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Ecological Characterization of Plant Communities in the Beni Affane Massif (Sdamas Chergui, Tiaret, Western Algeria)

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Abstract

This study explores the ecological and floristic structure of plant communities associated with *Tetraclinis articulata* (Vahl) Mast. in the Beni Affane massif, situated in the semi-arid region of Tiaret, western Algeria. Through a phytosociological approach and stratified field surveys, a total of 21 species were identified, with *Tetraclinis articulata (Vahl) Mast.* as the dominant species. The study area is characterized by a semi-arid Mediterranean bioclimate with pronounced seasonal rainfall variation and significant temperature fluctuations. The ecological heterogeneity of the site, particularly soil composition and slope variation, has led to the development of distinct vegetative facies, each indicative of specific environmental conditions. This research contributes to a deeper understanding of the adaptive strategies of Mediterranean flora and offers valuable insight for sustainable management and conservation of degraded forest ecosystems in North Africa.

Keywords: *Tetraclinis articulata*, ecological gradient, floristic diversity, Beni Affane, Algeria.

1. Introduction

Understanding the organization and dynamics of biodiversity remains a complex issue and a major challenge for both ecologists and biogeographers. The distinct composition of Mediterranean ecosystems is the result of a combination of paleogeographic, climatic, and ecological processes, as well as the persistent influence of human activity, which has shaped both the landscapes and their biological diversity. (Blandin, 1986).

Numerous studies have been conducted on *Tetraclinis articulata (Vahl) Mast.* stands across North Africa in general, and Algeria in particular (Fennane, 1987; Hadjadj, 2009; Miloudi, 1996) and this is due to the fact that analyses of floristic richness, together with biological and morphological traits, help to highlight the originality, conservation status, and heritage value of these plant groupings (Dahmani, 1997)

The characterization of plant communities within Mediterranean forest ecosystems is essential for understanding ecological dynamics, assessing biodiversity, and informing conservation strategies. Mediterranean ecosystems, particularly in semi-arid zones, present a complex interplay of climatic, edaphic, and anthropogenic influences that shape vegetation patterns and species assemblages. *Tetraclinis articulata* (Vahl) Mast., a relict conifer endemic to the western Mediterranean basin, holds both ecological and heritage value in Algeria, where its populations are increasingly threatened by land degradation and climatic stressors.

Situated within the Sdamas Chergui forest massif in Beni Affane, the study area offers a representative model for evaluating the spatial organization and ecological amplitude of *Tetraclinis articulata* (Vahl) Mast. groupings under semi-arid conditions. This research aims to assess the floristic composition and ecological structure of plant communities associated with this species. Emphasis is placed on analyzing the influence of topographic and climatic conditions, on species distribution. The study employs a combination of classical phytosociological methods and ecological interpretation to provide an integrative overview of vegetation dynamics in a context of environmental vulnerability.

2. Material and methods:

2.1.Presentation of the study area:

The study area is entirely located within the Wilaya of Tiaret (although it overlaps the territories of the Wilayas of Tiaret and Mascara). The Sdamas forest massif is administratively attached to the following municipalities: Frenda, Medroussa, Sidi-Bakhti, Djillali Ben Amer, Mechraa Sfa, Louhou, and Takhmart.

The study area is located in the Beni Affane Forest, a sample of semi-arid continental regions in western Algeria. The forest is situated at approximately 35°17' North latitude and 01°03' East longitude.

