SYNTAXONOMY OF OPEN OAK FORESTS ON BASALT FORMATIONS IN NORTH LEBANON

Jean Mikhael Stephan[1], Julien Barhoun[2], Elias Maatouk[1], Bruno Christian Foucault[3] and Samir Safi[4]
[1]Lebanese University, Faculty of Sciences, L2GE, Fanar, Lebanon
[2]Former student at the Lebanese University, Faculty of Sciences, Fanar, Lebanon
[3]Former professor at Lille University, France
[4]Former professor at the Lebanese University, Faculty of Sciences, Fanar, Lebanon

(Received February 2019 – Accepted July 2019)

ABSTRACT

Stephan, J-M. Barhoun, J. Maatouk, E. Christian Foucault, B. and Safi. S. 2019. Syntaxonomy of open oak forests on basalt formations in north Lebanon. *Lebanese Science Journal*. 20(3): 391-412.

This phytosociological study of the Dreib Region in Akkar-Lebanon is the first on basaltic bedrock in Lebanon. The synusial methods is used and compared by numerical classification. The latter shows satisfactory results when compared to the synusial manual classification. The following plant associations are defined: Quercetum veneris – ithaburensis, Calicotomo villosae – Rhamnetum punctati, Eryngio cretici – Echietum angustifolii and Sileno aegyptiacae – Isatidetum lusitanicae. Consequently, the alliance Quercion ithaburensi is stated for the first time in Lebanon. Vegetation series for progressive and regressive successions are also produced. Further relevés are required to consolidate additional associations that are depicted from both synusial and numerical vegetation classifications.

Keywords: phytosociology, synusial method, numerical vegetation classification, Akkar, *Quercus ithaburensis.*

INTRODUCTION

The studies of plant communities and their associations started in the Mediterranean region few decades ago, which had permitted a thorough description of plant associations. Braun-Blanquet (1936) determined the major class of vegetation in the Mediterranean region, dominated by evergreen oak formations of *Quercus ilex*: *Quercetea ilicis,* under which he defined a single order named *Quercetalia ilicis,* and two alliances: *Quercion ilicis* and *Oleo – Ceratonion.* Further investigations resulted into the

http://dx.doi.org/10.22453/LSJ-020.3.391-412

lsj.cnrs.edu.lb/vol-20-no-3-2019/

addition of the alliance *Quercion calliprini* (Zohary, 1962; Quézel *et al.*, 1978; Quézel, 1976) and the order *Pistacio – Rhamnetalia alaterni* (Rivas-Martínez & Rivas-Goday, 1975).

However, in the eastern Mediterranean basin and the Near East region, phytosociological investigations are incomplete. Collaborative works amongst researchers led to the identification of additional orders, alliances, and associations that concern the eastern Mediterranean basin (Zohary, 1962, 1973; Nahal, 1962, 1974; Chouchani *et al.*, 1974; Barbero *et al.*, 1976; Barghachoun, 1976; Akman *et al.*, 1978; Barbero & Quézel, 1989). The phytosociology works were completed or revived in most east Mediterranean countries (Al Issaoui, 1996; Danin & Orshan, 1999; Neumann *et al.*, 2005; Ghazal, 2008; Ketenoğlu *et al.*, 2010).

The most influential works in Lebanon were conducted by Abi Saleh and allies who focused on the syntaxonomic characterization of forest communities and degraded woodlands, based on bioclimatic zones, vegetation levels, and major mother rock formations of the country (Abi Saleh, 1978; Abi Saleh *et al.*, 1976, 1996). These vegetation levels were more or less similar to those described by Blondel *et al.* (2010). Under these investigations, plant associations for forests and degraded woodlands, and their respective affiliation to alliances, orders and classes were listed. Since plant associations and vegetation series are clearly influenced by bioclimatic conditions, the interaction of vegetation levels and soil substrate diversity resulted into the identification of different vegetation series (Abi Saleh *et al.*, 1996). Moreover, the authors added equivalent pre-steppe vegetation levels for the Bekaa and Anti-Lebanon, allowing Abi Saleh and Safi (1988) to develop a vegetation map of Lebanon.

Three distinctive alliances are cited under the order of *Quercetalia ilicis* for evergreen sclerophyllous forests and woodlands in Lebanon (Abi Saleh *et al.*, 1976): *Oleo – Ceratonion*, *Gonocytiso – Pinion* and *Quercion calliprini*.

The syntaxonomy for the eastern Mediterranean basin and the Middle East as given by Zohary (1962; 1973) describes under the order *Quercetalia calliprini* several alliances, including *Quercion ithaburensi* in open forest formation for Mediterranean plains and foothills below 500 m altitude under deep soils, whether on limestone or basaltic bedrocks. This alliance was based on four associations for open forests on coastal sand dunes, another on limestone in the central plains and hills of Southwestern Syria and central Palestine, and another two in the Golan-upper Jourdan valley, mainly on basaltic bed rock.

Investigations in the field of plant sociology were abandoned for thirty years, and investigations remained unfinished as some habitats were not comprehensively analyzed.

Lately, de Foucault *et al.* (2013) studied plant communities on sandstone in central Lebanon, using the synusial approach of the vegetation, where basic units of vegetation are delineated on a structural floral and biological homogeneity. New syntaxa were added to the Lebanese prodrome. However, many of them were not affiliated to higher phytosociological syntaxa since there are limited defined orders for the East Mediterranean.

Plant communities on soils deriving from basaltic bedrock were neglected in all previous investigations in Lebanon. Consequently, *Quercus ithaburensis* Decne. open forests which covered basaltic formations in Akkar in North Lebanon are never mentioned amongst the syntaxonomic checklist for Lebanon (Abi Saleh *et al.*, 1976, 1996; de Foucault *et al.*, 2013), nor in recent investigations related to the distribution of these species at regional level (Dufour-Dror & Ertas, 2004). Nonetheless, Zohary (1962) described three associations with *Quercus ithaburensis* on alluvial soils in Palestine as part of the vegetation formations of the Thermo-Mediterranean, with its own alliance (*Quercion ithaburensi*). Stephan *et al.* (2016) found that *Quercus ithaburensis* is solely found on mature soils, mainly in Akkar in northern Lebanon.

The Dreib plateau in Akkar is characterized by its gentle topography ranging between 100 and 700 m altitude, and considered the biggest basaltic formation in Lebanon which resulted from large-scale basaltic volcanism back to the Pliocene (Walley, 1998).

The average monthly precipitation and average maximal and minimal temperatures as extracted from the only available data for Qlaiaat airport (Ministère des Travaux publics, 1966) indicate that the climate is under a typical Mediterranean influence (Tables 1 and 2). Moreover, the wind Atlas of Lebanon describes this region as the windiest in Lebanon (UNDP, 2011).

Table 1. Mean monthly and Average Annual preicipations (mm) in Qolaiaat Meteo Station in Akkar.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
208	124	110	48	18	1	0.5	0.5	13	25	110	157	815

Table 2. Average monthly temperature ($T\bar{x}$), Average maximal (T_M) and minimal (T_m) temperatures in in Qolaiaat Meteo Station in Akkar.

˚C	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
$T\bar{x}$	11.9	13.5	14.1	17.0	20.0	23.9	26.3	27.3	25.7	22.5	17.5	13.2	**19.4**
T_M	16.2	17.4	18.1	20.6	23.5	26.9	29.3	30.4	29.8	27.5	22.4	17.4	**23.3**
T_m	8.1	9.3	9.7	12.1	14.7	18.7	21.2	22.2	20.4	17.2	12.8	9.5	**14.7**

This work aims at filling the gaps present in earlier plant sociology investigations by:

(i) Describing the syntaxa in a specific ecological unit: the open forest formations dominated by *Quercus ithaburensis* on the largest basaltic plateau in Akkar in the north of the country using a synusial approach;
(ii) Identifying the vegetation series for these syntaxa;
(iii) Understanding what statistical hierarchical classification method would validate the identified associations of the synusial approach.

MATERIALS AND METHODS

Site selection

The ecological unit of our concern is the open oak forest formations on a basaltic deep mature soil in Akkar, north Lebanon. It lies between the coastal alluvial plain and Mount Lebanon, ranging from 150 to 750m above sea level. It covers an area of 100 km^2.

Site selection for (i.e. quadrats) was made according to Walter (1994), in order to cover in a representative way the entire ecological unit of the basaltic plateau present in the region of Akkar (Table 3).

Table 3. Site characteristics.

