellea* and *Logfia gallica*.

The classical phytosociological method results

The surveys table analysis (Tab. 2) taken at the SBEI of Kharouba, allowed us to identify and confirm the existence of a new association, and the features are presented below.

Floristic and ecological description of the new association

This association is dominated by *Pistacia lentiscus* and *Rhus pentaphylla*. Together, they constitute the core of this new association which is characterised by some typical characteristic species of *Pistacio-Rhamnetalia alaterni* order. *Tetraclinis articulata* remains the only tree stratum in this association.

This new association is not to be considered as a climax. Moreover, our observations and extensive analysis of the association floristic cortege allow us to assert that this is a drift of *Coronillo viminalis-Tetraclinium articulatae* climax by degradation phenomena (Barbero et al., 1981).

As for the degradation of *Rhus pentaphyllae-Pistacietum lentisci* ass. nova, it shows considerable infiltration by *Hyparrhenia hirta*, *Lamarckia aurea*, *Lavandula multifida*, etc..

The plant community is located between 400 and 600 m of altitude. It occupies the Southern and South-eastern expositions of Oued-Beht, over rough terrain with more than 30% slopes in subhumid and semi-arid

Tab. 1 - Inertia explained and eigenvalues of the first three FCA axes.

	F1	F2	F3
Eigenvalues	0.635	0.468	0.41
Inertia rate (%)	15.849	11.684	10.23
Cumulative Inertia%	15.849	27.533	37.763

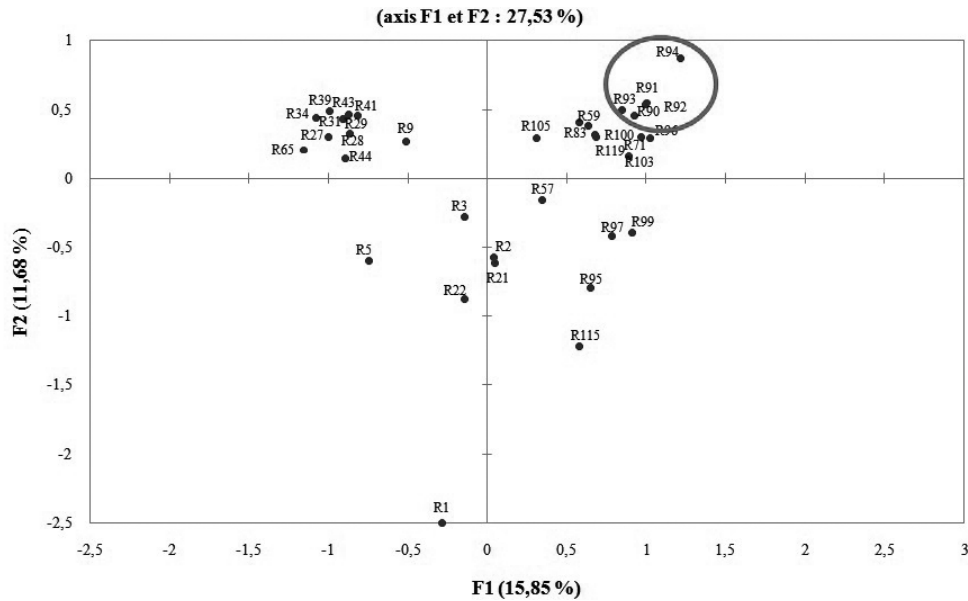


Fig. 1 - Factorial plan graph (Legend: R: survey).

Tab. 2 - Association of *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova (The criteria used in nomenclature of taxa are based on our field samples and phytosociological studies done in Morocco and North Africa since early 20th century). (Legend: Substrate - S: Schist; G: Sandstone; Soil - Sh: Shallow)

