

# Characterization of Habitat of *Rhamnus alaternus* L. at the Jebel Tessala (North-Western Algeria)

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**Abstract:** In this study, the authors were interested to the evaluation of biodiversity in the Jebel Tessala. Ten stations were selected based on altitudinal gradient, inside each station, identified flora has been conducted and a soil sample was taken from. A floristic inventory was carried out from all stations characterizing habitat of our studied taxon which is *Rhamnus alaternus* L. The authors established a list of plants represented by 94 species, distributed in 46 botanical families that are dominated by *Asteraceae*. The biological spectrum of these species reveals the dominance of hemicryptophytes and therophytes. The biogeographical element which predominates the vegetation is the Mediterranean-type. Statistical processing PCA (principal component analysis) from the pedological analysis of the examined stations reveals the formation of three groups defining a set of station that are marked by the presence of some components of the soil. Data processing obtained by FCA (factorial correspondence analysis) and the ascending hierarchical classification had underscored the existence of two groups of strata according to the soil substrate.

**Key words:** Altitudinal gradient, FCA, Jebel Tessala, PCA, statement flora.

## 1. Introduction

The Mediterranean area is highly diversified by plant species and presents a great interest to any scientific research. Its high floristic richness is related to the heterogeneity of paleogeographic, geological and ecological aspects [1], but the current situation is dramatic in various North African countries [2]. In Algeria, the recent work on the Mediterranean formation affirms the regression of this floristic diversity [3]. Disruptions to the origin of this regression are complex and difficult to quantify on phytosociologic and geobotanic terms [4]. The mounts of Tessala located at the west of Algeria, is a space which combines climatic, geographical and lithological factors. It is also noted that the distribution of different plant formations from that synchronizes our species study, in these mountains remains poorly studied to this day despite the many works carried [5-7]. In this context, the authors were interested on the study of a characteristic plant of our

region: *Rhamnus alaternus* L., this study presents a specific originality with phytoecological characters that used major ecologic variants: climate, altitude, soil and vegetation due to its important distribution of the north of Algeria. *Rhamnus alaternus* L. in a polymorphic plant in the form of a tree or a sub-shrub with non-thorny branches of 1 m to 5 m easily recognized by its red berries at first, then black at maturity, characteristic species of mediterranea scrublands [8]. These formations are represented by a species complex of particular interest but which remain subject to continuous uncontrolled human pressures [9]. These constitute a direct risk to the renewal of biological resources as well as to the equilibrium of our study area.

## 2. Experiments

### 2.1 Study of Area and Selection of Stations

The mounts of Tessala are one of the important chains of the Tellian Atlas of Algeria. Lying on a hundred kilometers from the south west to the north east, they rise above the hills of Ain Témouchent and plain sebkha Oran (Mléta) to the north, Isser and the

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plain of Sidi-bel-Abbes in the south. They provide fairly modest relief from 500 m to 1,000 m, where the soft and flattened forms for most of the peaks and ridges contrast with the youth of some valleys and landslides and gullies of certain aspects. It is in the east of Tessala mountain where the peak of 1,061 m that the chain has the most mountainous [10]. The pleated structure seems scarcely revealed only by the overall direction of the solid and that of the main ridge lines [11]. The climate is a Mediterranean type in cool winters, with average annual rain fall of 290 mm to 420 mm. Average monthly temperatures are between 9.4 °C and 26.6 °C, the average minimum temperature of the coldest month ranges between 2.5 °C and 3.3 °C and average maxima of the month most hot rarely exceed 30 °C [12]. Several field surveys allowed us a good prior knowledge of Jebel Tessala (Tessala Mountain). Then, we selected 10 stations (Table 1) at the north and south sides according to an altitudinal gradient.

2.2 Soil and Plant Analysis

The soil samples were taken from each station to the horizon surface depth of 10 cm to 20 cm, they are then allowed to dry the open air for 15 days. After drying, the soil is sifted with a mesh sieve of 2 mm separating the gross elements of less than 2 mm fine soil. After the sifting, the authors will access the physico-chemical analysis by Aubert methods [12] in his manual of soil test. Different parameters were

examined: the granulometry, the degree of humidity the total rate of limestone, the active limestone, pH, conductivity and the rate of organic matter. For floristic inventory, the authors used the method recommended by phytosociological approach, Braun-Blanquet [14], also called sigmatist methodology. This approach, widely used in ecology for the diagnosis of different vegetation communities, the authors allowed the elaboration of floristry table. In this study, the minimum area shall be 100 m<sup>2</sup>. This area was adopted in all station samples by referring to certain phytoecological studies undertaken on the vegetation of our study area [9-15]. On each of the selected stations, an exhaustive list of species is made during the period of optimal vegetation from April to May, 2012. The species are identified by reference to the flora [16-18] dried and then placed in herbarium and archived.

2.3 Statistical Treatment

The mean values of the different physico-chemical parameters of the examined soil samples and the number of species and botanical families were identified with comparison of the test of ANOVA (analysis of variance) and Tukey’s test by using the software Minitab 16. The similarity in species composition between the studied stations is performed by  $\beta$  Sorensen similarity index of [17, 18] and  $J$  (Jaccard) index [19]. Statistical analyses that can meet the primary objective of this ecological study include:

**Table 1 Geographical coordinates of stations sampled.**

Station	North latitude	West longitude	Altitude (m)	Exposition
St 1	35°16'34"	0°46'253"	797	South-East
St 2	35°16'161"	0°46'570"	842	South-East
St 3	35°16'729"	0°47'246"	874	North-West
St 4	35°16'186"	0°46'962"	891	South-West
St 5	35°16'249"	0°47'079"	907	South-East
St 6	35°16'504"	0°46'784"	929	North-East
St 7	35°16'378"	0°47'103"	941	South-West
St 8	35°16'370"	0°46'879"	967	South-West
St 9	35°16'511"	0°46'540"	986	South-West
St 10	35°16'482"	0°46'555"	990	South-West

the FCA (factorial correspondence analysis), AHC (ascending hierarchical classification) and PCA (principal component analysis).

