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Vegetation facies at Djebel Fernane, the extreme northeast of Oulad Nail Mountains (Algeria)

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Abstract

Djebel Fernane harbors a continental and semi-arid Mediterranean forest. It is located at the extreme northeast of Oulad Nail Mountains (Algeria). Mediterranean forests are known of their original vegetation and drought effect which can declines the phytodiversity. In these natural areas, it is important to have an idea of the spatial distributions of vegetation as there is no measure to preserve it. The methodology's study adopted is a mixed sampling which had been led to exposure and altitude. This sampling was applied in 36 floristic samples with a representative area of 120 m² each. The numerical analysis had shown distinguished groups of samples-species in different statements with special ecological conditions. Two gradients occur in the Correspondence Analysis graph appearance due to the exposure change and the altitude variation. The result of the physical environment disparities, on the home phytodiversity of Djebel Fernane, had given kinds of facies relating to spatial distributions of the existing Aleppo pine forest communities which conceal each various species and particular local conditions.

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Introduction

North Africa belongs to the hotspot of Mediterranean basin (Médail & Myers, 2004). For Quézel (1974) and Gómez-Campo (1985), the Mediterranean forest species richness is exceptional and contributes to the procession of individualized habitats. This fact is due to the great relief of the environment of the region which induced large kinds of local climates (Médail & Myers, 2004; Dernegi, 2010). The plant distribution in an area is submitted to its life requirements where the plant communities colonize particular environment places in a large part according to the natural factors such as topography, climate and soil type (Schwal, 2004).

The existence of a numerous microclimatic conditions of an area will have a variation in the topographical features directly (Muhidin *et al.*, 2016) like exposure and altitude, which distinguish a mountain and can hold a wealth of plant species (Tiokeng *et al.*, 2015). Here in these areas, the water can be a supply for the vegetation in the northern exposures against its opposite the southern ones. This richness may be distributed spatially and gets organized in vegetal communities ..., because the spatial distribution of species and the plant wealth had the same end result of the multitude of biotope factors and other (Philippe, 2012).

Our interest of this area was for the reason that this forest environment contributes as a natural barrier against the south influences. The biophysical environments and plant richness may contain the kinds of spatial plant distributions: "facies" of the existing Aleppo pine forest communities which might harbour each diverse species and particular local conditions and can be used as a tool for the preservation of this entity. The Djebel Fernane, in the extreme northeast of Oulad Nail Mountains is the case and the objective of this study.

Material and methods

Study Area

Djebel Fernane is far about 278 Km southeast Algiers, 35 Km south Boussaada City and 45 Km southwest Chott El Hodna, a saline dry lake and a Ramsar conservation wetland (Fig. 1). It belongs to the Mediterranean semi-arid climate with cool winter, it is subject to the influence of the Sahara and is typified by wet winter, dry-hot summer and high level of evaporation. Consequently, it is naturally a continental area with a dry forest. The substrate of the northeast of Oulad Nail Mountains is limestone rocks. The high elevations, in these mountains, are varying between an average of 1000 and down 1700 m where it found two major opposite exposures: northwest and southeast. In this forest, the Aleppo pine is the main essence mixed with green oak, Phoenician juniper, rosemary and other plants.

