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A contribution to the knowledge of the Moroccan forest ecosystems: association of *Quercetum rotundifolio-suberis* ass. nova in the Central Plateau of Morocco

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Abstract
This work results as an in-depth study of mixed cork-oak, by the necessity to profound the knowledge of Moroccan forest ecosystems, particularly in the Central Plateau. Accordingly, we describe a new association of the cork-oak forest subhumid, thermomediterranean and mesomediterranean, named *Quercetum rotundifolio-suberis* ass. nova and two new subassociations consecutively named *Quercetum rotundifolio-suberis chamaeropetosum humilis* subass. nova and *Quercetum rotundifolio-suberis cistetosum libanotidis* subass. nova. Their floristic and ecologic particularities are exposed.

Key words: BEIS of El Harcha, Central Plateau, cork-oak woodlands, Morocco, phytosociology.

Introduction

The phytosociological description of the site of vegetation is fundamental to group together plant communities that are perceived as similar and thus simplify the description of the vegetation patterns in a given geographical area (Braun-Blanquet, 1964; Daubenmire, 1968; Géhu *et al*., 1981; Quinto-Canas, 2010). Recently, vegetation classification has been emphasized as a communication tool in ecological science and in the application of ecological information in monitoring, planning, conservation, and management (Jennings *et al*., 2009). The vegetation association is the main component of biocoenoses and ecosystems. And it is impossible to research, monitor and control the processes unfolding within these biocoenoses and ecosystems on a different scale without profound knowledge of the origin, development, composition, structure, and classification of plant communities (Braun-Blanquet, 1964; Jennings *et al*., 2009).

Morocco is characterized by various high-potential areas of endemic plants (Sauvage, 1961). These areas which are considered as a hotspot of global biodiversity because of their high endemic species are known by their great loss of habitats (FAO, 2013). Oulmès region which belongs to the Central Plateau is one of the most important area in terms of biodiversity richness in Morocco (Chkhichekh *et al*., 2014). El Harcha site which is a part of this region is considered as an Ecological and Biological Interest Site (BEIS) (AFM, 1996). Its *Quercus suber* forests are one of the most important vegetal community. This region was subject for many phytosociological studies (Sauvage, 1961; Boudy, 1950; Fennane, 1988) but no one's classified cork oak forest as phytosociological association till now. Our choice focused on the BEIS of El Harcha which had been identified in the context of the national study on protected areas and their management plan in 1996. This area is characterized by these various reliefs, multitude exposures, and different slopes, generating varied soils and climatic conditions. The objective of this study is to determine the phytosociological associations of the sclerophyllous oaks and their floristic richness and diversity.

Materials and Methods

From the geological point of view, El Harcha sector which is a part of the central area belongs to the large anticline structural unit of the Khouribga-Oulmès. It is characterized by the presence of Ordovician rocks represented by various schists including slate, sandstone, quartzite, limestone and volcanic rocks (Beaudet, 1969). Geomorphologically, it is an area characterized by a multitude of exposures, relief and relatively steep slopes, derived from the paleo-geomorphological evolution and erosion. For altitudes, they vary between 430 m at Wadi Tabhrart in the northwest and 1030 m in the south eastern, near the road linking El Harcha to Oulmès.

Regarding climate, the average annual rainfall in the study area varies between 449 mm and 684 mm regi-

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stered respectively in Tiddas and El Harcha (Tab. 1), thereby placing the area in the temperate and cold sub-humid and temperate semi-arid.

From the pedological point of view and according to the French classification, the type of soils found in the area are:

- Lithosols (on shale or quartzite): - Soil erosion unsophisticated; - more or less leached brown soils, and - brown soil fersialitic more or less leached. Almost all of these soils are formed on monotonous schists and are characterized by an increasing stoniness depending on the type of exposure and slope. They have a brown dominant colour, sometimes reddish in-depth. The structure is generally granular more or less compact at the level of the sunny places. As for textures, they are of muddy and argilo-muddy types, favourable to the development of vegetation.

The approach to the description and analysis of associations and vegetation dynamics adopted for this study is focused on the classical phytosociological approach, called sigmatiste (International Station of Mediterranean and Alpine Geobotany Montpellier), which was developed by Braun-Blanquet. Our surveys have been allocated in the field on the basis of the ecological determinant factors (climate, soils, slopes, exposures, altitude) and taking into account the vegetation types stands map (Chkhichekh *et al.*, 2014).

Results

Based on the map of stand types of the study area, we identified the area of *Quercus suber* and *Quercus rotundifolia* which occupy 2.190 ha (Tab. 2) and where we identified a new association with various facies.

The comparison of the statements of our results with those of the previous studies shows that these forests groups belong to the class of *Quercetea ilicis* defined for the whole Mediterranean region.

Among the three orders distinguished in Morocco within the class of *Quercetea ilicis* Br.-Bl. in Br.-Bl., Roussine & Nègre 1952, only one of them called *Quercetalia ilicis* Br.-Bl. ex Molinier 1934 is individualized in the study area and includes all the forest stands which are close to the climax. It is situated in bioclimates semi-arid and sub-humid of the thermomediterranean and mesomediterranean stages. Besides, the species met in the study area, and characteristics of this order, are as follows: *Quercus suber*, *Quercus rotundifolia*, *Quercus canariensis*, *Cytisus triflorus*, *Cytisus arboreus*, *Phillyrea latifolia* and *Viburnum tinus*.