Sites	Plot #	Coordinates		Elevation (m)	Vegetation type	Canopy density	Disturbance
Noura	1	34˚N37.34’	36˚E09.67’	136	Open oak forest	35%	Limited cutting
Dabbabiye	2	34˚N36.91’	36˚E12.66’	392	Oak woodland	<10%	Overgrazing
Srar	3	34˚N36.73’	36˚E07.51’	196	Grassland with trees	< 5%	Overgrazing, recreational area
Haitla	4	34˚N36.23’	36˚E07.52’	136	Open oak forest	30%	Abandoned fields
Ain ez Zet	5	34˚N35.97’	36˚E13.13’	367	Oak woodland	<10%	Fragmented habitat, grazing, dumping
Menjez	6	34˚N36.45’	36˚E15.15’	387	Mixed broadleaved forest	40%	Fragmented habitat (agriculture)
Sfinet Dreb	7	34˚N34.22’	36˚E09.06’	277	Open oak forest	35%	Limited cutting, grazing
Qoubaiyat	8	34˚N34.88’	36˚E15.99’	565	Oak woodland	<10%	overgrazing
Deir Janin	9	34˚N34.18’	36˚E10.23’	342	Oak woodland	<10%	Overgrazing
Amaret El Bikat	10	34˚N35.96’	36˚E10.17’	313	Mixed broadleaved forest	50%	Limited grazing

Sites	Plot #	Coordinates		Elevation (m)	Vegetation type	Canopy density	Disturbance
Andqet	11	34˚N36.06’	36˚E18.56’	591	Open oak forest	30%	Fragmented habitat (agriculture)
Charbila	12	34˚N35.06’	36˚E08.34’	234	Mixed broadleaved woodland	40%	Fragmented habitat (agriculture)
Bire	13	34˚N34.91’	36˚E19.97’	727	Mixed broadleaved forest	60%	Protected forest; recreation area

The 13 relevés cover the altitudinal range of the plateau (between 131 m in Haitla to 727 m in Bireh; Figure 1). All 13 quadrats were selected in homogeneous areas within this ecological unit away from the urban and agriculture land, with at least a minimal distance of 20 m. The quadrats were defined following two parallel geographical transects that goes from west to east, in order to cover the altitudinal variation of the plateau. Phytosociological quadrats had a uniform size of 20 m x 20 m (400 m²), which is typical size for woodlands and forest ecosystems. Inside these, we delineated nested plots (5 m x 5 m) to cover the understory and herbaceous strata as adapted from previous methodologies (Braun-Blanquet, 1951; Westhoff & Van der Maarel, 1978).

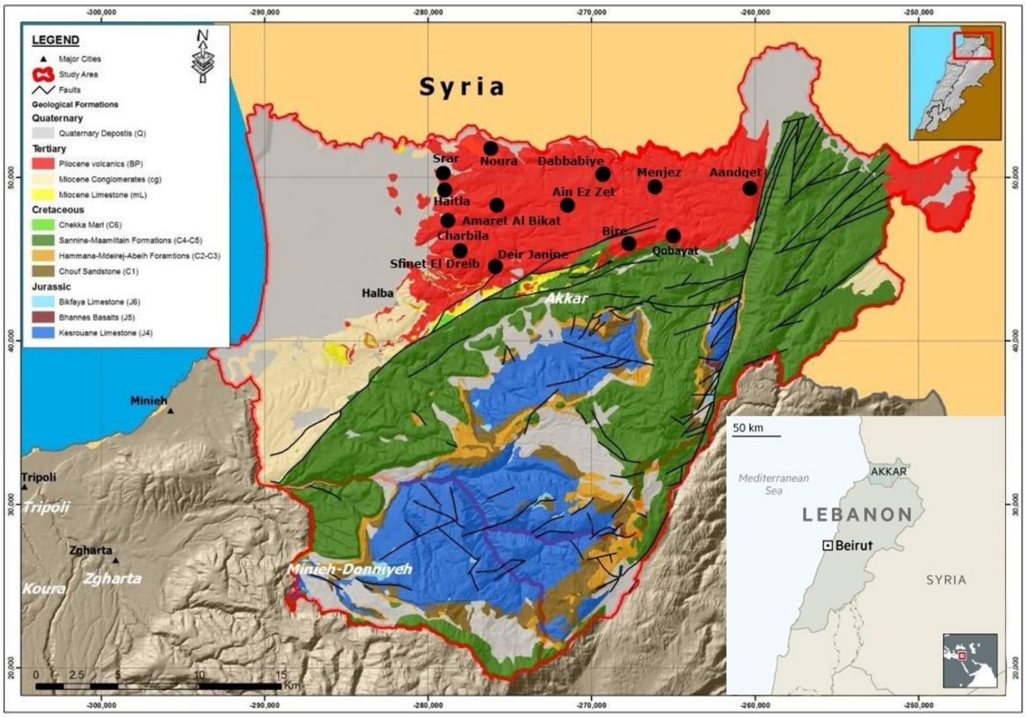

Figure 1. Sampling sites distribution on the basaltic plateau in Akkar and its location in Lebanon in the right corner of the map (source: CDR, AdelNord project, 2013).

Floristic study

In each quadrat, floristic sampling was conducted between March and September, with at least two visits per month in spring, and one visit in summer.

Physical characteristics (coordinates, slope, aspect and canopy) were recorded. Disturbances were also noted with a differentiation between anthropogenic and environmental threats. The type of threats and anthropogenic activities, and signs of degradation were based on physical evidence and observation in the field (signs of plant cutting, fire, grazing, etc.)

Plants were identified based on Mouterde (1966) and Tohmé & Tohmé (2014). But the nomenclatural reference is that of *Catalogue of life* (www.catalogueoflife.org).

Abundancy and sociability of different species were recorded, using the sigmatist Braun-Blanquet's method to be able to compare to previous investigations, and affiliate eventual new associations to the higher hierarchy classification of syntaxa, and further to determine accordingly the characteristic, indicator, and companion species of the identified syntaxa (Braun-Blanquet, 1951; Westhoff & Van der Maarel, 1978; Géhu, 1997).

In a second step, we moved towards a synusial approach as described in de Foucault *et al.* (2013), following the methodology of Gillet *et al.* (1991), where the data for each stratum (trees, shrubs and lianas, perennials and annuals) are treated separately.

Hence, the same identified plant abundancy and sociability, but segregated by plant strata.

All phytosociological classification followed the International Code of Phytosociological Classification (Weber *et al.*, 2000).

Plant successions and vegetation series as per Rivas-Martinez (2005) are proposed for the ecological unit of oak open forest ecosystem and extracted from the syntaxa of the different strata as identified by the synusial approach. Regressive or progressive successions relied on the evidence of disturbance or degradation within the characteristic sites.

Statistical analysis

In order to conducted statistical analysis, abundancy and sociability codes were converted into the same values, while the category rare (i.e. "+") was attributed a value of "05". Further sample maximum standardization was adopted, and rare species with a single encounter were removed.

Data was then exported into ExcelStat which allows to conduct in-depth statistical analysis.

To better understand what Hierarchical Agglomeration Classification (HAC) fits best for the synusial approach, we tested Euclidean Distance and Bray-Curtis dissimilarities due to their relative use in ordination and in ecology, using supervised and non-supervised classification via 3 clustering criteria methods: Complete, Flexible (Beta 0.5) and Ward as per Peet & Roberts (2013). The supervised classification using HAC was adjusted according to the number of identified communities (or associations) in the synusial approach. For the sake of brevity, we show the results supervised classification using Euclidian Distance with Ward's dissimilarity method with as compared with the expert's synusial classification.

Hierarchical Agglomerative Clustering (HAC) enabled to group the identified species in a dendrogram illustrating the main associations between species, and allowing to define the characteristic species on basaltic vegetation formation.

Principal component analysis (PCA) revealed the major environmental factors affecting the floristic composition in each site. PCA and HAC analysis (with supervised classification) were conducted to define whether the floristic composition identified in the open forests of Dreib-Akkar is part (or not) of the vegetation series of similar bioclimatic conditions and vegetation levels of Lebanon as per Abi Saleh *et al.* (1996), and with those of Zohary (1973) for Palestine. The classification of associations within a higher rank (alliance, order) or comparison with other associations rely on studying dissimilarities through HAC or other means. Although the tests are for dissimilarities, the association itself is actually looking for similarities of plants that grow in same conditions.

RESULTS AND DISCUSSION

PCA shows the major environmental factors that affect each site, as illustrated in the three biplots (Figure 2). Tree canopy density and slope are correlated, and therefore sites like Bireh, Charbila, Amaret el Bikat have high canopy cover. Oppositely, in sites where overgrazing is registered, it is the shrubby or herbaceous cover that tends to replace tree canopy (i.e. Deir Janin, Debbabiyeh). Aspect plays an important role in Noura, while altitude affects more Andqet and Bireh.