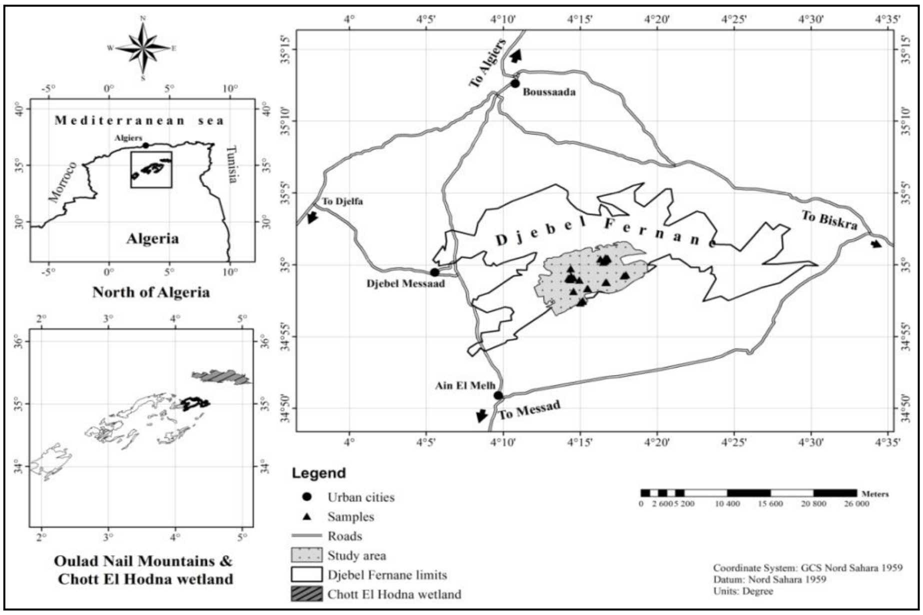

Fig. 1. Study area situation

This biological entity is influenced by the cumulative effect of drought (Guessoum *et al.,* 2016) and detrimental human activities: uncontrolled pasture and overgrazing, camping fires, illegal logging, uprooting plants, anarchic tourism.

To study the influence of topographical factors on the plant distribution, we have taken into account the floristic homogeneity. As the samples were selected by using a representative area since in the most cases the variability of the vegetation is primarily determined by the topographic heterogeneity (Schwal, 2004).

Sampling

We employed a mixed non-probability sampling: stratified and subjective. The stratified sampling was used to divide our study area into homogeneous units (strata). These reflect the reality of existing combined units course (Regoui, 2004; Zedam *et al.,* 2016) where the selected topographic factors are: exposure and altitude. The stratification gives four homogeneous units (Strata) where there are nine repetitions in each which equals to 36 samples. Concerning the subjective sampling, related to the first, it was used on land to implement the floristic samples in the homogenous and representative forest stations (Table 1). This part took place between spring 2014 and spring 2016. Each area's sample (releve) was 120 m^2. It is the minimal area needed for a floristic releve (Lacoste & Salanon, 2005). All plant species in the samples were assigned by a semi-quantitative coefficient "abundance-dominance" (Frontier, 1983). The obtained plants were determined by using the flora of: Quézel & Santa (1962-1963) and Ozenda (2004) where the nomenclature used for the plant species was the Quézel-Santa one (Quézel & Santa, 1962 - 1963). The voucher specimens of plants were deposed in the Botanical Laboratory of Agricultural Sciences - M'Sila University (Algeria).

Table 1. Samples distribution

	Topographical factors & determination means	Characteristics		Variants			
Stratified factors	Exposure "E" *(Compass)*	Wettest-Driest		Northwest: E1		Southeast: E2	
	Altitude (meter) "A" *(Altimeter)*	Temperate & Fresh		A1 ≤ 1000 m	A2 > 1200 m	A1 ≤ 1000 m	A2 > 1200 m
Homogeneous units (Strata)				E1-A1	E1-A2	E2-A1	E2-A2
Vegetation samples (Releves)			Repetitions	S1	S13	S7	S8
				S2	S14	S12	S9
				S3	S15	S16	S10
				S4	S18	S17	S11
				S5	S19	S21	S23
				S6	S20	S22	S24
				S29	S26	S33	S25
				S30	S27	S34	S31
				S36	S28	S35	S32

Data Analysis

a- The numerical analysis of the vegetation uses two techniques. First, the similarity index of two lists of species or two sites of study (Kouassi *et al.,* 2010) where we have chosen the Sørensen-Dice index but for a deeper analysis, we also utilize secondly, the Correspondence Analysis (CA). These numerical techniques were performed by the program of PAST (version 3.14). In these two analyses we operated with binary data species (Hill & Gauch, 1980; Wolda, 1981; Marcon, 2013; Hammer, 2016) where our semi-quantitative coefficient of abundance-dominance was transformed into a qualitative coefficient of presence-absence (Gillet, 2000).

b- An illustrative plan of the vegetation facies of Djebel Fernane was raised with arc GIS (version 10.2) following the studied factors, the personal observations in the study environment and according to the obtained results.

Results and discussion

Similarity

Similarity is any application with numerical values (Johnston, 1976) which makes it possible to measure the link between the variables (Marcon, 2013). Using similarity means search samples those are similar or separate the most dissimilar. Similarities between statements have important aspects to look for possible floristic/ecological groups (Walter, 2006). Where there is high similarity, it means low beta diversity: its low values denote the presence of the common species and that is to say that the diversity of the landscape (gamma) tends to equalize with the local diversity: alpha (Lévêque & Mounolou, 2008). It is interpreted as reflecting a strong similarity between the compared samples (Koleff *et al.,* 2003; Gonzalez Herrera, 2009) and the link's similarity is too strong as its value is great (Marcon, 2013). In accordance with Sorensen's similarity of our samples, they are assembled and separated into three groups (Fig. 2).