The forest groups encountered in Morocco in *Quercetalia ilicis* at the level of the thermomediterranean wet and sub-humid stage belong to the alliance *Quercо rotundifoliae-Oleion sylvestris* Barbero, Quèzel & Rivas Martínez in Rivas Martínez, Costa & Izco 1986, also present in Southern Spain, Algeria and Tunisia (Rivas-Martínez, 1974; Rivas-Martínez *et al.*, 1986; Meddour, 2010). In the present study, this forest group is dominated essentially by *Quercus suber* and, by locations, by *Quercus rotundifolia* or *Quercus canariensis*.

Discussion

According to the established map of stand types for the study area and the distribution of our floristic samples, we note that *Quercus suber* is pure or mixed with *Quercus rotundifolia* and locally with *Quercus canariensis*.

Related plant groups - climatic factors

Based on the Emberger's pluviothermic climagramme, *Quercus suber* of the study area belongs to the cold sub-humid bioclimate (m < 3°C) (Sauvage, 1961). Under these conditions, *Quercus rotundifolia* stands as a potential competitor of *Quercus suber*, as long as their ecological amplitude is substantially similar except that the distribution area of the first one is characterized by colder minimum values (m). Under these con-

Tab. 1 - Synthesis of the data of monthly average precipitation (PM) and annual (PA) of four representative stations of the El Harcha BEIS (MCEF, 2001; 2002).

Stations	Durations of observations	Monthly average precipitation (PM) (mm)												PA (mm)
		S	O	N	D	J	F	M	A	M	J	JT	A	
Tiliouine	26 years	10	38	52	64	55	65	68	66	42	8	1	2	471
El Harcha	30 years	16	55	79	112	86	112	98	76	37	11	1	1	684
Oulmès	30 years	9	44	88	78	94	84	80	77	32	13	1	1	601
Tiddas	18 years	10	36	59	82	64	62	63	45	19	5	2	2	449

Tab. 2 - Presentation of the various types of groups and their areas (ha) within the El Harcha BEIS (Chkhichekh *et al*., 2014).

Groups	Surface (ha)
Groups of *Quercus suber* and/or *Quercus rotundifolia*	**2190,79**
Groups of *Tetraclinis articulata*	1265,22
Groups of matorral	76,29
Riparian groups	5,80
Coniferous reforestation	85,76
Empty lots	326,18
Total	**3950,04**

ditions *Quercus suber* rarely manages to completely eliminate *Quercus rotundifolia* stands which are often mixed.

On some cooler slopes and the edges of sources and more or less permanent wadis, providing more humidity, *Quercus canariensis* is still in single tree or small groups. It sometimes presents with significant proportions of recovery mixed with *Quercus suber*.

Relationship groups plant - soil factors

At the El Harcha BEIS, the basement consists mainly of various schists, sandstones and quartzites. Its substrates are suitable for both *Quercus suber* and other species-climax, including *Quercus rotundifolia* and *Tetraclinis articulata*; that's when the soil depth, linked to other topographical factors, which would be behind their spatial allocation in the field. Indeed, from 900 m, *Quercus suber* grows on all exposures. It is replaced by *Quercus rotundifolia* when the soil is skeletal or at the bottoms where it is too cold during the winter. In the sub-humid climate, *Quercus suber* occupies all exposures but soil conditions limit its extension. At the middle part of the area, the climax is a mixed oak forest which, according to soil and mesoclimatic possibilities, ranging from pure cork oak in pure green oak. The *Myrto communis-Pistacietum lentisci* (Molinier 1954) Rivas-Martínez 1975 (*Pistacio-Rhamnetalia alaterni* order) is always encountered at low altitude. Also, in the semi-arid bioclimate, the impact of the multiple exposures in the deep valleys results in mixtures of *Quercus suber* with the secondary species, dominated by *Olea oleaster* and *Pistacia lentiscus*.

Phytosociological analysis

The chart analysis and the surveys conducted at the El Harcha BEIS show that *Quercus suber* is dominant. The species found with *Quercus rotundifolia* are not specific because they also cohabit with *Quercus suber*. Also, it is not unlikely that the current small groups of *Quercus rotundifolia* would be the result of ancient fires after which the green oak, known by its resilience and plasticity, could reclaim the land became free. Certain human practices, such as the extraction of tannin and channels cork, would likely be among the causes of removal of the cork oak of some locations where soil conditions are not behind his absence.