We identified 125 species in the inventoried sites. The floristic composition according to Raunkiær's life forms is dominated by a large number of annuals (65 therophytes), followed by 22 hemicryptophytes, 16 phanerophytes (8 forest trees, 6 shrubs, and 2 climbers), 15 geophytes, 6 chamephytes, and one parasite (Figure 3). These were used for sorting in the synusial approach.

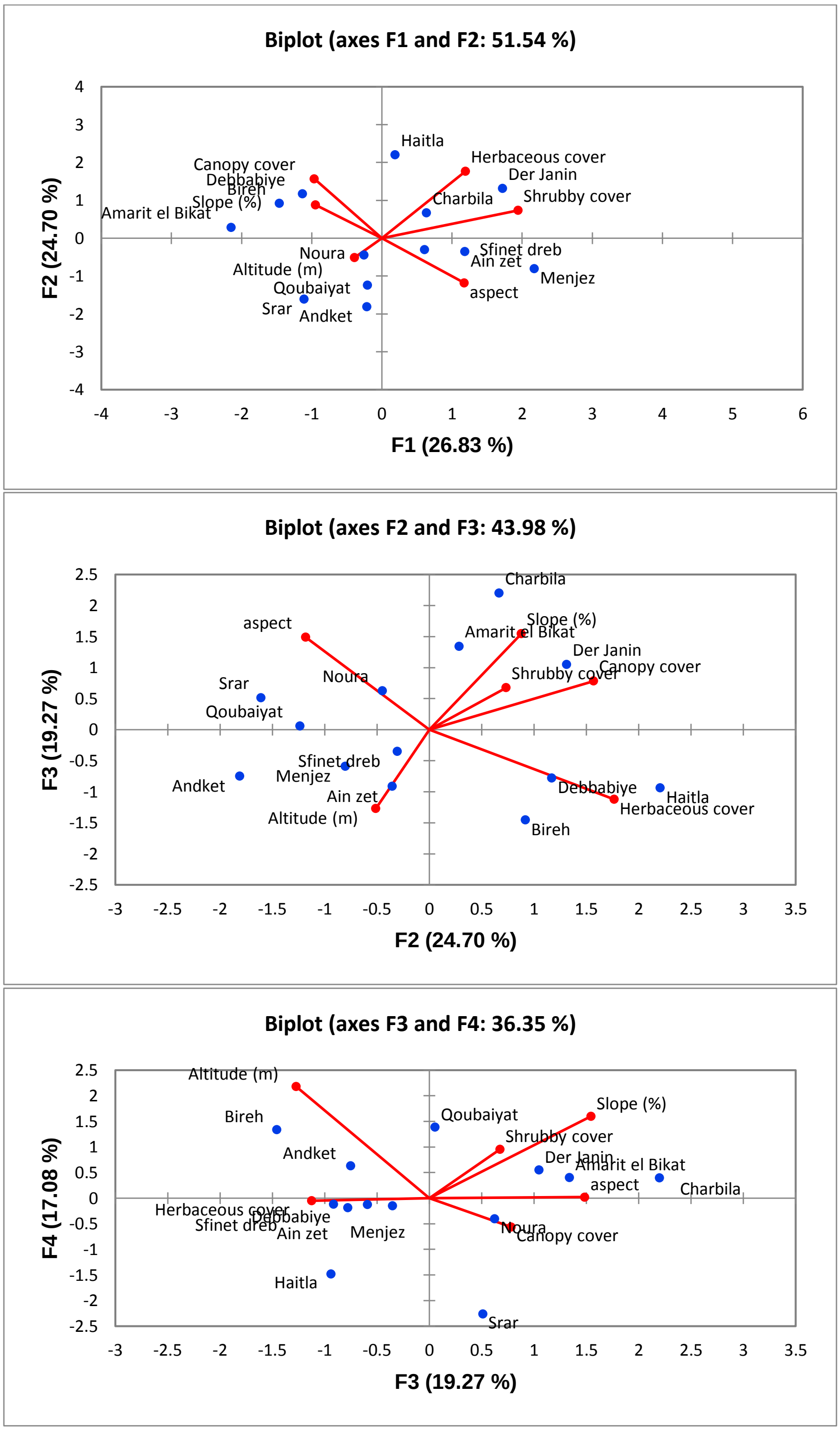

Figure 2. PCA biplots showing the respective contribution of environmental factors to site variability.

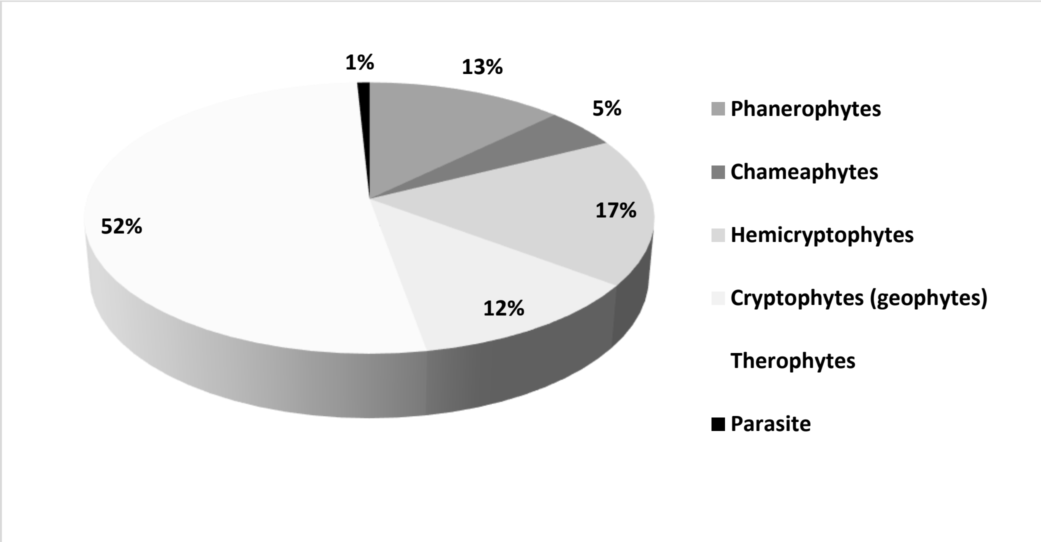

Figure 3. Distribution of inventoried plant species according to Raunkiær life forms.

Results of the synusial approach

Tree stratum

Table 4 brings together the thirteen tree relevés carried out. We will insist especially on the first nine, believing that the last four should correspond to altered tree synusias. These nine surveys are characterized by the combination of the following species: *Quercus ithaburensis* especially, but also *Q. infectoria* subsp. *veneris* (A.Kern.) Meikle, *Q. coccifera* L., and *Styrax officinalis* L. The association *Q. ithaburensis* and *Q. infectoria* subsp. *veneris* is mainly observed on sites which have significant slope, and a little anthropogenic action (Bireh, Amaret el Bikat, Andqet, Charbila). On degraded sites, only *Q. ithaburensis* is observed. We can define here the new association *Quercetum veneris – ithaburensis ass. nov. hoc loco, typus nominis*: relevé 1 of Table 4 *hoc loco*. The association differs from all those described in Lebanon by previous authors (Abi Saleh *et al*., 1976; Barghachoun, 1976; de Foucault *et al*., 2013). It is characteristic of the open forest formations in the basaltic plateau of Akkar, covering more than 100 km^2, in both Thermomediterranean and Mesomediterranean levels. The vegetation level seems to have a minor role in determining the characteristic species, when compared to other factors such as bedrock, precipitations, and anthropogenic activities, and the association could be affiliated to the *Quercion ithaburensi* (Zohary, 1973).

Table 4. Phytosociological relevés of the tree stratum in Dreib Akkar (in grey the differential characteristic taxa).

	Bireh	Charbila	Ain Zet	Amarit El Bikat	Andket	Debbabiye	Haitla	Deir Janin	Noura	Qoubaiyat	Menjez	Sfinet Dreib	Srar
Plot n°	1	12	9	7	10	3	4	2	6	8	11	13	5
Area (m²)	400	400	400	400	400	400	400	400	400	400	400	400	400
Altitude (m)	727	234	367	313	591	392	131	342	136	565	387	277	196
Slope (%)	38	55	11	65	18	33	19	38	42	42	0	23	0
Canopy density (%)	> 70	> 70	10-40	40-70	10-40	40-70	40-70	40-70	40-70	10-40	40-70	40-70	10-40
Quercus ithaburensis	3.2	3.3	3.2	2.2	2.2	3.2	4.3	4.3	3.3	2.3	4.3	3.3	4.3
Quercus infectoria subsp. *veneris*	3.3	3.2	0	4.3	3.2	.	.	.	.	.	.	.	.
Quercus coccifera	2.3	3.2	2.1	.	.	.	.	.	.	.	.	.	.
Quercus ithaburensis × infectoria	.	.	.	3.3	2.3	1.1	.	.	.	.	.	.	.
Styrax officinalis	3.2	.	.	.	.	1.1	2.1	.	.	.	.	.	.
Pistacia terebinthus subsp. *palaestina*	.	.	.	3.3	2.3	.	.	.	.	.	.	.	.
Crataegus sinaica	.	.	.	1.1	.	.	.	.	.	.	1.1	.	.
Olea europea	.	.	.	.	.	.	.	.	.	3.3	.	.	.