A first group (I) encompasses the samples 13, 14, 15, 18, 19, 20, 26, 27 & 28. They are belonging to high altitude and northwest exposure (E1-A2).

- A second group (II) contains the samples: 7, 12, 16, 17, 21, 22, 33, 34 & 35. They are related to low altitude and southeast exposure (E2-A1).
- A third group (III) is marked by samples: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 23, 24, 25, 29, 30, 31, 32 & 36. They feel right to :
- Low altitude and northwest exposure (E1-A1),
- High altitude and southeast exposure (E2-A2).

This numerical analysis of vegetation (similarity) shows (Fig. 2) that the cluster analysis translating a variation and consequently clarifies the study sites heterogeneity (Jenny *et al.,* 1990). This state reveals that the northern exposures are much watered than those located on the southern ones (Kherchouche *et al.,* 2011) and should shelter a wealth of plant species. This dissimilarity is due to:

- The Foehn effect is made by northwest winds which are humid and cause additional precipitations but when they cross the ridges they become less wet. This same state has been related by Schwal (2004) at the Lauragais and Marage (2004) at the Hautes-Alpes in France, where the exposure orientation let the south exposures present strong sunlight and high evaporation but the north facing has lower temperatures and low evaporation. Don't forget that in arid areas the water can be a supply for the vegetation (Marage, 2004) and can play a vital role in the life plants (Zoghmar *et al.,* 2016).
- In North Africa, the northern exposures are greatly watered (Kherchouche *et al.,* 2011).
- Hot and dry winds come from the Sahara in the south (Kadik, 1987).

The three groups of samples shown by the similarity reveal a difference in home vegetation with the presence of particular plants richness that reflects different states. The studied factors induce local climates where Médail and Myers (2004) have already mentioned this idea.

This difference puts seemingly aspects, types or forms that the vegetation took in front of local change of stationnal parameters like those studied where these distinguished facies follow a variation of the ecological gradients in concordances with the physiology and life requirements of the existing plants.

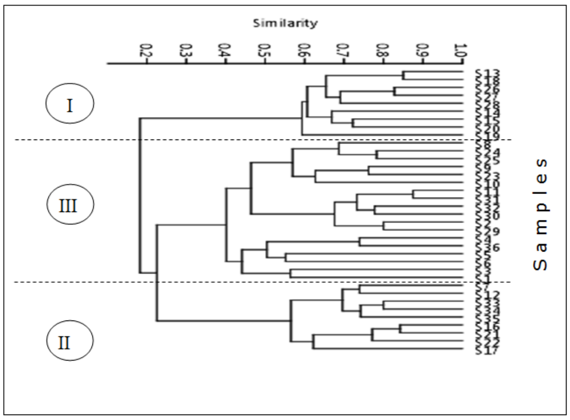

Fig. 2. Sørensen's similarity.

Correspondence Analysis (CA)

Correspondence analysis is a statistical technique that provides a graphical representation of cross tabulations (Yelland, 2010). One fundamental question in community ecology is: How do species respond to environmental gradients? Data involve sampling many sites and species; the ecologists have adopted and adapted multivariate methods such as Correspondence Analysis (CA) to best organize samples on the basis of the site attributes (Jackson & Somers, 1991). This technique of multivariate numerical analysis consists of searching for the best simultaneous representation of two sets of observation (samples) and variable (species) (Grall & Hily, 2003). After calculation, we obtained the CA ordination of the samples and species (Fig. 3).

Two gradients occur in this CA graph. The first gradient reflects decreasing moisture from up to down, induced by the passage from northern exposure to southern exposure and from high altitude to low altitude, and the second gradient shown a decrease of temperature from bottom to top caused by the exposure change and increasing altitude. This state has generated two opposite areas: temperate & dry - fresh & wet.

The distinguished groups of samples-species (1, 2, and 3) shown by the CA analysis (Fig. 3), let them in different statements. They are: spaced, enclosed many species and allowed different ecological conditions.