This analysis allowed us to propose within the El Harcha BEIS and elsewhere in the Central Plateau (Forests Ait Alla, Ait Ichou, Bouregreg, El-Khatouat, Sidi Hsaine, etc.) the association of *Quercetum rotundifolio-suberis* ass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015 (Weber *et al*., 2000) (*Typus* n. 19 of table 3) characterized by the following species (Tables 3, 4, 5, 6 and 7): *Quercus suber*, *Quercus rotundifolia*, *Quercus canariensis*, *Daphne gnidium*, *Cistus salviifolius* and *Cistus villosus*. It is connected with the alliance *Querco rotundifoliae-Oleion sylvestris* Barbero, Quézel & Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986.Within this association, a number of facies have been identified:

- Facies with *Quercus suber* and *Quercus canariensis* (Table 3): Stands compounds of *Quercus suber* mixed with *Quercus canariensis* are represented by spots and restricted areas are located between 650 and 1000 m altitude, always on the north side with cooler conditions. This facies develops at the upper of thermomediterranean and the lower part of mesomediterranean. The soil is relatively deep and the slope is generally strong.

- Facies with *Quercus suber*, *Cistus salviifolius* and *Cistus villosus* (Table 4): This is a facies indicating a fairly extensive degradation of the cork oak, consecutive or repeated fires (most likely) or the systematic cutting of the undergrowth. It occupies the upper slopes of the area from 800 m altitude exposure, where the presence of *Cistus villosus* certify cold. The abundance of *Cytisus triflorus* certifies that you are no longer in the semi-arid zone but in the sub-humid. The soil is relatively deep on schist and quartz sandstone substrate.

- Facies with *Quercus suber* and *Arbutus unedo* (Ta-

ble 5): This facies occupies a restricted area in the BEIS. It is characterized by a dense, moderate and clear tree layer. The latter is the result of anthropogenic pressure, resulting in cuts topping and limbing.

- Facies with *Quercus suber* and *Chamaerops humilis* (Table 6): This group is defined as a new subassociation with *Chamaerops humilis*: *Quercetum rotundifolio-suberis chamaeropetosum humilis* subass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015 (Weber *et al*., 2000) (*Typus* n. 20 of table 6). It operates in a dominant south slope, south-east with a shallow soil surface locally between 800 and 1000 m altitude. Weather conditions and edaphic reveal relatively dry stations. *Quercus suber*, with low densities and in state of stress, is in mixture, sometimes dominated by *Quercus rotundifolia*. It is characterized by *Quercus suber*, *Quercus rotundifolia*, *Chamaerops humilis* and *Lavandula stoechas*. Base on the field observations, the proliferation of *Chamaerops humilis* results in the dedensification of *Quercus suber* stands. In addition, due to adverse ecological conditions, added to the anthropogenic pressure, *Quercus suber* stands could not recolonize their natural area.

- Facies with *Quercus suber* and *Cistus libanotis* (Table 7): This facies which is localized in the northeastern limit of the BEIS is defined as a new subassociation with *Cistus libanotis*: *Quercetum rotundifolio-suberis cistetosum libanotidis* subass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015 (Weber *et al*., 2000) (*Typus* n. 76 of table 6) within the vegetal community of *Quercus suber* and *Cistus salviifolius*. It is noted that *Quercus suber* is in a low density and *Quercus rotundifolia* is often as a shrub. All growing on shallow soil with shale outcrop and medium to steep slope, resulting in a dominant southern exposure.

- Facies with *Quercus suber* and *Genista quadriflora* (Table 5): This is a facies occupying a very restricted within the El Harcha BEIS at its western area. It grows on a shallow surface soil, on a substrate with shale-sandstone quartzite at the upstairs stage mesomediterranean sub-humid. The degradation of this facies gives rise to the association of *Halimio villosissimi-Genistetum quadriflorae* Quézel *et al*., 1992 which is neighbouring to him (Benabid, 2000), being of the alliance *Genisto quadriflorae-Lavandulion atlanticae* (Benabid, 1982) of the order of *Cisto-Lavanduletalia* Braun Blanquet 1940 and 1952, of the class of *Cisto-Lavanduletea stoechadis* Br.-Bl. in Br.-Bl., Molinier & Wagner 1940.

In comparison with the others regions of Morocco, *Quercus suber* stands of the plateau of Oulmès present certain specificities. Their compositions and aspects are quite different depending on the stage and the soil nature. In the semi-arid bioclimate, Emberger (1938) distinguished two types of *Quercus suber* stands, the first one on sands (Mamora) and the second one on hard rocks (Ben Slimane). In the sub-humid bioclimate (Oulmès, Rharb-nord) and the humid bioclimate (Bab Azhar, Rif), the various *Quercus suber* stands are distinguished floristically. At the study area and the central plateau generally, *Quercus suber* and *Quercus rotundifolia* mixed over large areas, testifying of their originality. Their classification in the previous studies stops at the level of the alliance of *Querco rotundifoliae-Oleion sylvestris* Barbero, Quézel & Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986. On the other hand at the level of the cork oak forests of Rif (northern of Morocco), oriental Middle Atlas and the Atlantic ones, several associations were described there.

In Algeria the various associations described in the groups with cork oak are of the alliance *Quercion suberis* Loisel 1971 (Meddour, 2010).

Conclusion

The phytoecological study of the EL Harcha BEIS, led in the forest groupings allowed the highlighting of a new association and a new subassociation. It is about the association *Quercetum rotundifolio-suberis* ass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015 characterized by the following species: *Quercus suber*, *Quercus rotundifolia*, *Quercus canariensis*, *Daphne gnidium*, *Cistus salviifolius* and *Cistus villosus*. It is connected with the alliance *Querco rotundifoliae-Oleion sylvestris* Barbero, Quézel & Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986.