Statement number	90	91	92*	93	94	96	
Altitude (m a.s.l.)	597	527	500	457	412	424	
Exposition	S	SE	S	S	SE	SE	
Slope (%)	44	31	40	46	65	81	
Substrate	SG	SG	SG	SG	SG	SG	
Type of Soil	Sh	Sh	Sh	Sh	Sh	Sh	
Characteristic species of the association							
<i>Rhus pentaphylla</i>	2.2	+	1.2	1.2	1.2	+	6
<i>Pistacia lentiscus</i>	1.1	3.4	2.3	1.2	2.2	2.3	6
<i>Tetraclinis articulata</i>	1.1	+	1.2	+	1.1	1.1	6
Characteristic species of the <i>Pistacio-Rhamnetalia</i>							
<i>Olea europaea</i> var. <i>oleaster</i>	2.3	3.3	2.3	2.3	2.3	3.3	6
<i>Ephedra fragilis</i>	.	.	.	.	.	+	1
Characteristic species of the <i>Cisto-Rosmarinetea</i>							
<i>Lavandula multifida</i>	.	.	.	.	1.1	1.1	2
<i>Osyris lanceolata</i>	.	.	.	.	.	+	1
Other species							
<i>Lamarckia aurea</i>	1.1	1.1	1.1	+	+	.	5
<i>Dipsacus sativus</i>	+	+	.	+	+	+	5
<i>Hyparrhenia hirta</i>	1.1	.	1.1	.	1.1	1.1	4
<i>Ammi majus</i>	.	.	1.1	.	.	+	2
<i>Notholaena vellea</i>	.	.	.	+	+	.	2
<i>Logfia gallica</i>	+	+	.	.	.	.	2
<i>Carlina racemosa</i>	.	.	+	.	.	.	1
<i>Daucus carota</i>	1.1	.	.	.	.	.	1
<i>Carduus marianus</i>	+	.	.	.	.	.	1
<i>Leontodon picroides</i>	.	.	+	.	.	.	1
<i>Diplotaxis catholica</i>	.	.	.	+	.	.	1
<i>Eryngium tricuspidatum</i>	.	.	.	+	.	.	1
<i>Bupleurum glaucum</i> f. <i>maritimum</i>	.	.	.	.	+	.	1
<i>Lotus corniculatus</i>	.	.	.	.	+	.	1
<i>Avena sterilis</i>	.	.	.	.	.	+	1
<i>Sonchus asper</i>	.	.	.	.	.	+	1

bioclimate with temperate and cool variants. It has between 450 and 600 mm of rainfall per year during 50-70 days. The dry period lasts 5 to 6 months.

It is located on schists and sandstones substrates characterized by skeletal and eroded soils.

The name of this new association

Rhus pentaphylla is the key species of this association and *Pistacia lentiscus* is the most remarkable species among the characteristics of this same association. Therefore, it fits to name this new association: *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova (holotypus: rel. 92 of Tab. 2, this paper).

Comparison of this new association with different associations of *Pistacio-Rhamnetalia alaterni* Rivas-Martínez 1975

A rigorous examination of the association table (Tab. 1) highlights the floristic and biogeographic affinities of this plant community compared with those described in *Pistacio-Rhamnetalia alaterni* Rivas-Martínez 1975. In particular:

- *Rhoo pentaphyllae-Pistacietum atlanticae* Barbéro, Quézel & Rivas-Martínez 1981;
- *Rhoo pentaphyllae-Tetraclinetum articulatae* Hadjadj-Aoul 1991.

Comparison with *Rhoo pentaphyllae-Pistacietum atlanticae* Barbéro, Quézel & Rivas-Martínez 1981

Rhoo pentaphyllae-Pistacietum atlanticae described by Barbero *et al.* (1981) is located in the Moroccan Central Plateau on schist in semi-arid bioclimate. Once we confronted its features with those of our new association, we noticed a similarity, especially for *Asparagus-Rhamnion* and *Pistacio-Rhamnetalia* characteristic species. However, among the characteristics of the two associations, *Pistacia atlantica* is replaced by *Pistacia lentiscus* in our surveys. On the ecological side, *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova is located on relatively high altitudes and slopes.

Due to their floristic similarities, we can classify our plant community with *Rhoo pentaphyllae-Pistacietum atlanticae*, described by Barbero *et al.* (1981). It ranks in the same suballiance of *Pistacienion atlanticae* Barbero *et al.* 1981, which also falls within the alliance of *Tetraclini articulatae-Pistacien atlanticae* Rivas-Martínez *et al.* 1984.

Comparison with *Rhoo pentaphyllae-Tetraclinetum articulatae* Hadjadj-Aoul 1991

We also compared our new association table (Tab. 1) with the plant community table (Appendix I) described by Hadjadj-Aoul (1991) in Algeria.

The detailed analysis shows an affinity between the two associations in terms of the floristic composition, especially for some species common to Moroccan and

Algerian associations, such as: *Tetraclinis articulata*, *Rhus pentaphylla*, *Pistacia lentiscus*, *Lavandula multifida* and *Olea europaea*. Nevertheless, our new association is characterized by low cover degree of *Tetraclinis articulata*, in addition to the absence, in our surveys, of *Whitania frutescens*, characteristic species of the Algerian association.