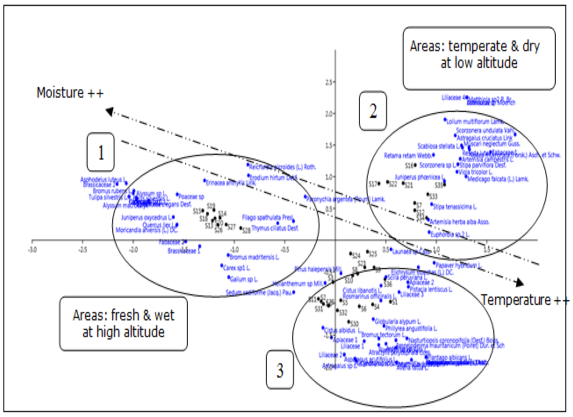

Fig. 3. The CA ordination of the samples and species.

The group (1) manifests at the northwestern exposure and high altitude. It belongs to semi-arid bioclimate with cool winter and an altitude above 1200 m. It is an Aleppo pine formation dominated by *Pinus halepensis* Mill. and particular shrubs: *Erinacea anthyllis* Link., *Quercus ilex* L. and *Juniperus oxycedrus* L. It is similar to the upper mesomedite rrannean (Ozenda, 1975) and mesomediterrannean (Rivas Martinez, 1981).

We recall, however, that a part of our study area is situated ahead of 1200 m in the semi-arid bioclimatic stage with cool winter. Note that *E. anthyllis*, is a small shrub found in lands with cold and very cold winters at altitudes above 1000 meters (Le Houérou, 1989 & 1995; Meddour, 2010). Relating to: *Q. ilex* and *J. oxycedrus*, these two shrubs belong to the primitive forest vegetation of the semi-arid zone of high altitude (Le Houérou, 1989 & 1995). They are classified in the semi-arid bioclimatic stage with cold winter (Djebaili, 1984). *Q. ilex* belongs to the mountains (El Mahi *et al.,* 2016) and *J. oxycedrus* is a Mediterranean shrub found in the upper altitudes in wetter forests (Vilar *et al.,* 2016) because the great altitude determines ecological conditions and essentially the climate (Muhidin *et al.,* 2016). The group (2) includes an Aleppo pine forest where *P. halepensis* is the essential forest tree with steppic species found in low altitude and southeast exposure. The identified steppic species are: *Stipa tenacissima* L., *Juniperus phoenicea* L., *Artemisia herba alba* Asso., *Artemisia campestris* L., *Stipa parviflora* Desf., *Noaea mucronata* (Forsk.) Asch. & Schw. and *Retama retam* Webb. They characterize a semi-arid area with cool winter: the authentic steppe (Djebaili, 1984). Marage (2004) notes that the south and southeast exposures engendered the installation of thermophilous and xerophilous plant formation associated and the south exposure models high radiation than in the north one where it's responsible for that of determinism of the plant distribution. Note that in this kind of dry forests and due to the drought, we can easily find the small shrub of *R. retam*. It is also encountered in sandy arid areas (Djebaili, 1984), sandy desert habitats like the Middle-East (Ward *et al.,* 1993). For his part, Kadik (1987) had mentioned, in the Aleppo pine forests at the Saharan Atlas, *J. phoenicea*, a shrub, that it is submitted to negative influences from the Sahara in the south. The last group (3) was made in two areas: low altitude-northwest exposure, which is wet and temperate and high altitude-southeast exposure which is drier and fresh. These areas appear to have the same ecological conditions. This group is composed principally by: *P. halepensis* (the main forest tree), *Globularia alypum* L., *Pistacia lentiscus* L., *Elichrysum stoechas* (L.) DC., *Phillyria angustifolia* L., *Rosmarinus officinalis* L., *Cistus libanotis* L., *Cistus albidus* L. and *Helianthemum cinereum* (Cav.) Pers. It illustrates the Aleppo pine formation in the Saharan Atlas: an Algerian continental forests (Kadik, 1987; Smaihi, 2009). In the Aurès Mountains (Oued Feddala – Batna province, East of Algeria) at 1250 meters high and northeast exposure, Kadik (1987) had revealed also in an Aleppo pine forest the presence of the same plants. This group of plants is heliophilous and colonizes areas where lack of water is compensated in part by the high altitude recorded especially in the southern exposures. These forest species belong to the thermomediterranean floor (Quézel, 1986) and can be placed according to Ozenda (1975) in the lower mesomediterrannean. It is necessary to note when the altitude decreases in the northwestern exposure less than 1000 meters, we observe an Aleppo pine forest dominated especially by *S. tenacissima*, *J. phoenicea* and *A. herba alba* (Personal observation in the study area). This statement is due to humidity decrease and temperature increase. Below this plant formation we find frequently the typical steppe, with rare Aleppo pine trees, dominated by *S. tenacissima* (Djebaili, 1984). In Mediterranean forest, the various forest communities are submitted according to ecological and geographical criteria (Barbero *et al.*, 2001) and the facies of Aleppo pine formation in Algerian continental forests according to the local variation of the two topographical factors studied gives us to manage this biological entity. The purpose will contribute entirely the efforts to protect this kind of vulnerable formation, its plants, its habitats and the preservation of all its compounds.