This alliance belongs to the order of *Quercetalia ilicis* Braun Blanquet, ex Molinier 1934. of the class of *Quercetea ilicis* Braun Blanquet ex A. & O. Bolòs 1950.

Within this association, a number of facies were identified:

Facies of *Quercus suber* with *Quercus canariensis*;

Facies of *Quercus suber* with *Cistus salviifolius* and *Cistus villosus*;

Facies of *Quercus suber* and *Arbutus unedo*;

Facies of *Quercus suber* and *Chamaerops humilis* with a new sub-association *Quercetum rotundifolio-suberis chamaeropetosum humilis* subass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015;

Facies of *Quercus suber* and *Cistus libanotis* with a new sub-association *Quercetum rotundifolio-suberis cistetosum libanotidis* subass. nova Chkhichekh A., El Aboudi A., Aafi A., Wahid N. and Benabid A., 2015;

Facies of *Quercus suber* and *Genista quadriflora*.

Tab. 3 - Facies of *Quercus suber* and *Quercus canariensis* (Relief *Typus* of the association is n. 19).
(Legend: Substrate - S: Schist; G: Sandstone; Q: Quartzite; Soil - P: Deep; MP: Moderately deep; PP: Shallow)

Statement number	13	19	75	82	84	92	93	
Altitude (m a.s.l.)	740	930	860	840	910	962	906	
Aspect	N	N	SO	N	N	NNW	N	
Slope (%)	60	40	40	75	70	50	40	
Substrate	S	S	GQS	GS	G	G	GS	
Soil	P	P	MP	MP	P	P	P	Presences
Characteristic species of the association								
Quercus suber	1.1	2.2	2.2	3.3	3.3	4.4	1.1	7
Quercus rotundifolia	1.1	1.1	2.2	+	1.1	2.2	+	7
Quercus canariensis	1.2	1.2	2.2	1.1	2.2	2.3	4.4	7
Daphne gnidium	+	1.1	.	1.1	1.1	+	.	5
Cistus salviifolius	.	1.2	1.1	3.3	3.3	1.1	.	5
Characteristic species of the alliance *Querco rotundifoliae-Oleion sylvestris*								
Arisarum vulgare	.	+	.	+	+	.	.	3
Aristolochia baetica	.	.	.	+	+	.	.	2
Olea oleaster	+	.	.	.	.	.	.	1
Phillyrea latifolia	.	2.2	+	.	.	.	.	2
Arbutus unedo	.	1.1	.	.	.	.	.	1
Quercus rotundifolia	.	.	+	.	.	.	.	1
Other species								
Asphodelus microcarpus	1.1	2.2	1.1	2.2	2.2	2.2	1.1	7
Biscutella didyma	+	1.1	.	+	+	1.1	1.1	6
Anagallis arvensis	+	1.1	+	.	.	1.1	1.1	5
Urginea maritima	1.1	.	+	1.1	.	1.1	1.1	5
Sherardia arvensis	+	+	.	+	.	.	+	4
Eryngium tricuspidatum	.	.	.	+	+	+	.	3
Medicago hispida	.	.	1.1	+	.	+	.	3
Vicia tenuifolia	+	.	+	+	.	.	.	3
Briza minor	.	.	.	+	.	+	.	2
Bromus mollis	.	.	+	.	.	1.1	.	2
Bromus rigidus	.	.	+	.	.	+	.	2
Capsella bursa pastoris	+	+	.	.	.	.	.	2
Emex spinosa	.	.	.	+	+	.	.	2
Erodium bipinnatum	.	.	.	+	+	.	.	2
Evax pygmea	.	+	+	.	.	.	.	2
Helianthemum guttatum	.	.	+	.	.	.	1.1	2
Trifolium stellatum	.	.	+	.	.	.	1.1	2
Umbilicus horizontalis	.	+	+	.	.	.	.	2
Ajuga iva	.	.	+	.	.	.	.	1
Astragalus lusitanicus	.	.	+	.	.	.	.	1
Brachypodium distachyon	.	.	.	.	+	.	.	1
Calamintha ascendens	.	.	.	.	.	+	.	1
Campanula dichotoma	.	.	.	.	.	.	+	1
Geranium molle	.	.	.	.	.	.	+	1
Lavandula multifida	+	.	.	.	.	.	.	1
Lavandula stoechas	.	.	+	.	.	.	.	1
Ormenis mixta	.	.	+	.	.	.	.	1
Orobanche ramosa	.	+	.	.	.	.	.	1
Osyris quadripartita	.	1.1	.	.	.	.	.	1
Paronychia argentea	.	.	+	.	.	.	.	1
Pistacia lentiscus	3.3	.	.	.	.	.	.	1
Tolpis barbata	.	.	+	.	.	.	.	1
Vicia sativa	.	.	+	.	.	.	.	1

Tab. 4 - Facies of *Quercus suber* with *Cistus salviifolius* and *Cistus villosus* (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)