<u>Shrub (and climbers) stratum</u>

For shrub vegetation, two types of communities stand out, which share *Asparagus acutifolius* L. (Table 5). On sites where the canopy density is high with a fairly shady environment, the first community with *Smilax aspera* L., *Asparagus acutifolius* and *Rubia tenuifolia* d'Urv., is present. On the other hand, on degraded sites, with a deteriorated tree layer, the heliophilous and xerophilous species of the second community replace them.

Table 5. Phytosociological relevés of the shrubs and climbers stratum in Dreib Akkar (in grey the differential characteristic taxa).

	Bireh	Amarit El Bikat	Char bila	Qoubai yat	Deir Janin	Debba biye	Hai tla	Nou ra	And ket	Men jez	Sfinet Dreib
Plot n°	1	7	12	8	2	3	4	6	10	11	13
Area	25	25	25	25	25	25	25	25	25	25	25
Altitude (m)	727	313	234	565	342	392	13 1	136	591	387	277
Slope (%)	38	65	55	42	38	33	19	42	18	0	23
Canopy density (%)	> 70	40-70	> 70	10-40	40-70	40-70	40-70	40-70	10-40	40-70	40-70
Smilax aspera	2.3	3.3	4.3	2.2	.	.	.	.	.	2.3	.
Rubia tenuifolia	2.2	2.1	1.1	.	.	.	.	.	1.3	.	.
Rhamnus punctatus	.	.	.	2.3	2.3	.	2.3	2.3	1.1	1.3	3.2
Calicotome villosa	.	.	.	.	.	4.3	3.3	3.3	2.3	1.1	.
Myrtus communis	.	.	3.2	.	2.3	.	.	2.3	.	1.3	3.3
Asparagus acutifolius	3.2	4.4	1.1	2.3	3.3	.	3.3	3.2	2.3	.	.
Pistacia lentiscus	.	.	.	.	+	.	.	.	.	.	.
Rubus praecox	.	.	4.4	.	.	.	.	.	.	.	.
Clematis vitalba	.	.	3.2	.	.	.	.	.	.	.	.

The first is described by four relevés and essentially combines *Smilax aspera* and *Rubia tenuifolia*, with an average of 4 taxa per relevé, mostly climbers.

The second is better defined statistically, because it is described on the basis of seven rather shrubby taxa: *Rhamnus punctatus* Boiss., *Myrtus communis* L. and *Calicotome villosa villosa* (Vahl) Link. (syn. *Cytisus lanigerus*), with an average of 3 taxa per survey. We define here the *Calicotomo villosae – Rhamnetum punctati ass. nov. hoc loco, typus nominis*: relevé 6 of the Table 5 *hoc loco*. This syntaxon can be affiliated to the class of *Cisto – Micromerietea* and its respective order *Cisto – Micromerietalia* as defined by Oberdorfer (1954). Further it can be reattached to the alliance *Helichryso sanguinei – Origanion syriaci* (Barbero & Quézel, 1989). It differs from previous associations described in Lebanon, either on marl, limestone or siliceous soils.

Perennial herbaceous and sub-woody communities

The thirteen relevés in Table 6 share *Carlina libanotica* Boiss., S*arcopoterium spinosum* (L.) Spach, *Daucus carota* subsp. *maximus* (Desf.) Ball, *Ruscus aculeatus* L., *Cota tinctoria* (L.) J. Gay, *Pimpinella cretica* Mill.) Vis., and *Hordeum bulbosum* L.

Table 6. Phytosociological relevés of the perennials and bulbs stratum in Dreib Akkar (in grey the differential characteristic taxa).

Plot n°	5	8	10	11	4	1	2	3	13	6	9	7	12
Area	25	25	25	25	25	25	25	25	25	25	25	25	25
Altitude (m)	196	565	591	387	131	727	342	392	277	136	367	313	234
Slope (%)	0	42	18	0	19	38	38	33	23	42	11	65	55
Canopy density (%)	10-40	10-40	10-40	40-70	40-70	> 70	40-70	40-70	40-70	40-70	10-40	40-70	> 70
Origanum syriacum	+	+	1.3	1.2	1.3	2.2	.	1.2	.	.	.	.	1.3
Geropogon hybridus	+	1.3	.	1.1	1.1	.	.	.	.	.	.	.	.
Onopordum carduiforme	1.1	1.1	.	.	.	.	.	.	.	.	.	.	.
Echium angustifolium	.	.	.	.	.	.	3.4	1.1	1.1	1.3	.	2.1	.
Eryngium creticum	.	.	.	.	2.2	.	.	2.3	3.1	2.3	.	.	3.1
Cyclamen persicum	.	.	.	.	.	.	4.4	4.4	.	.	1.3	4.4	.
Alcea setosa	.	.	.	.	.	.	.	.	.	2.1	.	2.3	1.1
Verbascum blancheanum	.	.	1.1	.	.	.	.	1.1	.	2.4	.	1.1	.
Drimia maritima	.	.	.	.	.	.	.	.	2.3	.	.	1.1	.
Gladiolus italicus	.	.	.	.	.	.	.	1.1	.	.	1.1	.	.
Umbilicus luteus	.	.	.	.	.	.	1.3	.	.	.	.	2.3	.
Dittrichia viscosa.	.	.	.	.	.	.	.	.	+	.	.	.	+
Asphodelus ramosus	.	.	.	.	.	.	3.3	1.1	.	.	.	.	.
Silene dichotoma	.	.	.	.	.	.	.	.	.	1.3	.	2.3	.
Carlina libanotica	2.3	.	3.2	2.2	1.2	1.3	1.3	2.3	2.3	3.3	.	3.3	.
Plot n°	5	8	10	11	4	1	2	3	13	6	9	7	12

Area	25	25	25	25	25	25	25	25	25	25	25	25	25
Altitude (m)	196	565	591	387	131	727	342	392	277	136	367	313	234
Slope (%)	0	42	18	0	19	38	38	33	23	42	11	65	55
Canopy density (%)	10-40	10-40	10-40	40-70	40-70	> 70	40-70	40-70	40-70	40-70	10-40	40-70	> 70
Sarcopoterium spinosum	.	2.3	.	.	3.4	3.3	2.3	3.3	2.3	3.3	.	3.3	3.3
Cota tinctoria	.	2.3	2.3	2.3	.	1.2	.	1.1	2.3	.	3.3	.	.
Pimpinella cretica	.	.	.	2.3	1.1	.	1.1	1.3	.	2.1	.	.	.
Ruscus aculeatus	.	.	.	2.3	.	3.2	2.3	.	.	.	.	.	2.2
Daucus carota	.	.	.	4.4	.	.	.	1.3	.	1.3	.	.	.
Hordeum bulbosum	.	.	.	.	3.3	.	3.3	.	.	3.2	.	.	.
Phlomis longifolia	.	.	.	.	.	1.1	.	.	.	.	.	1.1	.
Campanula rapunculus	.	.	.	.	.	1.3	1.1	.	.	.	.	.	.
Moraea sisyrinchium	3.2	.	.	.	.	.	1.1	.	.	.	.	.	.
Anchusa hybrida	.	.	1.1	.	.	.	.	.	.	.	.	.	1.1
Number of other taxa	0	1	1	0	0	3	3	0	2	2	1	2	4

The first association, based on six relevés and floristically quite poor (on average 8 taxa per relevé), corresponds to a community with *Origanum syriacum* L. and *Geropogon hybridus* (L.) Sch. Bip.

Sites in Hrar and Qobayyat are heavily overgrazed on bare, windswept hills (*Onopordum carduiforme* Boiss. is only seen in both sites). The tree layer and the lower strata are minimal. The other four sites, on the other hand, are particularly covered by a significant tree layer, and are characterized by the presence of *Origanum syriacum* in the openings or on the edge.