### 3. Results and Discussion

#### 3.1 Edaphic Studies

The observed physico-chemical analysis variations that appear on different soils are summarized (Table 2).

The soil analyses were performed at the level of soil laboratory of the NIAR (National Institute of Agronomic Research) in Sidi Bel Abbès. For each station, the authors took a single sample of the horizon surface, as the composition of the latter is the most important to study the vegetation. The sand is the dominant element in most soils, with rates varying between 45% and 68% at the stations (St 2 and St 4), this percentage is likely due to their location on rather steep where the runoff contributes to the depletion elements purposes of soil. The proportion of silts and clays varies with smaller percentages. The rate of up to 32% silts at the station (St 7) and clay content of no more than 25% by stations (St 9 and St 10). The structure is a balanced type, it is situated between Silty-Sand for the following stations (St 2-St 3-St 4-St 7-St 8) Silty-Clay to Sandy for the stations (St 1-St 5-St 6-St 10) and silt for the station (St 9). The authors note a humidity which reaches 30.51% and 23.3%, respectively in St 1 and St 8, this is because of the

important altitude. The importance of these percentage stations (St 3 and St 6) is explained by their location in the North Slope. However, there has been a low level, this is due to the evaporation of humidity which is due to exposure at lighting and hot wind. The pH is generally between 7.42 and 7.98 which defines alkaline pH where the biological activity of the soil is high and rapid. Only the station sample (St 5) has a substantially acid pH (6.75). The conductometer measures indicate on-saline soil (conductivity less than a 0.6 Ms/cm. Most samples define proportions of organic carbon higher than 4% indicating a relative richness in organic matter. The other stations are hovering around 2% to 4% that reflects soil with an average grade except for the station (St 2) where it is poorly represented with a content of only 1.53%. This wealth related to the humidity is relatively high and the rate of recovery of the studied plants. For the total limestone contents, the sketch of our results revealed on-limy soil for plants (St 6 and St 7), other medium limestone stations (St 4-St 8-St 9-St 10) and finally strongly limy stations (St 2 and St 5). The levels of active limestone are less than 4%, it reached 3.74 in St 4 and 3.75 in St 5. The statistical treatment was based on the soil cover and predestined that aims to PCA stations. This process is used to analyze quantitative numerical data tables to reduce the dimensionality of the main interaction between variable and plotting

**Table 2** Physico-chemical analysis of different soils.

Sample	pH	EC	Total lime	Active lime limestone	OM	Sand	Limon	Clay	Humidity
St 1	7.42	0.29	4.4	/	4.2	50	25	25	30.51
St 2	7.58	0.15	28.57	1.12	1.59	65.59	6.56	8.65	8.25
St 3	7.68	6.06	4.7	/	6.46	65	29	15	12.8
St 4	7.98	8.08	7.8	3.47	2.8	68	15	17	3.36
St 5	6.74	0.13	60.14	3.75	2.46	59.63	9.51	10.93	8.11
St 6	7.55	0.14	2.8	/	8.58	45	28	27	13.51
St 7	7.66	0.06	2.3	/	7.68	50	32	18	7.07
St 8	7.77	7.07	6.2	3.32	8.64	56	25	19	23.3
St 9	7.76	0.06	5.1	2.40	8.35	45	27	28	10.05
St 10	7.78	8.08	5.3	2.42	8.36	47	25	28	14

St: station; pH: hydrogen potential; EC: electric conductivity; OM: organic matter.

the interaction factors. The implementation of the CPA (principal component analysis) is performed using the software Statistiqua 6.0.

The circle of correlation shown in Fig. 1 gives us the formation of different groups. Thus, the F1 factorial axis which represents a percentage of inertia about 57.71% demonstrates three groups:

- G1: consists of St 9 and St 10 which offers high levels of clay, silt and organic matter. They are no saline soils with an alkaline pH;
- G2: defining a set of St 1, St 3, St 6, St 7 and St 8 correlated positively with active limestone which is absent in the whole set, although the structure is no discernible difference and the higher rate of humidity which is in relation with coincident altitude, these stations are marked by the importance of altitudinal gradient;
- G3: represented only by St 4, this isolation is due to the importance of the sand that is on the order of 68%.

3.2 Floristry Study

Surveys conducted in the field have allowed us to quantify the floristic richness and diversity of the ecosystem of Tessala Mountain. The systematic characterization of this plant diversity has shown that the total of 94 recorded species distributed over 39 different families, the family which is best represented is the *Liliaceae* with a rate of 10.59%, followed by *Asteraceae* (9.41%), then the *Poaceae* (8.62%) and the *Lamiaceae* (6.66%). The *Alliaceae*, *Amaryllidaceae*, *Crasulaceae*, *Orobanchaceae*, *Hyacinthaceae* and *Illecebraceae* are less represented in this flora with a proportion of 0.8%. The *Arecaceae*, *Liliaceae* and *Poaceae* dominate St 1, St 2 and St 6; the *Lamiaceae* and *Liliaceae* are better figured in station St 5, St 6, St 8, St 9 and St 10. The *Cistaceae* fits better in St 5 and St 10, a plant is the result of the vegetative part of his body, of all biological processes.