Statement number	1	3	4	7	8	9	11	18	23	25	27	33	34	35	36	43	45	54	57	61	63	64	66	67	68	69	70	80	
Altitude (m a.s.l.)	979	845	833	995	996	1000	980	841	730	881	894	809	930	937	949	739	898	864	892	890	856	874	785	861	970	1030	1020	982	
Aspect	SE	N	NO	SO	N	SO	SE	S	NNE	NE	N	E	NNE	O	SSO	NO	NE	SO	NO	EES	S	O	N	SE	SE	NO	O	SE	
Slope (%)	25	60	60	25	50	40	35	35	55	70	55	40	40	40	50	60	35	10	45	50	25	50	65	60	55	45	70	45	
Substrate	SG	GQS	GQ	S	S	S	S	S	G	GQ	GQ	G	GQ	GQ	GQS	GQ	GQ	G	GQ	Q	GQS	S	S	GQ	GQ	GQ	S	SQ	Presences
Soil	MP	P	P	P	P	PP	MP	PP	P	P	P	MP	MP	MP	PP	MP	P	P	P	MP	PP	PP	MP	MP	MP	P	MP	MP	
Characteristic species of the association																													
Qurercus suber	4.4	4.4	2.3	4.4	4.4	2.2	3.4	1.2	1.1	4.4	2.3	3.3	4.4	2.2	2.1	2.3	2.2	.	4.5	3.4	4.4	3.3	+	2.2	2.2	4.5	3.3	3.3	27
Cistus salviifolius	4.4	4.4	4.4	4.4	3.3	4.4	1.1	4.4	1.1	3.3	.	4.4	3.3	3.3	3.3	+	2.2	.	.	+	3.3	3.3	+	4.4	3.3	2.2	1.1	4.4	25
Daphne gnidium	+	1.2	+	1.1	1.1	+	1.1	+	1.2	1.1	+	.	1.1	.	.	.	1.1	+	+	.	1.1	+	.	.	+	1.1	.	+	20
Quercus rotundifolia	2.2	.	.	.	.	+	.	+	4.4	.	4.4	+	.	.	.	2.2	.	3.4	+	.	.	3.3	3.4	1.1	+	1.1	4.4	.	15
Cistus villosus	1.1	.	.	.	+	2.2	+	1.1	.	.	.	1.1	+	.	1.1	.	.	.	.	.	+	1.1	.	1.1	1.1	.	+	2.2	14
Characteristic species of the alliance *Querco rotundifoliae-Oleion sylvestris*																													
Arisarum vulgare	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Aristolochia baetica	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	3
Olea oleaster	.	.	.	.	.	.	.	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Rubia peregrina	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Characteristic species of the superior units																													
Chamaerops humilis	1.1	.	.	.	.	+	+	1.1	.	.	.	1.1	.	.	3.3	.	1.1	1.1	.	2.2	1.1	.	.	+	1.1	.	1.1	1.1	14
Phillyrea latifolia	.	.	.	+	+	+	+	.	.	3.3	1.1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	7
Cytisus triflorus	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Pistacia lentiscus	.	.	.	.	.	.	.	2.2	.	.	.	+	.	.	.	.	.	.	.	1.2	.	.	.	.	.	.	.	.	3
Arbutus unedo	.	.	.	.	+	3.3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Other species																													
Asphodelus microcarpus	1.1	2.2	3.3	2.2	2.2	1.1	4.4	.	2.2	2.2	2.2	1.1	2.2	2.2	.	1.1	2.2	+	1.2	1.2	3.3	2.2	2.3	2.2	2.2	2.2	1.2	1.1	26
Urginea maritima	1.1	+	+	1.1	1.1	+	.	.	.	1.1	.	1.1	+	1.1	.	1.1	1.2	1.1	1.1	+	1.1	1.1	2.2	.	.	1.1	1.1	.	20
Anagallis arvensis	+	1.1	1.1	.	+	.	+	1.1	+	+	.	.	.	+	.	1.1	.	+	+	1.1	.	.	.	+	.	+	+	+	17
Leontodon hispidulus	+	.	+	.	+	.	+	.	+	.	+	.	+	.	.	+	.	+	+	+	+	+	+	+	1.1	.	+	.	17
Helianthemum guttatum	.	.	.	.	.	.	+	.	+	+	.	.	.	1.1	+	.	1.1	+	.	.	+	1.2	+	+	+	+	+	+	15
Tolpis barbata	2.2	.	.	.	.	+	.	+	.	.	+	+	.	.	.	1.1	.	.	.	+	1.2	1.2	+	+	1.1	.	1.1	.	13
Lavandula stoechas	1.1	.	.	1.1	.	.	+	1.1	+	.	.	2.2	.	1.1	1.2	.	.	.	.	.	.	1.1	.	1.1	2.2	.	+	2.2	13