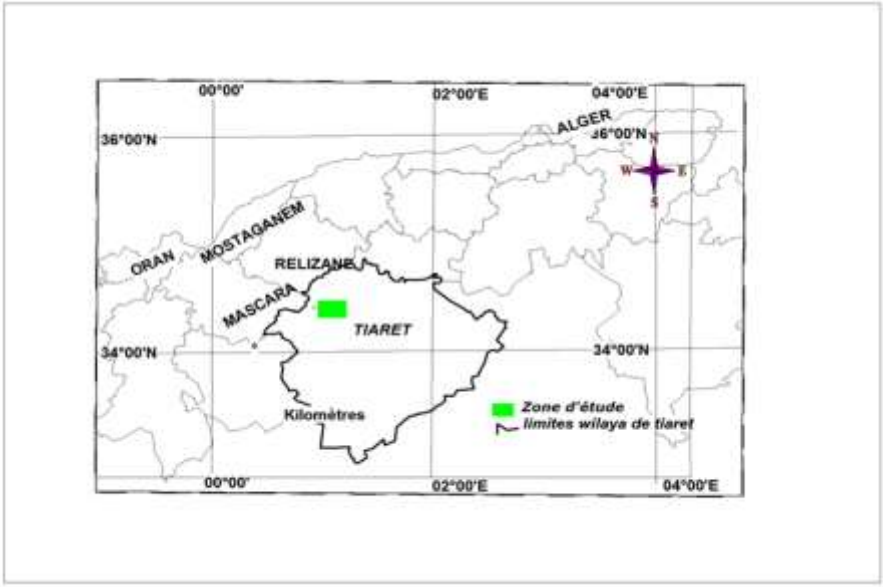

Figure 1: Location map of the study area (Azzaoui, 2013)

2.2. Slopes

Gentle slopes (less than 3%) cover only 86.51 hectares**,** accounting for 4.51% of the total forest area. Moderate slopes, ranging from 3% to 12.5%**,** extend over 846.03 hectares, representing just under half of the total surface area. Slightly more than one-third of the forest 34.33%, or 658.45 hectares—consists of slopes within this range. Steep slopes, exceeding 25%, account for 17.05% of the total area, equivalent to 327.01 hectares. Table 1 summarizes the slope classes and their corresponding proportions within the study area.

Table 1 : Slope Classes (Azzaoui, 2013)

Slopes (%)	**0 - 3%**	**3 - 12,5 %**	**12,5 - 25 %**	**> 25 %**
Surface area (ha)	86,51	846,03	658,45	327,01

Rate (%)	4,51	44,11	34,33	17,05

2.3.The vegetation cover:

The vegetation composition of the study area has been degraded, resulting in a transition from forested areas to pre-forest vegetation and, ultimately, to shrubland (matorral). Plant communities can serve as references and, to some extent, provide insight into local conditions. These ecologically homogeneous areas guided the selection of our survey locations.

The study area is primarily dominated by *Tetraclinis articulata*, which is undoubtedly the most prevalent species. Due to variations in the physical environment, other species may also be present, including *Olea europaea* var. *oleaster*, *Macrochloa tenacissima (L.) Kunth*, *Pistacia lentiscus L.*, *Phillyrea angustifolia*, *Globularia alypum L.*, *Quercus coccifera L.*, and others.

Other species, such as *Pinus halepensis* and *Eucalyptus*, have been recorded in the meadows of the Bakhadda Dam.

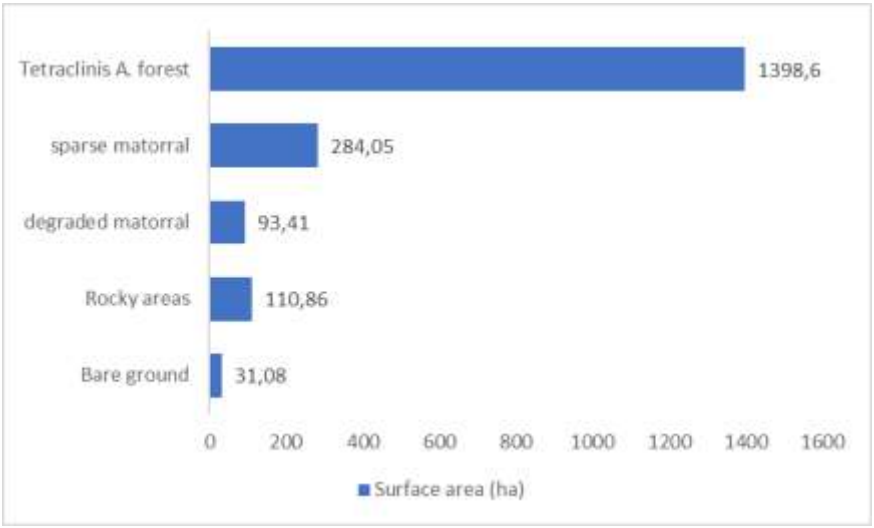

Figure 2: land cover in the Study Area

2.4. Climate Synthesis:

As it is revealed in the figure above, there is an equitable distribution of precipitation across the three seasons: winter, autumn, and spring, with an average of 109.15 mm. Thus, the seasonal rainfall pattern follows the WASS (Winter, Autumn, Spring, Summer) model.

Temperatures also exhibit significant fluctuations, with a large thermal difference between summer and winter. Based on these, the coldest month is January, with a median temperature of 4°C, while

the warmest is August, with an average of 35°C. Due to its continental nature, the study area experiences a high frequency of winter frosts, which significantly contribute to the drop in temperatures, averaging 40 days per year, with a peak in December and January. (Azzaoui, 2017).