The therophytes are clearly dominating all stations.

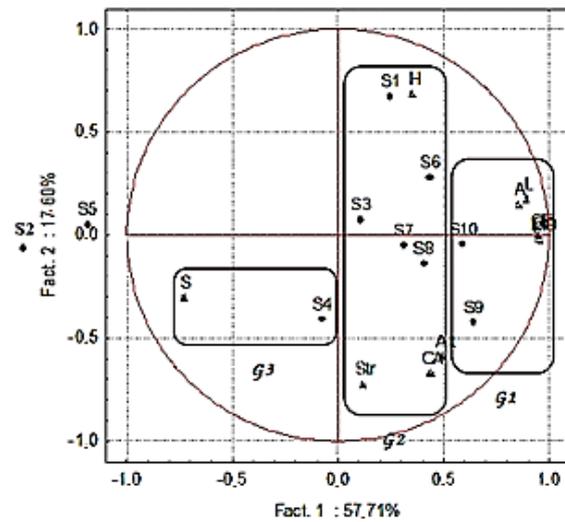


Fig. 1 Circle correlation (PCA) from the soil analysis of the studied plants.

Table 3 Distribution of biological types of the inventoried vegetation.

Biological type	Rate (%)
Therophytes	39.25
Hemichryptophytes	23.14
Chamaephytes	6.2
Geophytes	11.16
Phanerophytes	20.25

The analysis of Table 3 shows that the hemichryptophytes are more present in St 4, St 5 and St 10. The phanerophytes and the geophytes marked the St 5, St 6, St 7 and St 9. The chamaephytes are less represented. The annual herbaceous plants define the highest (58.37%) rate, followed by perennial herbaceous plants with 22.45%.

Ligneous plants and biennial herbaceous plants, respectively 17.96%, 1.22%. Perennial herbaceous plants dominate St 3 and St 10 and perennial ligneous plants are better St 5 and St 7. The biennial herbs are the least represented.

The results of the phytoecological study for 10 stations are shown in Table 4.

For 94 inventoried species those affected by a factor of 5 and 4 are defined as very abundant species, we recorded only two species, respectively *Eucalyptus globulus* in St 2 and *Pinus halepensis* in St 9. They represent rarely grouped isolated individuals. Most

**Table 4** Phytoecological rebuilt of different stations.

Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	F (%)
<i>Aegylops triuncialis</i> L.	1.1	-	-	-	-	-	-	-	-	-	10
<i>Allium ampeloprasum</i> L.	-	-	-	-	-	1.2	-	-	-	1.3	20
<i>Ammi visnaga</i> L.	1.1	-	-	-	-	-	-	-	-	1.1	20
<i>Ampelodesma mauritanicum</i> (Bir) et Schiz		1.1		++	1.2	1.1	1.1			++	60
<i>Anacyclus clavatus</i> (Desf.) Person	1.1	1.+	-	-	-	-	-	-	1.1	-	30
<i>Anacyclus cyrtolpidoides</i> (Pomel) Humphries	-	-	-	-	-	-	-	1.1	-	-	10
<i>Anagallis arvensis</i> L.	2.3	1.3	1.2	1.1	2.3	1.3	1.2	2.1	-	-	80
<i>Anthyllis tetraphylla</i> L.	-	-	-	-	-	-	-	-	-	1.2	10
<i>Arum</i> sp.	-	-	-	-	-	++	-	-	-	-	10
<i>Asparagus acutifolius</i> L.	-	++	-	++	++	++	-	-	++	++	60
<i>Asparagus stipularis</i> . Forsk.	++	-	++	-	-	-	-	-	-	++	30
<i>Asperula hirsuta</i> Desf.	-	-	-	++	++	-	-	++	-	-	30
<i>Asphodelus microcarpus</i> Sal et Viv.	++	++	-	++	-	-	++	++	++	++	70
<i>Astragalus vogelli</i> . (Webb) Bornm	-	-	-	-	-	-	-	-	++	-	10
<i>Avena sterilis</i> L.	1.1	-	-	-	-	-	-	-	1.1	-	30
<i>Ballota hirsuta</i> Benth.	1.1	++	-	1.+	-	-	++	1.+	-	1.2	60
<i>Bellis anua</i> L.	1.1	1.1	-	-	++	1.1	1.2	-	-	1.2	60
<i>Borago officinalis</i> L.	-	-	-	-	1.+	-	++	1.+	-	-	30
<i>Bromus rubens</i> L.	-	-	-	-	-	++	-	-	-	-	10
<i>Calycotome villosa</i> (Poirot) Link	1.1	++	1.2	-	1.2	++	1.2	1.1	-	-	70
<i>Centaurea acaulis</i> L.	1.+	-	-	-	-	-	++	++	-	1.+	40
<i>Centaurea calicitrappa</i> L.	-	-	-	-	-	-	-	-	++	-	10
<i>Centaurea euriophora</i> L.	++	-	-	-	-	-	-	-	-	-	10
<i>Cerinthe major</i> L.	-	-	-	-	1.+	++	-	-	-	-	20
<i>Chamaerops humilis</i> L.	1.1	++	++	-	1.+	1.1	++	2.+	-	-	70
<i>Cistus albidus</i> L.	-	-	-	-	++	-	-	1.+	-	-	20
<i>Cistus crispus</i> L.	-	-	-	-	-	-	++	-	-	-	10
<i>Cistus salviifolius</i> L.	-	-	1.1	-	-	-	-	-	-	1.1	20
<i>Convolvulus althaeoides</i> L.	1.1	2.1	++	++	++	1.1	++	++	-	1.+	90
<i>Cynoglossum</i> sp.	-	-	-	++	-	++	-	-	++	-	30
<i>Dactylis glomerata</i> L.	-	-	-	-	-	-	-	-	-	++	10
<i>Daphne gnidium</i> L.	++	-	-	-	++	-	++	++	-	-	40
<i>Daucus carota</i> L.	-	-	-	-	-	-	-	++	-	1.1	20
<i>Echium plantaginum</i> de Coincy	-	-	-	++	++	-	++	-	-	-	30
<i>Eeuphorbia</i> sp.	-	-	-	++	-	-	-	-	-	-	10
<i>Erodium chium</i> (L) Willd	-	-	-	++	-	1.1	-	-	-	-	20
<i>Erodium</i> sp.	-	-	-	++	-	-	-	-	++	++	30
<i>Eryngium tricuspdatum</i> L.	-	++	-	-	-	-	-	++	-	-	20
<i>Eucaliptus globulus</i> Labill.	-	5.4	-	-	-	-	-	-	-	-	10
<i>Fracsinus angustifloria</i> L.	-	1.2	-	-	-	-	-	-	-	-	10
<i>Fumaria caprioliata</i> L.	-	-	-	-	-	1.2	-	-	1.2	++	30
<i>Helianthemum polyanthum</i> (L.) Mill.	-	-	1.4	-	-	-	-	-	-	1.1	20
<i>Helianthemum appeninum</i> (L.) Mill.	-	-	-	-	1.+	-	-	-	-	++	20
<i>Hordeum murinum</i> L.	++	-	++	-	-	++	++	++	++	-	60
<i>Juniperus oxycedrus</i> L.	-	-	-	-	-	-	++	-	-	-	10
<i>Lagurus ovatus</i> L.	1.+	-	-	-	-	++	-	-	-	-	20