Biscutella didyma	+	+	+	+	+	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	.	+	.	.	.	+	+	+	12
Medicago hispida	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1.1	+	1.2	+	.	.	+	1.1	+	12
Bromus mollis	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	+	+	.	+	+	.	12
Sherardia arvensis	.	+	+	.	+	.	.	.	.	+	+	.	.	.	+	.	.	+	+	.	.	.	.	.	.	1.1	+	.	10
Cynosurus elegans	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	1.1	.	+	+	.	+	.	.	10
Briza minor	.	.	.	+	.	.	+	.	.	1.1	+	.	.	.	.	.	+	.	+	.	+	.	+	.	.	+	+	.	10
Eryngium tricuspidatum	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1.1	.	.	+	+	1.1	9
Cytinus hypocistis	.	+	.	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	7
Paronychia argentea	+	+	+	.	.	.	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Daucus carota	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	1.1	.	.	.	.	.	.	.	.	+	.	6
Lavatera trimestris	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	.	+	6
Ranunculus paludosus	.	+	+	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	6
Astragalus lusitanicus	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1.2	.	5
Briza maxima	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	+	5
Aegylops ovata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	+	1.1	.	5
Bromus rigidus	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1.1	4
Trifolium angustifolium	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	4
Geranium molle	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	4
Stachys arvensis	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	.	.	4
Ormenis mixta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	+	.	4
Trifolium stellatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	.	4
Centaurea pullata	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	3
Evax pygmaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	1.1	.	.	.	.	.	.	.	.	3
Dactylis glomerata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	2
Anchusa azurea	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Calamintha ascendens	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Cynara humilis	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	2
Filago gallica	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Lotus ornithopodioides	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	2
Sedum hirsutum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	2
Silene longicaulis	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Tamus communis	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Campanula dichotoma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	2

Tab. 5 - Facies of *Quercus suber* and *Arbutus unedo* and statement number 78 concerning the grouping of *Genista quadriflora* (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)

Statement number	10	29	53	62	30	31	28	74	79	N:	78
Altitude (m a.s.l.)	919	932	935	877	850	691	947	827	963	9	102
Aspect	NNE	N	N	NO	NO	N	ONO	NE	NO		O
Slope (%)	65	60	55	65	60	80	70	65	85	Presences	1
Substrate	S	G	GQ	GQ	G	G	G	S	S		GQS
Soil	P	P	P	MP	MP	MP	MP	P	P		PP
Characteristic species of the association											
Quercus suber	2.1	2.2	3.3	1.1	1.1	1.1	1.1	.	3.3	8	2.2
Quercus rotundifolia	1.1	.	1.1	.	3.3	1.1	2.2	2.2	+	7	+
Cistus salviifolius	+	.	2.2	.	1.1	1.1	+	.	1.1	6	4.4
Quercus canariensis	+	.	.	.	.	.	.	+	+	3	.
Daphne gnidium	+	.	+	.	.	.	.	.	1.1	3	1.1
Cistus villosus	.	.	+	.	.	.	+	.	.	2	.
Characteristic species of the alliance *Querco rotundifoliae-Oleion sylvestris*											
Arisarum vulgare	+	.	.	.	.	.	.	+	.	2	.
Olea europaea	.	.	.	.	.	.	.	+	.	1	.
Rubia peregrina	+	.	.	.	.	.	.	.	.	1	.
Characteristic species of the superior units											
Arbutus unedo	3.3	3.3	2.2	2.2	2.2	2.2	1.1	1.1	1.1	9	.
Phillyrea latifolia	2.3	.	.	2.2	3.3	2.2	2.2	4.4	3.3	7	.
Cytisus triflorus	+	.	.	.	.	.	.	.	+	2	+
Viburnum tinus	.	.	.	+	.	.	.	+	.	2	.
Olea europaea	.	.	.	.	.	.	.	+	.	1	.
Other species											
Asphodelus microcarpus	1.1	.	2.1	.	1.1	1.1	1.1	+	1.1	7	3.3
Daucus carota	+	1.1	.	1.2	+	.	+	+	+	7	.
Medicago hispida	+	.	1.1	+	.	+	+	+	+	7	+
Urginia maritima	1.2	.	1.1	1.1	1.1	+	1.1	.	1.1	7	+
Anagallis arvensis	+	.	+	+	+	.	+	+	.	6	+
Briza minor	+	+	1.1	1.1	.	.	+	+	.	6	.
Leontodon hispidilus	+	.	.	+	+	+	+	.	+	6	+
Eryngium tricuspedatum	+	.	.	+	+	.	+	.	+	5	+
Biscutella didyma	+	+	.	.	+	.	.	+	+	5	.
Erodium bipinnatum	+	.	.	+	+	.	.	+	+	5	.
Trifolium stellatum	+	.	.	.	1.1	+	+	+	.	5	.
Sedum hirsutum	+	.	.	.	+	+	.	+	.	4	.
Sherardia arvensis	.	.	.	+	.	.	+	+	+	4	+
Adianthus capillus-veneris	.	.	.	+	.	+	.	+	.	3	.
Bromus mollis	.	.	1.1	+	.	.	.	+	.	3	+
Helianthemum guttatum	+	.	+	.	.	.	+	.	.	3	+
Tamus communis	.	.	.	.	.	.	+	+	+	3	.
Trifolium angustifolium	+	.	.	.	+	+	.	.	.	3	.
Astragalus lusitanicus	.	.	.	.	1.1	.	+	.	.	2	.
Geranium molle	.	.	.	+	.	.	.	.	+	2	.
Chamaerops humilis	.	.	+	.	+	.	.	.	.	2	.