Even more ecological conditions (altitudes and substrates) are different. Indeed, *Rhoo pentaphyllae-Tetraclinetum articulatae* Hadjadj-Aoul 1991 occupies the southern exposition in the Sahel of Oran between 100 and 300 m altitude and can be found on relatively warm carbonate substrate or basalts (Hadjadj-Aoul, 1991). On the contrary, our association thrives in South and South-Eastern expositions, on schists and sandstone substrates characterized by skeletal soils, and at higher altitudes ranging from 400 to 600 m.

The mapping method results

The plant communities' map reflects the results of phytosociological study. Once we go through the identification of the new phytosociological association, we start the mapping procedure. Indeed, surveys with common ecological and floristic affinities were put together in the same stratum, allowing us to map the new plant community (Fig. 2) and calculate its surface as well.

According to the mapping results, the association oc-

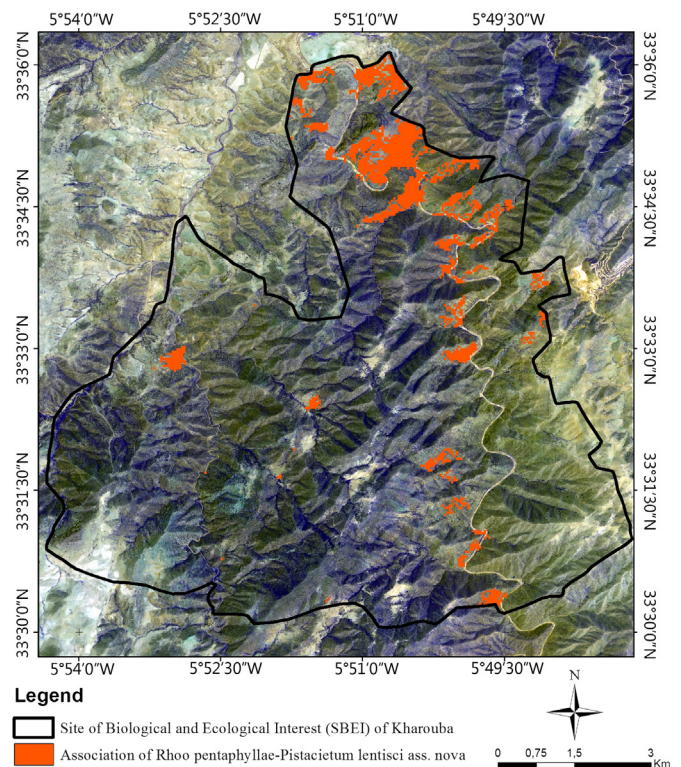


Fig. 2 - Distribution of the association *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova across the broader study area.

cupies an area of about 306 ha or approximately 5% of the SBEI total extent, located mainly on the shores of Oued-Beht.

Conclusions

The detailed phytosociological study of the Site of Biological and Ecological Interest (SBEI) of Kharouba and its forest ecosystems allowed us to pinpoint a new association: *Rhoo pentaphyllae-Pistacietum lentisci* ass. nova.

This association extends over an area of about 306 ha, is located between 400 and 600 m of altitude. It oc-

cupies the South and South-East expositions, in subhumid and semi-arid bioclimate with temperate and cool variants, characterized by skeletal soils. It is distinguished by the following species: *Rhus pentaphylla*, *Pistacia lentiscus* and *Tetraclinis articulata*.

The phytosociological classification connects this new association to the suballiance of *Pistacienion atlanticae* Barbero *et al.* 1981, consequently relating to the alliance of *Tetraclini articulatae-Pistacion atlanticae* Rivas-Martínez *et al.* 1984 of the order of *Pistacio-Rhamnetalia alaterni* Rivas-Martínez 1975 and therefore the class of *Quercetea ilicis* Br.-Bl. 1947.

Syntaxonomic scheme

QUERCETEA ILICIS Br.-Bl. 1947

PISTACIO-RHAMNETALIA ALATERNI Rivas-Martínez 1975

Tetraclini articulatae-Pistacion atlanticae Rivas-Martínez *et al.* 1984

Pistacienion atlanticae Barbero *et al.* 1981

Rhoo pentaphyllae-Pistacietum lentisci ass. nova

Other syntaxa quoted in the text

Rhoo pentaphyllae-Pistacietum atlanticae Barbéro, Quézel & Rivas-Martínez 1981; *Rhoo pentaphyllae-Tetraclinetum articulatae* Hadjadj-Aoul 1991.