Table 4 continued

Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	F (%)
<i>Launea nudicaulis</i> L.	-	-	++	++	-	1.+	-	-	-	++	40
<i>Lavatera cretica</i> L.	-	-	-	-	-	-	-	-	-	++	10
<i>Lobularia maritima</i> (L.) Desvaux.	1.1	1.1	-	++	-	-	1.1	-	-	1.1	50
<i>Muscari comosum</i> L. Mill.	++	1.+	++	-	-	++	-	-	1.1	++	60
<i>Olea europaea</i> L. Var. oléaster.	-	++	-	++	1.1	++	++	-	-	-	50
<i>Ornithogallum umbellatum</i> L.	-	-	++	-	-	-	-	-	++	-	20
<i>Orobanche</i> sp.	-	-	-	-	++	-	-	-	-	-	10
<i>Pallensis spinosa</i> (L.) Cass.	1.1	-	-	-	-	-	++	-	-	1.2	30
<i>Paoaver roheoas</i> L.	-	-	-	++	-	-	-	-	-	-	10
<i>Paronychia argentea</i> (Pour.) Lamk.	1.2	-	1.1	-	-	-	-	-	-	-	20
<i>Phlomis crinite</i> Cav.	1.2	-	-	-	-	-	-	-	-	-	10
<i>Pinus halepensis</i> Mill.	-	-	-	-	++	-	-	-	4.4	-	20
<i>Pistacia atlantica</i> Desf.	-	-	-	++	-	-	-	-	-	-	10
<i>Pistacia lentiscus</i> L.	-	-	++	-	++	-	++	++	-	++	50
<i>Plantago logopus</i> L.	1.2	-	-	++	1.1	++	-	-	-	-	40
<i>Plantago major</i> L.	-	-	1.1	-	-	-	1.1	-	-	-	20
<i>Plantago</i> sp.	-	-	-	-	-	-	-	++	-	-	10
<i>Quercus ilex</i> L.	-	-	1.1	++	1.1	1.1	1.2	++	-	++	70
<i>Raphanus raphanistrum</i> L.	1.1	++	++	-	++	++	++	++	++	++	90
<i>Reseda alba</i> L.	1.1	-	-	-	-	-	-	-	1.2	1.2	30
<i>Rhamnus alaternus</i> L.	-	-	++	-	1.+	1.1	++	-	-	1.2	50
<i>Rubia peregrina</i> L.	-	++	-	-	-	++	-	-	-	++	30
<i>Rubus ulmifolius</i> Schott.	-	-	-	-	-	++	-	-	-	++	20
<i>Rumex bucephalophorus</i> L.	++	-	1.1	++	-	-	++	-	-	-	40
<i>Rumex thyrsoides</i> Desf	-	-	++	-	-	++	-	-	-	-	20
<i>Ruta chalepensis</i> L.	1.2	-	-	-	-	-	-	-	-	-	10
<i>Ruta Montana</i> (Cluss.) L.	-	-	++	-	-	-	-	-	++	-	20
<i>Scarbiosa stellata</i> L.	++	-	-	++	-	-	-	-	-	++	30
<i>Scilla peruviana</i> L. Speta	-	-	++	-	-	-	-	-	1.2	-	20
<i>Sederitis incana</i> L.	-	-	++	-	1.+	-	-	1.+	-	++	40
<i>Sedum</i> sp.	-	-	++	-	++	1.1	-	-	-	-	30
<i>Silene colorata</i> L.	++	-	-	-	1.1	-	++	-	-	++	40
<i>Silybum marianum</i> L. Gaertn	-	-	-	++	-	-	-	-	++	-	20
<i>Sinapsis arvensis</i> L.	++	-	-	-	-	-	-	-	-	-	10
<i>Smilax aspesa</i> Var. altissima	-	-	++	-	-	++	-	-	-	-	20
<i>Smilax aspera</i> Var. genuina	-	-	-	-	-	++	-	-	-	-	10
<i>Stachys ocymastum</i> (L.) Briq.	-	-	-	-	-	-	-	-	-	++	10
<i>Stellatum</i> sp.	-	-	-	-	-	-	-	++	-	-	10
<i>Stipa tenacissima</i> L.	-	-	-	-	1.1	-	-	-	-	-	10
<i>Teucrium pollium</i> L.	-	-	-	-	++	-	-	-	-	-	10
<i>Teucrium pseudochamaepitys</i> L.	-	-	-	-	++	-	-	-	-	-	10
<i>Thymus ciliatus</i> Desf.	-	-	-	-	-	-	-	1.1	-	-	10
<i>Thymus vulgaris</i> L.	++	-	-	-	-	-	-	-	-	-	10
<i>Trifolium angustifolium</i> L.	++	-	-	-	-	-	-	-	-	-	10
<i>Trifolium stelatum</i> L.	++	1.2	-	-	++	-	-	-	-	-	30
<i>Urginea maritima</i> (L.) Baker.	1.2	1.1	1.1	++	-	++	++	1.1	-	-	70
<i>Urtica membranica</i> L.	-	-	-	-	-	-	-	-	-	++	10
Number of species	35	21	26	24	30	30	25	23	18	35	