Cynosurus elegans	.	.	+	+	.	.	.	.	.	2	.
Lavandula stoechas	.	.	1.1	.	.	.	+	.	.	2	.
Tetraclinis articulata	.	.	.	.	+	1.1	.	.	.	2	.
Tolpis barbata	.	+	+	.	.	.	.	.	.	2	1.1
Vicia tenuifolia	.	.	.	.	.	+	+	.	.	2	.
Umbilicus horizontalis	.	.	.	.	.	+	.	+	.	2	.
Campanula dichotoma	.	.	.	+	.	.	.	.	.	1	.
Capsella bursa pastoris	.	+	.	.	.	.	.	.	.	1	.
Cuscuta sp.	.	.	.	.	.	.	.	+	.	1	.
Euphorbia sp.	.	.	.	.	+	.	.	.	.	1	.
Matricaria recutita	.	.	.	.	.	+	.	.	.	1	.
Mercurialis annua	.	.	.	+	.	.	.	.	.	1	.
Ormenis mixta	.	.	.	+	.	.	.	.	.	1	+
Osyris quadripartita	.	.	.	.	+	.	.	.	.	1	.
Phillyrea media	.	.	.	.	.	.	.	+	.	1	.
Phagnalon saxatile	.	.	.	.	.	+	.	.	.	1	.
Pistacia lentiscus	.	.	.	.	.	.	.	+	.	1	.
Ranunculus sp.	+	.	.	.	.	.	.	.	.	1	.
Rumex bucephalophorus	.	.	.	.	.	+	.	.	.	1	.
Sellaginella denticulata	.	.	.	1.1	.	.	.	.	.	1	.
Smilax aspera	+	.	.	.	.	.	.	.	.	1	.
Sonchus asper	.	.	.	.	.	.	.	.	+	1	+
Genista quadriflora	.	.	.	.	.	.	.	.	.		2.2
Cytinus hypocistis	.	.	.	.	.	.	.	.	.		+
Evax pygmaea	.	.	.	.	.	.	.	.	.		+
Paronychia argentea	.	.	.	.	.	.	.	.	.		+
Scolymus hispanicus	.	.	.	.	.	.	.	.	.		+

Tab. 6 - Sub-association of *Quercetum rotundifolio-suberis chamaeropetosum humilis* subass. nova (*Typus* n. 20) (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)

Statement number	2	20	36	38	56	26	
Altitude (m a.s.l.)	990	870	950	910	880	839	
Aspect	S	SE	SSE	S	SO	SE	
Slope (%)	60	55	50	50	40	45	
Substrate	QS	S	GQS	GQ	Q	S	
Soil	PP	MP	PP	PP	PP	PP	Presences
Characteristic species of the association and superior units							
Quercus suber	2.2	2.2	2.1		1.1	1.1	5
Quercus rotundifolia	2.2	3.3	+	2.2	2.2	1.1	6
Cistus villosus	+	3.3	1.1				3
Cistus salviifolius	1.1	1.2	+				3
Daphne gnidium					+		1
Olea oleaster		+		+			2
Differential species of the sub-association *Quercetum rotundifolio-suberis chamaeropetosum humilis*							
Chamaerops humilis	3.3	3.3	3.3	3.3	3.4	2.2	6
Lavandula stoechas	+	2.2	1.2	+		2.2	5
Other species							
Tetraclinis articulata				+			
Leontodon hispidulus	+	+		1.1	1.1	+	5
Anagallis arvensis	+	+			+	+	4
Lavatera trimestris	+	+		1.1		+	4
Paronychia argentea	+	+			+	+	4
Ajuga iva	+			+	+		3
Lavandula multifida		+		1.1		1.1	3
Tolpis barbata	+			1.1	1.1		3
Aegylops ovata				+		+	2
Asphodelus microcarpus	+				1.1		2
Cynosorus elegans	2.2				1.1		2
Daucus corota				+		+	2
Medicago hispida	+				+		2
Ormenis mixta	1.1				+		2
Phagnalon saxatile		+	+				2
Rumex bucephalophorus				+		+	2
Scolymus hispanicus	+	+					2
Stipa capensis	2.2					+	2
Astragalus lusitanicus						+	1
Avena sterilis		+					1
Capsella bursa pasteuris					+		1
Diplotaxis catholica		+					1
Evax pygmaea	+						1
Hyparhenia hirta		1.1					1
Helianthemum guttatum			+				1
Jasminum fruticans				+			1
Lotus ornithopodioides	+						1
Papaver rhoeas		+					1
Pistacia lentiscus				+			1
Rumex tuberosus	+						1
Scherardia arvensis			+				1
Sedum hirsutum						+	1
Sonchus asper			+				1
Sonchus oleraceus					+		1
Trifolium angustifolium	+						1
Urginea maritima					1.2		1

Tab. 7 - Sub-association of *Quercetum rotundifolio-suberis cistetosum libanotidis* subass. nova (*Typus* n. 76) (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)