The second association, based on seven relevés, more diversified (on average 11.5 taxa per relevé, 13 if we exclude the particularly poor relevé 9), corresponds to an original community with *Eryngium creticum* Jan ex Guss., *Echium angustifolium* Lam., *Cyclamen persicum* Mill., *Lomelosia palestina* (L.) Rafin., *Verbascum blancheanum* Boiss., etc. These sites are characterized by a fairly high degree of fragmentation, with pasture of varying intensity. Some sites (Ain ez Zeit) are occasionally plowed and planted with seasonal and rainfed crops. *Verbascum blancheanum* is only present on basaltic soils (Tohmé & Tohmé, 2014), while *Cyclamen persicum* grows in the shade of trees. Most of these species are not palpable by ruminants, and spared from grazing. We define here the new *Eryngio cretici – Echietum angustifolii ass. nov. hoc loco, typus nominis*: relevé 3 of Table 6 *hoc loco.*

These syntaxa are likely to be affiliated to the class of *Cisto – Micromerietea* and its respective order *Cisto – Micromerietalia* as defined by Oberdorfer (1954), and the alliance *Helichryso sanguinei – Origanion syriaci* (Barbero & Quézel, 1989). This association differs from the more basiphilous *Hyparrhenio hirtae – Thymbretum spicatae* defined by Barbero and Quézel (1989) or the acidophilous association described by de-Foucault *et al.* (2013) for central Lebanon.

Other taxa of the plots for Table 6 – plot 8: *Orchis italica* Poir., nom. cons. prop. 1.1; plot 10: *Ornithogalum neurostegium* Boiss. & Blanche 1.1; plot 1: *Salvia judaica* Boiss. 3.3, *Gagea reticulata* (Pall.) Schult. & Schult.f. 1.1, *Hyacinthus orientalis* L.: 1.3; plot 2: *Hyparrhenia hirta* (L.) Stapf 2.2, *Cistus creticus* L. 1.1, *Ranunculus asiaticus* Gueldenst. 1.3; plot 13: *Bellevalia trifoliata* (Ten.) Kunth 2.3, *Lythrum junceum* Banks & Solander 1.3; plot 6: *Exoacantha heterophylla* Labill. 1.1, *Teucrium orientale* L. 2.1; plot 9: *Anemone coronaria* L. 1.1; plot 7: *Allium ampeloprasum* Boiss., sensu auct +, *Scrophularia rubricaulis* Boiss + ; plot 12 : *Echinops spinosissimus* subsp. *macrolepis* (Boiss.) Greuter 1.1, *Geranium pyrenaicum* Burm. f. 2.3, *Arum palaestinum* Boiss 1.1, *Anchusa strigosa* Banks & Sol. 3.3.

<u>Therophytic communities</u>

Two communities share the thirteen relevés, having in common *Lysimachia foemina* (Mill.) U. Manns & Anderb., *Crepis syriaca* (Bornm.) Babc. & Nav., *Carduus argentatus* L., *Alopecurus utriculatus* Sol., *Hymenocarpos circinnatus* (L.) Savi, *Briza humilis* M.Bieb., *Trifolium scutatum* Boiss, *Trifolium Purpureum* Loisel., *Lathyrus basalticus* Rech.f., *Papaver rhoeas* L., etc. (Table 7).

The first, based on ten relevés, averaging about 14 taxa per relevé, is well differentiated from the second by *Isatis lusitanica* L., *Silene aegyptiaca* (L.) L. fil., *Cota palaestina* Reut. ex Unger & Kotschy, *Ranunculus marginatus* var. *trachycarpus* (Fisch. & C. A. Mey.) Hayek, *Lupinus digitatus* Frossk., *Raphanus raphanistrum* L., *Trifolium hirtum* All., *Lathyrus aphaca* L., *Agrostemma githago* L.,etc.

The second only shows three relevés, with an average of 17 taxa per relevé, differentiated by *Parentucellia viscosa* (L.) Caruel (syn. *Bellardia viscosa*), *Eremogone minuartioides* Dillenb. & Kadereit, and *Bellardia trixago* (L.) All. This second community is distinguished from the first by its presence on abandoned agricultural terraces, which explains its relative wealth in species.

We define here the new *Sileno aegyptiacae – Isatidetum lusitanicae ass. nov. hoc loco, typus nominis*: relevé 9 of the Table 7 *hoc loco*. The relevés illustrate the dry lawn, characteristic of the thermo-Mediterranean level *sensu* Blondel *et al.* (2010) and Abi Saleh *et al.* (1996). Yet they are different from the acidophilous dry lawns described by de Foucault *et al.* (2013). Therophytic lawn is poorly investigated in Lebanon (Abi Saleh *et al.*, 1976; Abi Saleh, 1978) with only a single description of an association for *Hyparrhenia hirta*, which is rarely observed in Dreib, Akkar. These dry lawns are low-intensity grazing zones, at the edge of tree and tree formations, and more likely to be categorized as "vernal therophytic hem" without the possibility to confirm the existence of a real association and describe the respective alliance.

Table 7. Phytosociological relevés of the annuals stratum in Dreib Akkar (in grey the differential characteristic taxa).

Plot n°	5	9	8	10	7	12	4	3	6	1	2	11	13
Area	25	25	25	25	25	25	25	25	25	25	25	25	25
Altitude (m)	196	367	565	591	313	234	131	392	136	727	342	387	277
Slope (%)	0	11	42	18	65	55	19	33	42	38	38	0	23
Canopy density (%)	10-40	10-40	10-40	10-40	40-70	> 70	40-70	40-70	40-70	> 70	40-70	40-70	40-70
Isatis lusitanica	2.3	2.3	2.3	2.3	2.3	2.2	.	2.3	2.4	1.2	.	.	.
Silene aegyptiaca	.	4.3	3.3	.	.	.	1.3	1.3	1.3	.	.	.	.
Cota palaestina	1.1	.	1.3	1.3	1.1	+	1.3	.	.	.	1.1	.	.
Raphanus raphanistrum	.	2.3	.	+	.	3.3	.	1.1	.	.	.	1.3	.
Trifolium hirtum	1.1	.	3.3	.	3.3	+	3.3	.	.	.	.	.	.
Ranunculus marginatus	.	2.3	.	.	.	3.3	2.1	1.1	.	.	.	1.3	.
Lupinus digitatus	.	1.3	.	1.1	.	1.1	.	.	.	.	.	.	.
Lathyrus aphaca	.	2.3	.	.	.	.	1.3	.	.	2.1	.	.	.
Agrostemma githago	.	1.1	.	.	1.1	.	.	.	.	2.2	.	.	.
Vicia hybrida	.	.	3.4	.	.	1.3	.	.	.	3.2	.	.	.
Lagurus ovatus	2.3	.	.	4.3	.	.	.	.	.	.	.	.	.
Salvia viridis	.	.	.	.	1.1	.	.	.	2.3	.	.	.	.
Lupinus angustifolius	.	1.3	2.3	.	.	.	.	.	.	.	.	.	.
Lepidium spinosum	3.3	1.3	.	.	.	.	.	.	.	.	.	.	.
Lomelosia palaestina	.	.	.	.	1.3	.	.	2.3	2.3	.	.	.	.
Galium samuelssonii	.	4.3	.	2.3	.	.	.	.	.	.	.	.	.
Bellardia viscosa	.	.	.	.	.	.	.	.	.	.	3.3	2.3	1.3
Eremogone minuartioides	.	.	.	.	.	.	.	.	.	.	2.3	.	3.3
Bellardia trixago	.	.	.	.	.	.	.	.	.	.	2.3	2.3	.
Lysimachia foemina	1.3	1.3	1.2	1.2	1.3	1.3	1.1	1.2	1.1	.	1.1	1.1	1.2
Crepis syriaca	1.3	1.3	1.2	1.3	1.3	1.2	1.2	1.3	1.2	1.2	.	1.3	1.2
Carduus argentatus	.	1.2	2.3	1.2	3.1	3.3	1.2	3.3	1.2	.	1.3	3.4	1.3
Alopecurus utriculatus	.	.	.	3.4	3.3	4.3	.	2.3	.	3.3	3.3	4.4	2.3
Briza humilis	.	.	3.3	2.3	.	2.3	2.3	2.3	3.3	.	3.2	.	3.2