**Table 5** Indices of diversity.

Stations	St 1	St 2	St 3	St 4	St 5	St 6	St 7	St 8	St 9	St 10
Number of species	35	21	26	24	30	30	25	23	18	35
ShI (bit/individual)	1.66	2.07	1.95	1.76	2.03	1.75	2.07	1.94	2.02	2.07
<i>E</i>	0.15	0.32	0.25	0.24	0.22	0.19	0.27	0.28	0.37	0.20

ShI: the Shannon index; *E*: equitability index.

species are assigned by an index ranging between 1 and 2 where the recovery is from less than 25% to less than 5%, the latter species are abundant or may be present as: *Anagalis arvensis*, *Ballota hirsuta*, *Ruta chalepensis*, *Calycotum spinosa*, *Convolvulus althaeoides*, *Phlomis crinita*, *Quercus ilex* and *Helianthemum polyanthum*.

With regard to the frequency of species, we can distinguish very constant species such as *Convolvulus althaeoides*, *Raphanus raphanistrum*. This class corresponds to the species found in all records. This category corresponds to homogeneous vegetation and brings together the most commonly answered species:

- Abundant species; they indicate *Ampelodesma mauritanicum*, *Anagalis arvensis*, *Ballota hirsuta*, *Calycotome villosa*, *Cerentia major* and *Quercus ilex*;
- Frequent species such as *Anagalis monelli*, *Centaurea acoulis*, *Daphne gnidium*, *Launea nudicaulis*, *Lobularia maritima*, *Olea europea*, *Pistacia lentiscus*, *Rumex bucephalophorus* and *Silene colorata*;
- Rare species; we cite *Trifolium stelatium*, *Smilax aspesa*, *Silybum marianum*, *Sedum* sp., *Scabiosa stellata* and *Rubia peregrina*;
- Very rare species; this is the case of *Sinapis arvensis*, *Stachys ocyrmastum*, *Plantago major* and *Lavatera cretica*.

For the last two classes, the rarity of a species may be due to three reasons: either it is typical of an environment other than the one studied and there is an accident, or it is naturally rare and its frequency is low in all ecological conditions, or finally, it has very narrow ecological conditions: it is very low, it is frequent in a very small range of environments and absent elsewhere [20].

To evaluate the floristic diversity of the study site, the calculated species richness through the Shannon diversity index and equitability index was designed (Table 5).

The Shannon diversity index calculated for each station varies between 2.07 bit/individual for St 2, St 7, St 10 and 1.66 bit/individual for St 1. This variability is related to the heterogeneity of species. That said, the importance of the Shannon diversity index coincides with the environmental conditions favoring the installation of many species.

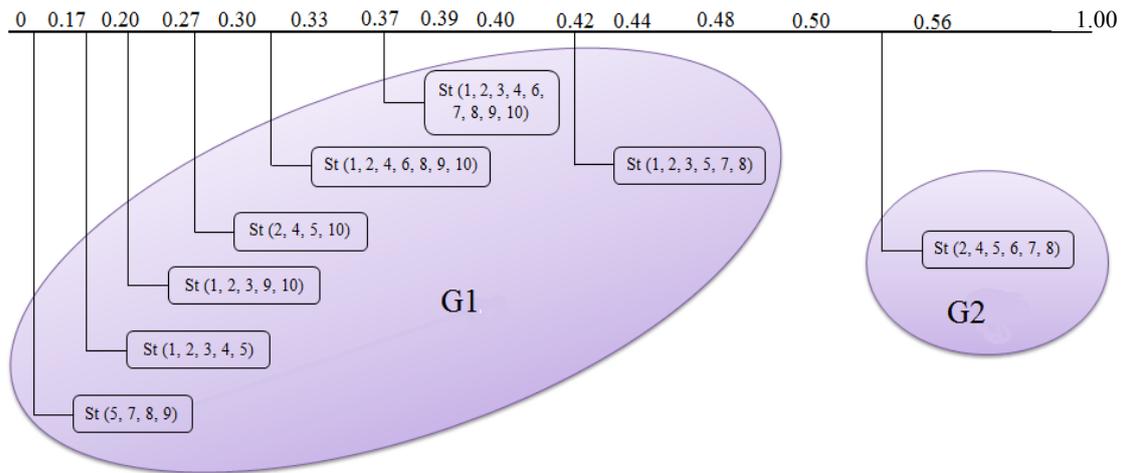
These variations in the equitability index are related primarily to the multiple human pressures and pastures. In our study, the stations are defining an equitability index relatively important between 0.20 and 0.37 (St 2, St 3, St 4, St 5, St 7, St 8, St 9, St 10) defining weakly distributed species. In contrast, those with low equitability index (0.15, 0.19) define evenly distributed species. The calculation of the Sorensen similarity index allows us to know the two stations.