Statement number	76	86	87	88	89	90	
Altitude (m a.s.l.)	942	962	967	963	975	936	
Aspect	OOS	N	S	S	S	S	
Slope (%)	35	40	10	35	35	30	
Substrate	S	S	GS	S	S	S	
Soil	S	PP	S	S	S	S	Presences
Characteristic species of the association *Quercetum rotundifolio-suberis*							
Quercus suber	2.2	2.2	1.2	1.1	1.1	1.2	6
Quercus rotundifolia	1.1	1.2	1.1	1.1	1.1	1.2	6
Cistus salviifolius	3.4	3.3	1.2	2.2	2.2	3.3	6
Daphne gnidium	+	+	.	.	.	.	2
Cistus villosus	1.1	.	.	.	.	.	1
Differential species of the sub-association *Quercetum rotundifolio-suberis cistetosum libanotidis*							
Cistus libanotis	3.3	3.3	3.3	4.4	3.3	2.2	6
Lavandula stoechas	2.2	2.2	+	2.2	1.2	2.2	6
Other species							
Helianthemum guttatum	1.2	+	1.2	+	+	+	6
Trifolium angustifolium	+	+	2.2	+	+	1.1	6
Asphodelus microcarpus	+	2.2	.	+	+	1.1	5
Lamarkia aurea	.	+	+	+	+	+	5
Logfia germanica	+	+	.	+	+	+	5
Biscutella didyma	+	+	.	+	+	.	4
Eryngium tricuspidatum	.	+	+	+	.	+	4
Stipa capensis	1.1	.	+	+	.	+	4
Tolpis barbata	+	.	+	+	.	1.1	4
Adenocarpus boudii	+	.	+	.	+	.	3
Briza maxima	+	+	+	.	.	.	3
Medicago hispida	.	+	.	+	+	.	3
Ornithopus compressus	+	+	+	.	.	.	3
Trifolium stellatum	+	1.1	.	+	.	.	3
Anagallis arvensis	.	+	+	.	.	.	2
Bromus hordeaceus	1.1	.	.	+	.	.	2
Chamaerops humilis	1.2	.	.	.	.	+	2
Echium plantagineum	.	+	.	+	.	.	2
Ferula communis	.	+	+	.	.	.	2
Ormenis mixta	2.2	.	.	+	.	.	2
Taraxatum hispidum	.	2.2	+	.	.	.	2
Adenocarpus cytisoides	.	.	+	.	.	.	1
Ajuga iva	+	.	.	.	.	.	1
Anchusa azurea	.	+	.	.	.	.	1
Anthoxanthum odoratum	.	+	.	.	.	.	1
Asterolinon linum-stellatum	.	+	.	.	.	.	1
Avena sterilis	.	+	.	.	.	.	1
Cochrys sp.	.	+	.	.	.	.	1
Cronanthus biflorus	.	.	.	.	+	.	1
Cynosorus elegans	.	.	+	.	.	.	1
Lathyrus sp.	.	+	.	.	.	.	1
Linum ostreacum	.	+	.	.	.	.	1
Ornitogalum umbellatum	.	.	+	.	.	.	1
Orobanche ramosa	.	.	+	.	.	.	1
Ranunculus paludosus	.	1.1	.	.	.	.	1
Rumex bucephalophorus	.	.	+	.	.	.	1
Sedum sediforme	.	.	+	.	.	.	1
Thapsia garganica	.	.	+	.	.	.	1
Vicia tenuifolia	.	+	.	.	.	.	1

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Appendix I: Sporadic species

Tab. 4 - Rel. 1: Logfia germanica +; Rel. 3: Cerastium dichotomum +, Stipa lagascae +; Rel. 7: Carlina corymbosa +, Linaria simplex +; Rel. 8: Asterolinum linum-stellatum +, Erodium robertianum +, Polycarpon tetraphyllum +, Ornithogalum umbellatum +; Rel. 9: Fedia pallescens +, Hypericum perforatum +, Lotus corniculatus +, Osyris quadripartita +; Rel. 11: Pulicaria odora +; Rel. 18: Anthoxanthum odoratum +, Anthyllis tetraphylla +, Anthyllis vulneraria +, Olea oleaster 1.1, Urtica dioica +; Rel. 25: Rubia peregrina +; Rel. 27: Trifolium ochroleucon +; Rel. 33: Rumex bucephalophorus +; Rel. 34: Tamus communis +; Rel. 36: Phagnalon saxatile +; Rel. 45: Umbilicus horizontalis +; Rel. 54: Papaver rhoeas +, Salvia verbenaca +; Rel. 57: Geranium molle +; Rel. 63: Linum exiguum +, Matricaria recutita +, Scolymus hispanicus +, Sonchus asper +, Vicia tenuifolia +; Rel. 64: Adianthum capillus-veneris +, Campanula rapunculus +; Rel. 66: Vicia sativa +; Rel. 67: Calendula algeriensis +, Euphorbia sp.+; Rel. 68: Ornithopus compressus +; Rel. 69: Centaurea sp. +; Rel 70: Sanguisorba minor +; Rel. 80: Adenocarpus complicatus ssp. intermedius +, Avena sterilis +, Cistus libanotis +.