Plot n°	5	9	8	10	7	12	4	3	6	1	2	11	13
Area	25	25	25	25	25	25	25	25	25	25	25	25	25
Altitude (m)	196	367	565	591	313	234	131	392	136	727	342	387	277
Slope (%)	0	11	42	18	65	55	19	33	42	38	38	0	23
Canopy density (%)	10-40	10-40	10-40	10-40	40-70	> 70	40-70	40-70	40-70	> 70	40-70	40-70	40-70
Trifolium scutatum	.	.	.	.	.	.	4.2	2.1	1.1	3.2	3.3	1.3	3.3
Lathyrus basalticus	.	.	2.3	.	2.1	1.3	.	.	4.4	.	3.3	2.1	.
Hymenocarpos circinnatus	.	.	.	.	2.3	1.3	.	3.2	3.3	.	.	3.3	1.3
Papaver rhoeas	1.1	.	.	1.1	.	.	1.1	1.1	.	.	1.1	.	1.1
Trifolium purpureum	.	.	1.3	.	.	1.1	1.1	2.3	.	.	.	3.3	.
Vicia palaestina	.	.	2.4	.	.	.	2.3	.	.	1.1	.	.	1.3
Linum pubescens	.	.	.	.	.	.	.	2.1	1.1	.	1.1	1.1	.
Trifolium resupinatum	.	.	.	.	.	.	.	.	1.3	.	.	4.3	3.3
Trifolium xerocephalum	.	.	.	3.4	.	.	.	.	.	.	1.3	.	3.3
Myosotis refracta	.	.	.	.	.	.	.	.	.	1.1	.	.	3.3
Clypeola jonthlaspi	.	.	.	.	.	.	.	.	.	1.1	1.1	.	.
Dianthus tripunctatus	.	.	.	.	1.1	.	.	.	.	.	1.3	.	.
Number of other taxa	0	4	2	2	2	2	0	1	1	5	4	1	5

Other taxa of the plots for Table 7 – plot 9: *Lathyrus ochrus* (l.) DC. 2.3, *Papaver syriacum* Boiss. & Bl. 1.1, *Veronica polita* Fries 1.1, *Vicia sativa* L. 3.3; plot 8: *Trifolium glanduliferum* Boiss. 2.3, *Geranium rotundifolium* L. 2.3; plot 10: *Veronica syriaca* Roem. & Schult. 1.1, *Geranium molle* L. 2.3; plot 7: *Geranium robertianum* L. 2.3, *Ainsworthia trachycarpa* Boiss. 2.3; plot 12: *Ammi majus* L. 2.3, *Trifolium tomentosum* L. 3.3; plot 3: *Malva multiflora* (Cav.) Soldano & Banfi 1.1; plot 6: *Stachys neurocalycina* Boiss. 1.1; plot 1: *Asperula orientalis* Boiss. & Hohen. 1.2, *Capsella bursa-pastoris* (L.) Medik. 1.1, *Draba verna* L. 2.3, *Cerastium fragillimum* Boiss. 1.1, *Vicia villosa Roth* 1.3; plot 2: *Lathyrus blepharicarpus* Boiss. 2.3, *Trifolium israeliticum* D. Zohary & Katzn. 1.1, *Crepis palaestina* (Boiss.) Bornm. 3.2, *Hippocrepis unisiliquosa* L. 2.3; plot 11: *Eclipta alba* (L.) Hassk. 2.3; plot 13: *Securigera parviflora* (Desv.) Lassen 1.3, *Schenkia spicata* (L.) G. Mansion 1.3, *Solanum nigrum* L. 1.1, *Veronica cymbalaria* Bodard 2.3, *Ranunculus pinardii* (Stev.) Boiss. 2.4.

Consequently, the vegetation series would be defined based on the observed floristic composition and regeneration counts (successions), canopy cover and type of threats (regressive successions) as well as the indicator plants for the evolution stages. The phytodynamic succession is illustrated in Figure 4.

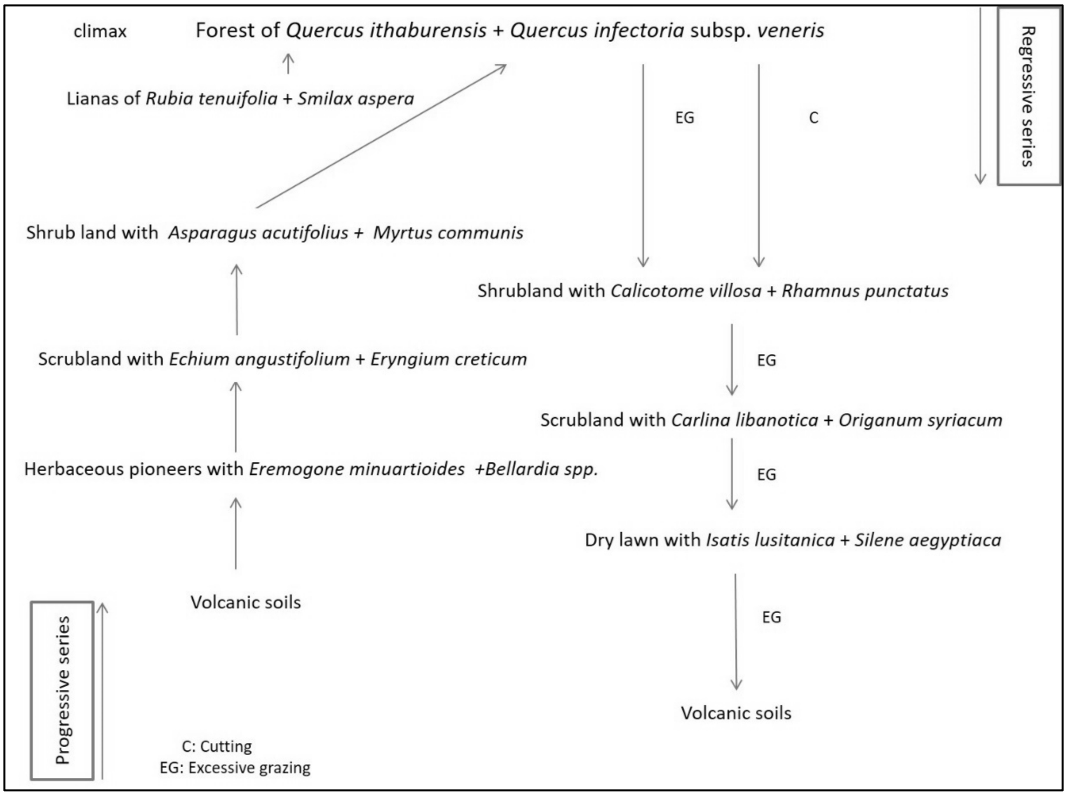

Figure 4. Phytodynamic succession of the *Quercetum veneris – ithaburensis*.

These series would integrate all the identified associations using the synusial methodology. It is evident that degradation due to overgrazing and cutting is keeping the vegetation cover low, and the xerophytic plants dominating (*Sarcopoterium spinosum*, *Carlina libanotica*, *Calicotome villosa* and *Origanum syriacum*). However, from our field observation, it is clear that, when grazing is limited and sites are protected, and agriculture is abandoned, annuals such as *Bellardia spp.* and *Eremogone minuartioides* would grow. Further, the vegetation would develop into a para-climax that includes not only *Quercus ithaburensis* as a dominating species, but, whenever disturbances are absent or minor, a climax has developed where *Q. ithaburensis* is found in association with *Q. infectoria* subsp. *veneris*. Once a thick canopy layer is established, the vegetation in the understory may develop some shade tolerant species like *Asparagus acutifolius, Rubia tenuifolia*, *Cyclamen persicum,* and *Ruscus aculeatus.*

Results of the numerical classification

By comparing the variance decomposition within and between classes, we found that Bray-Curtis's dissimilarity method irrelevant to the synusial phytosociological analysis needs showing different results from those of the synusial approach (results not shown here). Bray-Curtis is to be read from the center towards the two sides of the dendrogram, which complicates defining associations. It doesn't show clear cut between classes, and, if used, flexible dissimilarity should be avoided.

Euclidean distance (ED), which is more convenient for our data set, shows similar results to those of the manual classification for a small set of recorded species, like the case of trees, shrubs and climbers as illustrated in Figures 5 and 6 and compared to the synoptic Tables 2 and 3**.** For instance, there is a single class corresponding to a single association for trees using flexible linkage.