The formation of groups is done by evaluating the similarity coefficient:

- G1: defining a set which is less than 0.5 (0.12-0.45), this plant formation indicates low similarity thus heterogeneity between stations by the point of view of specific richness that is clearly appeared in Fig. 2;
- G2: having a high similarity (0.50-0.56), these stations show homogeneity in terms of floristic composition.

### 3.3 Characterization of the Habitat of *Rhamnus alaternus* L.

The factorial analysis of correspondences is an approach that is well suited to phytosociological



**Fig. 2 Schematic of the formation of similar groups.**

studies, as it allows to jointly treating floristic variables and soil variables [21]. This type of analysis allows discriminating objectively particular entities or comparing stations in pairs [22]. However, the projection points “species” and “variables” in the axes plane F1 (17.77% of inertia) and F2 (16.75%) reveals two large groups (G1 and G2) in Fig. 3.

In its negative part, the F1 axis is related to the G1 which forms the floristic cortege which are present in our study. The following species that are present: *Asparagus stipularis*, *Ammi visnaga*, *Avena sterilis*, *Anagallis monelli*, *Asphodelus microcarpus*, *Bellis anua*, *Centaurea acaulis*, *Cynoglossum* sp., *Erodium* sp., *Launea nudicaulis*, *Paoaver roheoas*, *Raphanus rafanistrum*, *Reseda alba*, *Rhamnus alaternus*, *Rumex bucephalophorus*, *Scarbiosa stellata*, *Urginea maritima*, *Ballota hirsuta*, *Pinus halepensis*, *Pallensis spinosa*, *Asparagus stipularis*, *Phlomis crinite* and *Helianthemum polyanthum*, had affinities with the fine soil (contents in silt and clay), humidity, altitude and organic matter. These species are emerging as scarce in these species in St 1, St 2, St 4, St 5 and St 10 on soil texture that is relatively balanced. They consist of degraded scrubs on slopes facing south. The tree stratum is virtually nonexistent. This project marks two endemics *Phlomis crinite* and *Helianthemum polyanthum* which is defined as rare species.

As the one progresses along the axis, we have the

formation of another group G2 characterizing its positive side, we have a succession of species formed. *Ampelodesma mauritanicum*, *Calycotome villosa*, *Chamaerops humilis*, *Teucrium pollium*, *Asparagus acutifolius*, *Anagallis arvensis*, *Cerinthe major*, *Helianthemum polyanthum*, *Stipa tenacissima*, *Pistacia atlantica*, *Daphne gnidium*, *Arum* sp., *Trifolium stelatum*, *Bromus rubens*, *Eucaliptus globules*, *Juniperus oxycedrus*, *Pistacia lentiscus*, *Quercus ilex* and *Thymus ciliatus*.

The dendrogram of HCA (ascending hierarchical classification) (Fig. 4) after the floristic analysis of the studied plants highlights two main groups (GA and GB):

- GA: divided itself into two groups; the first A1 is distinguished by its rich flora where the majority of species belong to the shrub and herbaceous strata (*Asphodelus microcarpus*, *Ballota hirsuta*, *Ampelodesma mauritanicum*, *Calycotome villosa*, *Chamaerops humilis*, *Paronychia argentea* and *Urginea maritima*), this does not preclude the presence of the stratum trees such as *Pistacia lentiscus* and *Quercus ilex* with a remarkable presence. The St 1 discerned by its altitude is less important than other stations. The second subgroup A2 consists of stations where the altitudinal gradient is very important, thus benefiting from precipitation and humidity. There are species such as: *Convolvulus althaeoides*, *Doucus*