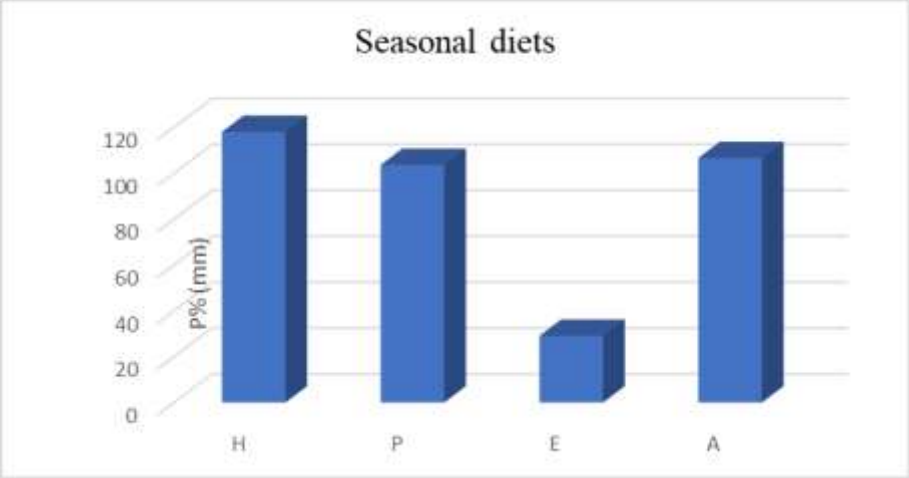

Figure 3: Seasonal Rainfall Regime (1986-2015)

3. Methodology of work (study):

3.1.Sampling and Station Selection:

Sampling, by definition, refers to the process of selecting individuals from a population for study. According to Dagnelie (1970) and Guinochet (1973), it denotes the operation that involves selecting a certain number of elements to be observed or treated.

The method used to identify the groupings of these species across the region consists of several phases:

❖ Recognition of stands through surveys in the main areas;

❖ Selection of zones that represent different ecological conditions.

ecologically homogeneous zones have guided the choice of the stations' location.

Within these zones, the selection of stations was largely determined by the presence of *Tetraclinis articulata (Vahl) Mast.* formations, which are the focus of our study. These two phases made it possible to profile four representative plots in each cardinal direction (North, East, West, and South) across the study site. These plots are representative of the different groupings of *Tetraclinis articulata (Vahl) Mast.* and the various stages of degradation within these groupings.

3.2. Type and shape of the plots:

The installation of the plots primarily targets Tetraclinis groupings. In this context, plots are established within the study area as temporary sample units covering small surface areas (typically a few square meters). These temporary plots are chosen to facilitate the exploration of ecological relationships that are independent of the time variable (Lecomte and Rondeux, 2002, Rondeux et *al*., 2002, Thibaut et *al*., 2002).

The circular shape is the most widely recommended plot form in the literature. It simplifies plot delineation, compensates for limited tree density, and avoids directional bias (Palm, 1977; Rondeux, 1999).

Several field surveys were scheduled with the aim of better understanding the existing vegetation formations and identifying the main homogeneous zones in the region. Within each zone, we selected a site that represents average ecological conditions, where we conducted floristic surveys, including various information on environmental characteristics such as site location, exposure, slope, presence of erosion effects, coverage rate, and so on.

3.3.Reading Method:

The method of floristic analysis is a key factor in determining the current status of a given region. Hence, the phytosociological or sigmatistic method of Braun-Blanquet (1951) was employed to identify the key issues and achieve the study's objectives. The location of the survey was selected subjectively to ensure homogeneity, representing the plant community accurately.

The floristic data consists of an exhaustive list of all species present in the surveyed area. This floristic list varies from one station to another and can also change over the years within the same station. Field-recognized taxa (genus and species) are identified in the Ecology and Management of Natural Ecosystems Laboratory, using the Quezel and Santa flora (1962-1963), the *Flora of France* by Gaston Bonnier (1990) and Dobignard and Chatelin (2010–2013).

The surveys were conducted at the end of winter and spring, the optimal seasons for such studies. Each survey includes ecological traits of a stationary nature, recorded or measured on-site: Location and date; Altitude; Exposure; Slope; Survey area size; Vegetation recovery; Physiognomic type of vegetation.

We were thus able to select a site within the study area. Within this site, the selection of plots was made according to the objective of our study, where floristic surveys were conducted based on the four exposures. (Figure 4).