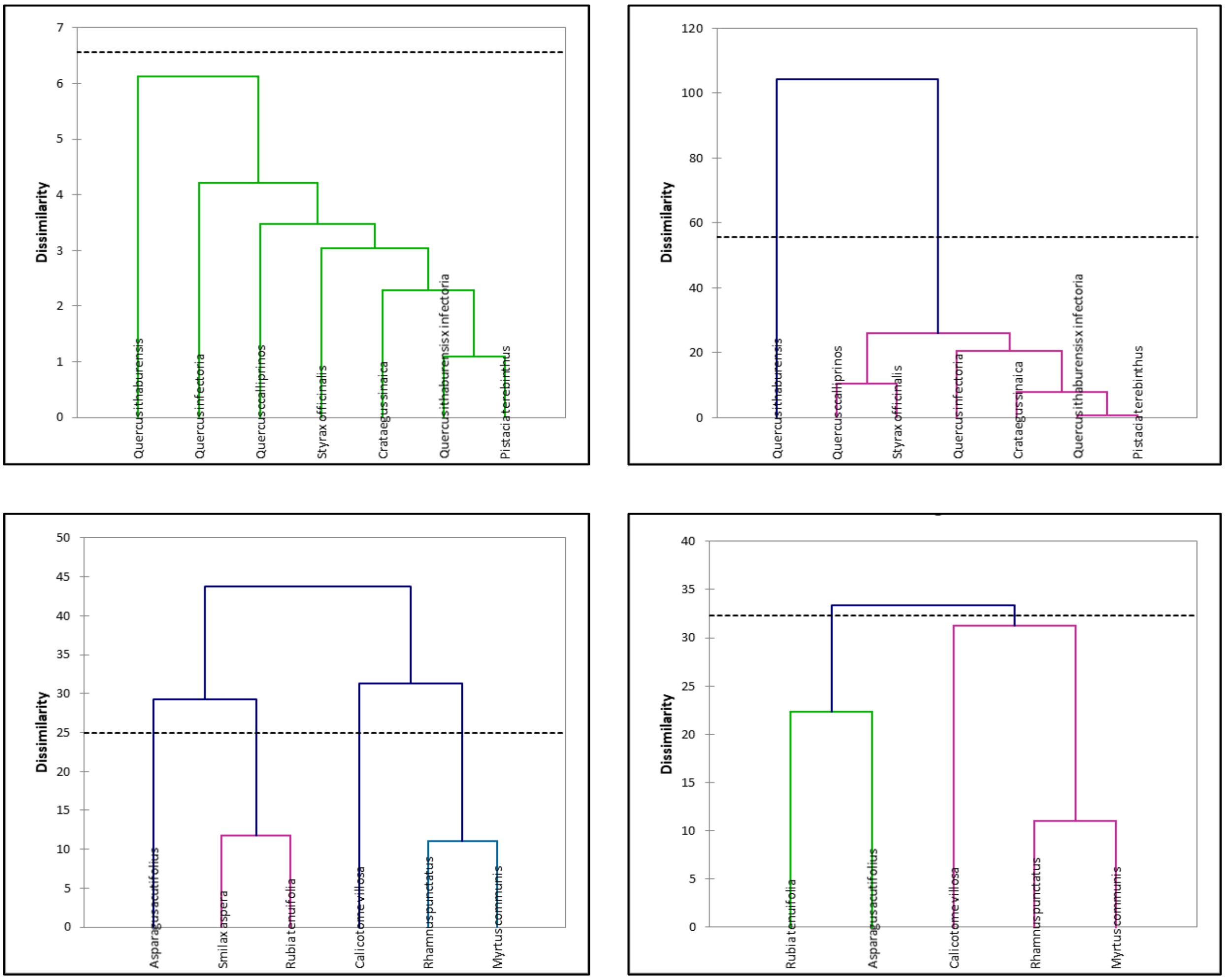

Figure 5. ED Supervised classification using both Flexible (left) and Ward (right) linkages for tree stratum (upper figures), and shrubs and climbers (middle figures).

Yet, the two classes shown using Ward linkage correspond to both the degraded and non-degraded forests, as explained in the synusial approach results. The same goes for shrubs and climbers, where both linkage types show two associations, one for the climbers (*Smilax, Asparagus, Rubia*) and another for shrubs (*Calicotome, Pistacia, Myrtus*). However, when the number of inventoried species is high, discrepancies may be encountered; Ward linkage sorts the common species (*Carduus argentatus*, *Alopecurus utriculatus*, *Hymenocarpos circinnatus*, and *Briza humilis*) apart from the differentiating communities, without further sorting between the two associations as defined manually in the synusial approach. The common species listed in the manual classification are the same, yet with additional few species. A careful reading from the center towards the edges of the dendrogram would allow to differentiate the major group of *Isatis lusitanica* and *Silene aegyptiaca* from the one of *Eremogone minuartioides,* even though in both numerical and manual classification, these two communities are not statistically differentiated from each other. In the flexible linkage dendrogram, the reading should be done from the edges towards the center in order to be compare with the manual classification. In both cases, results are satisfactory, if we consider the sequence of clustering of the species, rather the discrimination into classes.

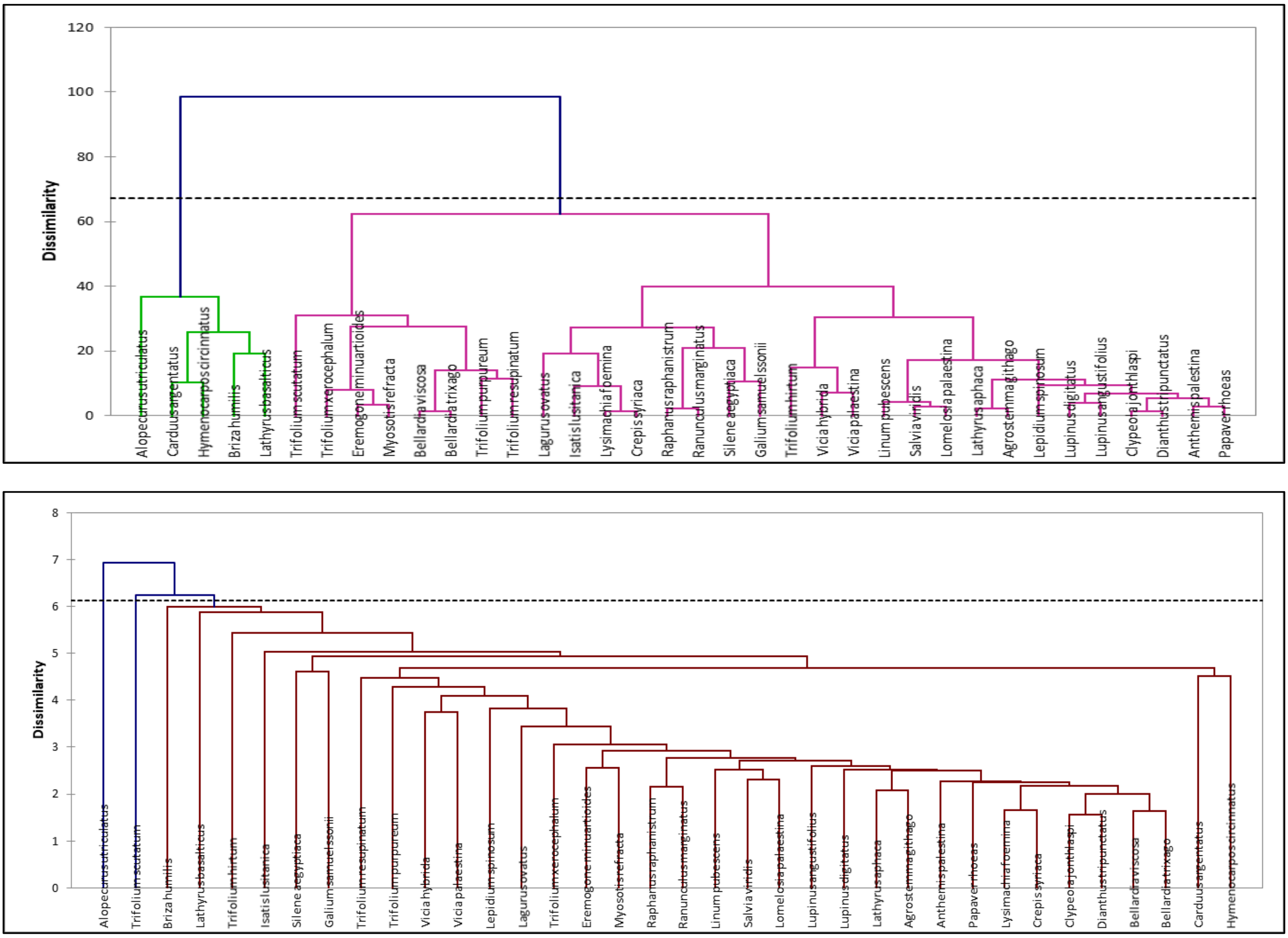

Figure 6. ED Supervised classification using Flexible (lower demdrogram) and Ward (upper dendrogram) linkages for the herbaceous stratum.