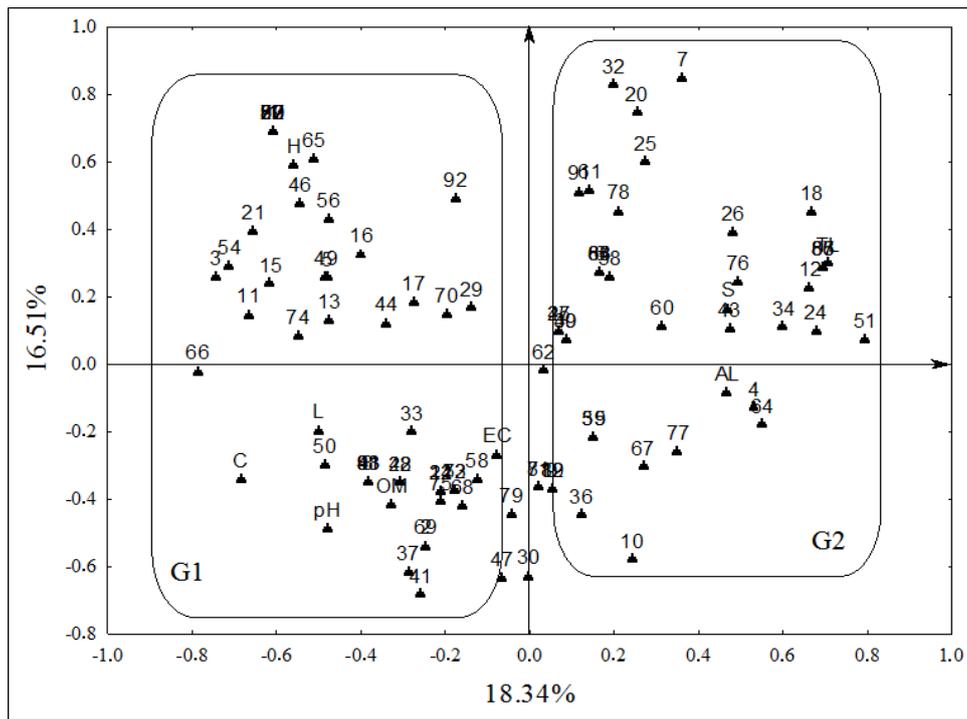


Fig. 3 Factorial analysis of the correspondences.

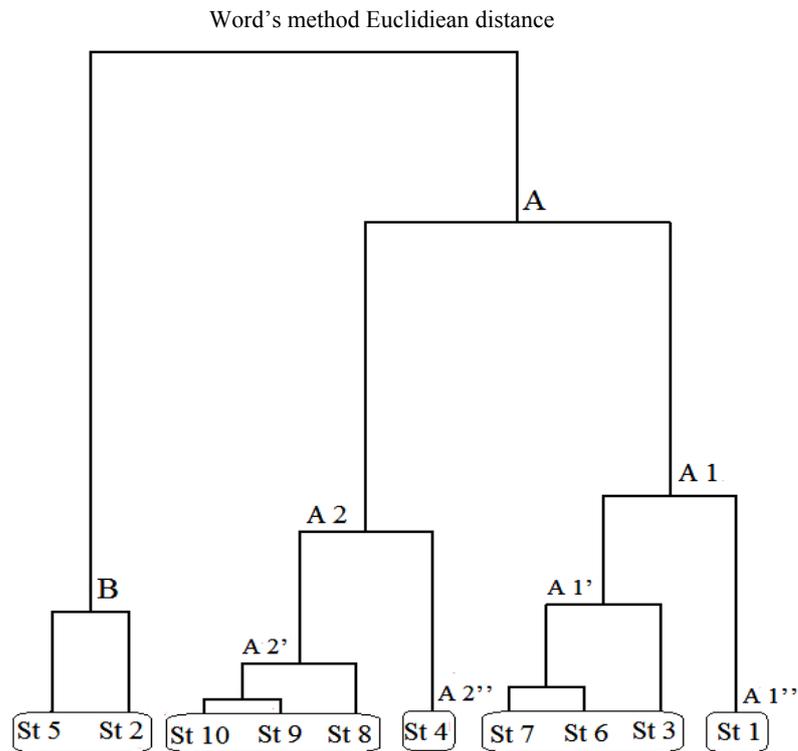


Fig. 4 Dendrogram of HCA.

*carota*, *Fumaria caprioliata*, *Pistacia* and *Pinus halepensis*. These formations are characteristic of scrubland;

- GB: according to the dendrogram, the group is considered as an out group. He is represented by two stations (St 2 and St 5) in southeast exposure, they are characterized by limestone substrate where species of herbaceous, shrub and tree *Eucalyptus globulus* which is very abundant in St 2 sync, *Olea europaea* Var. *Oleaster* and *Pinus halepensis*.

### 3.4 Discussion

#### 3.4.1 Edaphic Analysis

The physico-chemical characteristics of the 10 stations have a high percentage of sand and a significant amount of silt. Previous work in the area of Tessala evoke the color of the soil is very heterogeneous, there are yellowish, blackish soil, others reddish brown and clear land [14]. Pouquet [11] asserted that the lumpy structures predominate on different soils. He added that the sandy texture and balanced texture were characteristic of soils in the region of Tessala. Our results corroborate those of the author; since the prevalence of balanced structure was observed on 10 stations. The hydrogen potential (pH) is a slightly alkaline soil, with the exception of the station which defines St 5 as slightly acidic soil. According to Dajoz [23], the pH is not a stable characteristic of the soil but depend on different cations absorbed of the nature of the vegetation and climatic conditions. It is also related to the amount of limestone in the soil, the mineral composition and soil salinity [24]. However, statistical analysis (PCA) revealed a correlation between pH and total calcium, it is quite important at St 2, St 4, St 5 and St 8.

The electrical conductivity indicates unsalted soils in all samples. The humidity is very variant on the studied soils. It depends on the nature of the substrate, the nature of humus and the sampling period [25]. However, the soil content of organic matter evokes the rich and medium quantities. Fluctuating soil

conditions can affect the floristic cortege that accompanies these species. According to Quezel et al. [1], species richness is the first approach to assess biodiversity.