Illustrative plan of vegetation facies

In the term of what was evoked, according to the found results and in use of our personal observation reports in the study environment, we can raise an illustrative plan of the vegetation facies of Djebel Fernane (Fig. 4).

According to the illustrative plan of the vegetation facies of the study area of Djebel Fernane (Fig. 4), we can observe these kinds of vegetation depending on the local topographic factors:

- An Aleppo pine forest and high altitude species in coldest areas above 1200m (E1-A2).
- An Aleppo pine forest with typical species in Algerian continental forests at low altitude (E1-A1) and high altitude above 1200m (E2-A2).
- An Aleppo pine forest dominated by steppic species at low altitude (E2 – A1).
- In the down altitudes at the foothills Mountain, it is the steppe formation with rare or no Aleppo pine trees.

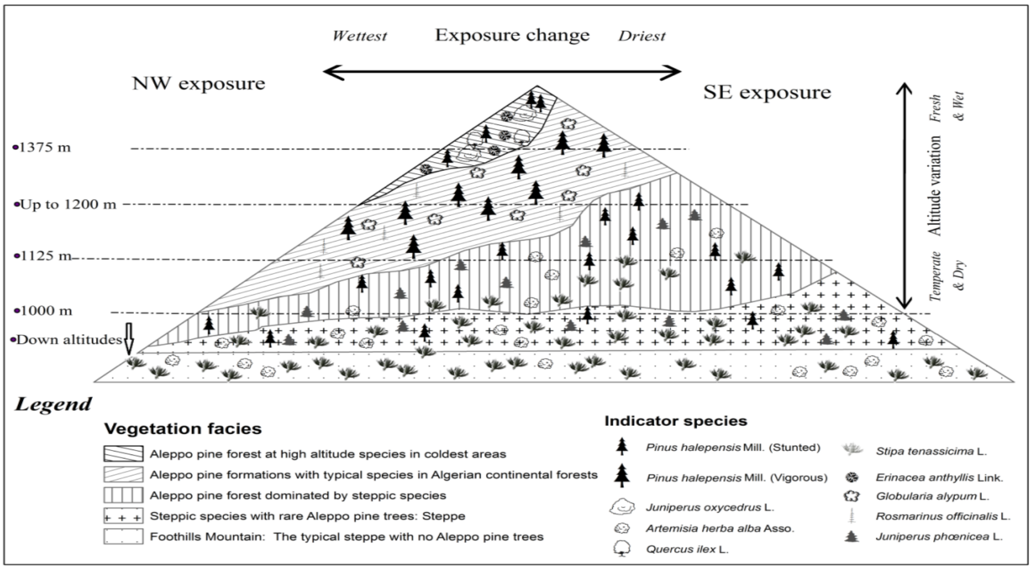

Fig. 4. Illustrative plan of Djebel Fernane's vegetation facies (Original drawing)

Conclusion

The Mediterranean Aleppo pine forest of Djebel Fernane, located in the extreme northeast of Oulad Nail Mountains and belongs to the Algerian Saharan Atlas, presents a plant distribution greatly influenced by the studied topographical factors: exposure and altitude. Its vegetation facies show that the northern exposures with high altitudes are much watered than those located on the southern ones located in low altitudes, harbor a particular wealth of plant species and illustrate the Aleppo pine vegetation in Algerian continental forests. This study area entity is an inheritance of humanity and the preservation of this natural ecosystem must be registered in emergency concerns more than ever as they constitute a part of the whole existing biodiversity resources and urgent management must be found to guarantee their continuing existence.

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