CONCLUSION

This work allowed to define a new vegetation series for open oak forests on basaltic bed rock in Akkar. It is the first attempt to study plant associations on volcanic soils in Lebanon. The analysis resulted into the confirmed presence of a new alliance present in Lebanon (*Quercion ithaburensi*), and the identification of several plant associations including *Quercetum veneris – ithaburensis, Calicotomo villosae - Rhamnetum punctati, Eryngio cretici - Echietum angustifolii* and *Sileno aegyptiacae - Isatidetum lusitanicae.* Additional associations need to be confirmed, as well as their affiliation. It is evident that the synusial approach allows to better depict the vegetation series within its progressive and regressive successions. Numerical classification is satisfactory and need to be fine-tuned. For supervised classification, ED with Ward or Flexible dissimilarity are both valid if the number of listed species is low. Once larger syntaxa data sets are collected, specific software (i.e. TWINSPAN, JUICE) would allow to elaborate a synsystematic classification for Lebanon that would be in concordance with the efforts that were made in vegetation classification in the Near East and around the Mediterranean Basin.

ACKNOWLEDGEMENTS

The field work is the result of the master thesis of Julien Barhoun at the Lebanese University, Faculty of Sciences, the Biodiversity-Conservation and Management of Natural Resources master program.

REFERENCES

Abi-Saleh, B. 1978. Etude phytosociologique, phytodynamique et écologique des peuplements sylvatiques du Liban. Thèse présentée à l’Université d’Aix-Marseille III, 171 pp.

Abi Saleh, B. Barbero, M. Nahal, I. and Quézel, P. 1976. Les séries forestières de végétation au Liban. Essai d’interprétation schématique. *Bulletin de la Société botanique de France*., 123(9): 541-560.

Abi Saleh, B. Nazih, N. Hannah, R., Safi, S. and Tohmé, H. 1996. Etude de la diversité biologique du Liban. Ministère de l’Agriculture et Programme des Nations Unies pour l’environnement.

Abi-Saleh, B. and Safi, S. 1988. Altitudinal zonation of vegetation in Lebanon. *Ecologia Mediterranea*, 14(1): 123-141.

Akman, Y. Barbero, M. and Quézel, P. 1978. Contribution à l’étude de la végétation forestière d’Anatolie méditerranéenne. *Phytosociologia*, 5(1-3): 277-346.

Al Issaoui, D. 1996. Vegetation of Jordan. Regional office for science and technology for the Arab states. UNESCO Cairo office. 283 pp.

Barbero, M. Chalabi, N. Nahal, I. and Quézel, P. 1976. Formations of Mediterranean conifers in the coastlines of Syria. *Ecologia Mediterranea*, 2: 87-99.

Barbero, M. and Quézel, P. 1989. Contribution à 1’étude phytosociologique des matorrals de Méditerranée orientale. *Lazaroa*, 11: 37-60.

Barghashoun, A. 1976. Etude écologique phytoécologique et phytosociologique des forêts des chênes à feuilles caduques du Liban. Thèse présentée à l'Université d'Aix-Marseille III, 66 pp.

Blondel, J. Aronson, J. Bodiou, J-Y. and Boeuf, G. 2010. The Mediterranean Region Biological Diversity in Space and Time, 2nd edition. Oxford University Press. 384 pp.

Braun-Blanquet, J. 1936. La chênaie d'yeuse méditerranéenne (*Quercion ilicis*). Monographie phytosociologique. *Communication SIGMA*, 45: 150.

Braun-Blanquet, J. 1951. Phytosociologie, bases de la science de la végétation. 631 pp.

Chouchani, B. Khouzami, M. and Quézel, P. 1974. A propos de quelques groupements forestiers du Liban. *Biologie et Ecologie Méditerranéenes*, I: 63-77.

Danin, A. and Orshan, G. 1999. Vegetation of Israel. I - Desert and coastal vegetation. Bayhuys Publications, Leiden.

Dufour-Dror, J-M. and Ertas, A. 2004. Bioclimatic perspectives in the distribution of *Quercus ithaburensis* Decne. Subspecies in Turkey and in the Levant. *Journal of Biogeography*, 31: 461-474.

Foucault, B. (de), Beyrouthy M. and Arnold-Apostolides N. 2013. Résultats d'investigations phytosociologiques récentes au Liban central. *Acta Botanica Gallica*, 160: 65-75.

Géhu, J-M. 1997. Le devenir de la bibliothèque de l'ancienne SIGMA dans la continuité scientifique de Josias Braun-Blanquet. *Braun-Blanquetia*, 21: 3-73.

Ghazal, A. 2008. Landscape Ecological, Phytosociological and Geobotanical Study of Eu-Mediterranean in West of Syria. Faculty of Agricultural Sciences University of Hohenheim Institute of Landscape and plant ecology. Stuttgart. Germany. 260 pp.

Gillet, F. de Foucault, B. and Julve, Ph. 1991. La phytosociologie synusiale intégrée: objets et concepts. *Candollea*, 46: 315-340.

Ketenoğlu, O. Tug, G-N. Bingol, U, Geven, F. Kurt, L. and Guney, K. 2010. Synopsis of syntaxonomy of Turkish forests. *Journal of Environmental Biology*, 31: 71-80.

Ministère des Travaux publics (direction générale des Transports, direction de l'Aviation civile), 1966. Atlas climatique du Liban, 1 - Pluie, température, pression, nébulosité. Imprimerie Catholique, Beyrouth. 90 pp.

Mouterde, P. 1966. Nouvelle Flore du Liban et de la Syrie**,** 3 tomes. Beirut. Imprimerie catholique.

Nahal, I. 1962. Contribution à l'étude de la végétation dans le Baer-Bassit et le Djebel Alaouite de Syrie. *Webbia*, XVI(2): 477-641.

Nahal, I. 1974. Réflexion et recherche sur la notion de climax de la végétation sous le climat méditerranéen oriental.

Neumann, F. Scholzel. Litt, T. Hense, A. and Stein, M. 2005. Holocene vegetation and climate history of the northern Golan heights (Near East). *Vegetation History and Archaeobotany*, 16: 329-346.

Oberdorfer, E 1954. Nordaegaeische Kraut- und Zwergstrauchfluren im Vergleich mit den entsprechenden Vegetationseinheiten des westlichen Mittelmeergebietes. *Vegetatio*, 5-6: 88-96.

Peet, R.K. and Roberts, D.W. 2013. Classification of Natural and Semi-natural Vegetation. *In*: Vegetation Ecology, 2nd edition. E. Van der Maarel and J. Franklin. Wiley and Sons, Ltd. 28-69.

Quézel, P. 1976. Les forêts du pourtour méditerranéen. *In*: Forêts et maquis méditerranéens, écologie, conservation et aménagements. Note technique MAB, Paris, UNESCO, 2: 9-33.

Quézel, P. Barbéro, M. and Akman, Y. 1978. L'Interprétation phytosociologique des groupements forestiers dans le bassin Méditerranéen Oriental. *Documents Phytosociologiques*, 2: 329-352.

Rivas-Martinez, S. and Rivas-Goday, S. 1975. La végétation de la classe *Quercetea ilicis* en Espagne et Portugal. *Anales del Instituto Botanico A. J. Cavanilles*, 31: 205-259.

Rivas-Martinez, S. 2005. Notions on dynamic-catenal phytosociology as a basis of landscape science. *Plant Biosystems*, 139(2): 135 – 144.

Stephan, J. Chayban, L. and Vessella, F. 2016. Abiotic factors affecting oaks distribution in Lebanon. *Turkish Journal of Botany*, 40: 595-609.

Tohmé, G. and Tohmé, H. 2014. Illustrated Flora of Lebanon, 2nd edition. Publication of National Council for Scientific Research, Lebanon. 610 pp.

UNDP, 2011. The national wind atlas of Lebanon. Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO). 64pp.

Walley, C. D. 1998. The Geology of Lebanon, a summary. American University of Beirut, http://almashriq.hiof.no/ddc/projects/geology/geology-of-Lebanon/

Walter, J-M. 1994. Méthode d'étude de la végétation. Institut de Botanique. Faculté des Sciences de la Vie. Université Louis Pasteur, Strasbourg. 23 pp.

Weber, H-E. Moravec, J. and Theurillat, J-P. 2000. International Code of Phytosociological Nomenclature, 3rd Edition. *Journal of Vegetation Science*, 1: 739-768.

Westhoff, V. and Van der Maarel, E. 1978. The Braun-Blanquet approach. *In*: Classification of plant communities. R.H. Whittaker (ed.): 289-399.

Zohary, M. 1962. Plant life of Palestine-Israel and Jordan. *Chronica Botanica* (New Series of Plant Science Books), 33, Ronald, New York. 262pp.

Zohary, M. 1973. Geobotanical Foundations of the Middle East. Second Volume. G. Fischer Verlag, Stuttgart. 739pp.