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Appendix I: Association of *Rhoo pentaphyllae-Tetraclinum articulatae* Hadjadj-Aoul 1991 (Legend: Substrate - G: Sandstone, Ca: carbonate, Ba: basalts)

Statement number	142	158	156	5	165	178	95	96	76	25	83	Presence
Altitude (m a.s.l.)	-	200	350	200	150	200	200	200	50	50	50	
Exposition	E	O	SE	S	SE	S	SE	SO	O	-	SO	
Slope (%)	30	25	20	10	15	5	30	30	-	-	10	
Substrate	-	G	-	G-Ca	Ca	-	Ca	Ca	Ba	-	Ba	
Characteristic species of the association												
Tetraclinis articulata	3.2	1.1	3.3	1.2	2.2	2.1	3.3	2.2	.	.	.	8
Rhus pentaphylla	.	.	.	1.1	1.1	+	2.1	.	2.2	+	+	7
Whitania frutescens	.	.	.	+	.	.	.	1.1	1.1	1.1	+	5
Characteristic species of the <i>Pistacio-Rhamnetalia</i> and <i>Quercetea ilicis</i>												
Pistacia lentiscus	1.1	1.1	+	+	2.2	3.1	2.1	3.1	2.1	.	+	10
Chamaerops humilis	+	+	.	+	2.1	2.2	1.1	1.1	1.1	.	+	9
Arisarum vulgare	+	2.1	1.1	+	2.1	+	+	2.1	+	.	.	9
Calycotome intermedia	1.1	+	.	1.1	.	2.1	1.1	+	1.1	+	.	8
Olea europaea	.	.	1.1	+	1.1	.	1.1	+	.	.	.	5
Asparagus stipularis	.	.	+	.	1.1	+	.	1.1	.	.	.	4
Asparagus albus	.	.	.	.	+	.	.	1.1	1.1	.	.	3
Eryngium tricuspidatum	+	.	1.1	+	.	.	.	.	.	.	.	3
Rubia peregrina	.	.	.	.	.	+	.	.	2.1	.	+	3
Ceratonia siliqua	.	.	.	.	+	1.1	.	.	.	.	.	2
Prasium majus	.	.	.	.	1.1	.	.	2.1	.	.	.	2
Asparagus altissimus	.	.	.	.	.	.	.	+	2.1	.	.	2
Ziziphus lotus	.	.	.	.	.	.	.	.	.	1.1	+	2
Ampelodesma mauritanica	1.1	.	.	.	.	.	.	.	.	.	.	1
Ephedra altissima	.	.	.	.	.	.	.	.	+	.	.	1
Crataegus maura	.	.	.	.	.	.	.	.	.	+	.	1
Aristolochia baetica	.	.	.	.	.	.	.	.	1.1	.	.	1
Asparagus acutifolius	.	.	.	.	.	.	.	.	.	+	.	1
Characteristic species of the <i>Cisto-Rosmarinetea</i>												
Lavandula dentata	+	2.1	1.1	+	2.1	2.2	3.1	+	1.1	.	+	10
Ruta chalepensis	.	.	.	+	1.1	1.1	.	1.1	.	.	+	5
Fagonia cretica	.	.	.	.	.	.	.	+	1.1	+	+	4
Teucrium polium	+	.	+	+	.	.	.	.	.	.	.	3
Cistus monspeliensis	2.1	+	.	.	.	.	.	.	.	.	.	2
Lavandula stoechas	.	+	.	.	.	.	.	+	.	.	.	2
Helianthemum ledifolium	.	.	.	+	.	.	.	.	.	.	.	1
Lavandula multifida	.	.	.	.	.	.	.	.	.	.	+	1
Other species												
Anagallis arvensis	+	+	2.2	1.1	+	1.1	3.1	2.2	+	.	+	10
Urginea maritima	1.1	2.1	.	+	1.1	+	.	2.1	1.1	.	.	7
Plantago psyllium	.	+	.	+	+	1.1	+	+	.	.	.	6
Asphodelus microcarpus	.	.	.	+	.	.	2.1	+	1.1	.	+	5
Linum strictum	+	+	+	.	.	.	.	.	.	.	.	3
Brachypodium distachyon	+	.	+	.	.	+	.	.	.	.	.	3
Ferula communis	.	.	.	+	.	.	.	.	1.1	.	+	3
Atractylis cancellata	+	.	+	.	.	.	.	.	.	.	.	2
Filago spathulata	+	.	+	.	.	.	.	.	.	.	.	2
Plantago lagopus	+	.	.	.	+	.	.	.	.	.	.	2
Asterolinum linum-stellatum.	.	.	.	+	.	.	+	.	.	.	.	2
Sedum sediformis	.	.	.	.	.	.	1.2	1.2	.	.	.	2