#### 3.4.2 Index Calculation

This wealth is uneven on all stations with a maximum value of 35 (St 1, St 10) and a minimum value of 18 at St 9. This heterogeneity is due to the distribution of the floras with relation to different environmental factors, sheep grazing and cuts that strongly contribute to the degradation of vegetation. This plant has an average of 24 species/station, it is there by qualified by average according to the classification of Daget and Poisson [26]. The Shannon diversity index calculated for each station varies between 2.07 bit/individual and 1.66 bit/individual. This facilitates the installation of many species. In contrast, the calculated of equitability index (*E*) reflects a weak presence of the dominant species in most stations except for St 1 and St 6 where species are well distributed.

The Sorensen similarity index shows that the majority of stations group a plant formation defining a low similarity where heterogeneity of stations is clearly observed. Lists of plants represented by 94 species were inventoried, they relate to 39 different botanical families with a predominance of *Liliaceae*, *Asteraceae*, *Poaceae* and *Alliaceae*. This importance is due to their overall contribution in Tessala flora and their Mediterranean area distribution.

#### 3.4.3 Floristic Analysis

According to the floristic analysis, annual species and perennial herbaceous plants hold the first place. This increase is due to the invasion of therophytes and hemicryptophytes. For Roman [27], there is a good correlation between biological types and many phenomorphologic characters.

In addition, human action influences the morphological species distribution. However, Lefloc'h [28] claimed that, the sheep and goats differently like species classified by main

morphological types (Ligneous, erect, perennial herbaceous plants, annual, etc.). Sheep like annuals and almost regardless of the life stage where they are, while goats instead consume only little annuals plant.

The composition of the biological spectrum shows a predominance of therophytes (39.25%). This high proportion is due to the soil conditions and microclimate especially where the winter and spring period is relatively wet, alternating with a rather prolonged drought [29] period. Likewise, Floret et al. [30] reported that, when a system is influenced by man, therophytes are growing, reflecting the strong anthropic pressure experienced by the region of Tessala. Despite the importance of therophytes, hemicryptophytes keep a particularly important place with a rate of 23.14%. This can be explained by the richness of soil of organic matter; this phenomenon was confirmed by Barbero et al. [22]. The phanerophytes come in the third position with a share of about 20.25%. The geophytes and chamaephytes are the least represented. The chamaephytes type is described as best suited to the dry and settles proportionally and present a adaptation of forest environments [31]. Biogeographically, we have considered the inventory of present species at the mountains of Tessala. The latter is characterized by a heterogeneous distribution of species where dominate the formations of matorrals and scrublands. The formation that still plays a pre-forest and forest role is mainly the green oak. The distribution of phytochoric elements is very heterogeneous. Quezel [32] explains the biogeographical diversity of Africa hit by climate change suffered severely in this region since the Miocene, resulting in the migration of tropical flora. The Mediterranean type is very high with a rate of 43.81%, followed by the Euro-Mediterranean with 7.62%.

Concerning the frequency of occurrence, recovery varies across species stations. However, *Calycotome villosa*, *Ballota hirsuta*, *Chamaerops* and *Quercus ilex* by their presence in almost all stations stands-out as

being the abundant species. However, rare species are the majority in this inventory. We note for example, *Phlomis crinite*, *Pistacia atlantica*, *Juniperus oxycedrus*, *Thymus ciliatus* and *Helianthemum polyanthum*.

Dethier et al. [33] indicated that, rare species were generally stenoeccious species with very specific ecological requirements, both for their habitat and their food needs. In addition, they often have a slow and complex cycle. Many species are not yet known by only a few occurrences (sometimes older) and are thus sometimes wrongly called "rare". The rarity of species is sometimes connected to specialists by ignorance or failure of identification of this species. On the phytoecological plan, a statistical treatment through the FCA and HCA provides additional information for the distribution of plant communities. This allowed us to distinguish two facets on both side of the flaxis: the first group shows the major characteristics of the two species (*Phlomis crinite* and *Helianthemum polyanthum*), the latter is distinguished by the presence of taxa present in low abundance and by the abundance of herbaceous and shrub species. For soil parameters, this group is negatively correlated with the hydrogen potential ( $R_2 = -0.72$ ) with organic matter ( $R_2 = -0.72$ ), with electrical conductivity ( $R_2 = -0.71$ ), the clay ( $R_2 = -0.80$ ) and moisture ( $R_2 = -0.53$ ). This is explained by the development of these taxa most often near croplands where organic matter is often important, and on soils where the fine fraction is needed (clay, silt), thus promoting the increase of moisture in the soil. In contrast, the second group characterized by the presence of four species (*Pistacia atlantica*, *Juniperus oxycedrus*, *Thymus ciliatus* and *Quercus ilex*) corresponds to a fairly advanced fascinated degradation. This formation defines generally scrublands with *Calycotome*.

#### 4. Conclusions

Following this work, it is clear that the frequent heterogeneity of vegetation in a mountainous

environment, annual and even seasonal variations of the floristic richness and the condition of this one raise many problems of the final interpretation.

Through this ecological study that aims to assess the biodiversity of Jebel Tessala, we were able to identify in the entire inventory 94 species belonging to 46 families of vascular plants, the study of the species *Rhamnus alaternus* L. showed that this species is associated with scrubland to *Calycotome*, with great repartitions at low altitude. This species is related to light soil, moderately to strongly rich in organic matter, slightly humid with alkaline pH.

This shows very clearly that the study sites and the mountains of Tessala in general area important reservoir for either the amount of the flora presenter to the stock of medicinal plant species and aromatic characters, profitability offered by medicinal plants in this mountainous ecosystem, and is certain to be an economic priority that should be exploited, provided that all measures of accompaniments, conservation and recycling are met to ensure the protection of the plant heritage.

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