Indeed, at each exposure, four circular units with a fixed center and an area of 5 ares were established.

Figure 4: The different sites in the study area.

3.4. Abundance-Dominance Coefficient

Abundance expresses the approximate number of individuals of each species, while dominance estimates the area covered by all individuals of that species. These two characteristics are related.

It is preferable to present the results obtained according to the abundance-dominance method based on Braun-Blanquet's scale, which is assessed as follows:

+ : Species present, with a very low number of individuals and coverage;
1 : Species scarce with a low coverage degree, less than 5%;
2 : Species abundant, covering about 25% of the survey area;
3 : Species covering between 25% and 50% of the survey area;
4 : Species covering between 50% and 75% of the survey area;
5 : Species covering more than 75% of the survey area.

4. Results and discussions

Table 2: Abundance-Dominance Coefficient

Number of plots	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Altitude (x10)	**91,1**	**70,5**	**69,1**	**68,2**	**71,4**	**75,8**	**81,7**	**85**	**84**	**89,4**	**86,2**	**79,2**	**75,54**	**77,5**	**76,4**	**83,53**
Exposure	**N**	**N**	**N**	**N**	**E**	**E**	**E**	**E**	**S**	**S**	**S**	**S**	**W**	**W**	**W**	**W**
Slope (%)	**35**	**25**	**20**	**5**	**10**	**15**	**30**	**5**	**20**	**25**	**15**	**20**	**15**	**5**	**20**	**25**
Tetraclinis articulata (Vahl) Mast.	**2**	**1**	**1**	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**
***Pistacia lentiscus* L.**	**1**	**1**	**1**	**1**	**1**	**+**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**
***Globularia alypum* L.**	**+**	**1**	**1**	**+**	**1**	**1**	**1**	**2**	**2**	**1**	**2**	**.**	**+**	**.**	**.**	**1**
***Phillyrea latifolia* L.**	**.**	**1**	**1**	**1**	**1**	**+**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**
***Rosmarinus officinalis* L.**	**.**	**3**	**+**	**1**	**1**	**.**	**1**	**2**	**2**	**2**	**2**	**2**	**+**	**.**	**2**	**2**
***Quercus coccifera* L.**	**.**	**+**	**1**	**+**	**+**	**+**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**1**	**1**
***Cistus salviifolius* L.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**2**	**.**	**+**	**3**	**1**	**.**	**.**	**3**	**1**
***Ferula communis* L.**	**.**	**.**	**.**	**.**	**+**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**
Olea europaea* L. subsp. *europaea	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**2**	**2**	**.**	**.**
Macrochloa tenacissima (L.) Kunth	**1**	**1**	**.**	**.**	**.**	**.**	**1**	**1**	**1**	**1**	**.**	**.**	**.**	**.**	**.**	**2**
***Cistus monspeliensis* L.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**+**	**.**	**.**	**.**	**2**	**.**	**.**	**.**	**.**
Trifolium repens L.	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**
Ampelodesmos mauritanicus (Poir.) T.Durand & Schinz	**1**	**.**	**.**	**.**	**.**	**.**	**.**	**1**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**
Juniperus oxycedrus* L. subsp. *oxycedrus	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**.**	**.**
***Asparagus acutifolius* L.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**.**
***Calicotome intermedia* C.Presl**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**+**	**.**	**.**	**1**	**1**
***Chamaerops humilis* L.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**+**
Thymelaea hirsuta (L.) Endl.	**.**	**+**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**

***Thymus algeriensis* Boiss. & Reut.**	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Teucrium aureiforme Pomel	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
***Drimia numidica* (Jord. & Fourr.) J.C.Manning & Goldblatt**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+

Beni Affene forest is primarily composed of *Tetraclinis articulata*, which forms the dominant stand. The understory, with an average cover of around 33%, consists mainly of a less dense lower coppice. Under specific stationary conditions, thuja has been able to establish itself. *Rosmarinus officinalis L.* ranks second, with a recovery rate of 15%.

Pistacia lentiscus L. ranks third, with a recovery rate of around 11%. The secondary species are mainly represented by *Globularia alypum L.*, *Phillyrea latifolia L.*, and *Quercus coccifera* L.

In this forest, *Tetraclinis articulata (Vahl) Mast.* has reached the arborescent stage, accompanied by an undergrowth characteristic of this formation and consisting of three distinct facies: the first associated with *Rosmarinus officinalis L.*, the second with *Ampelodesmos mauritanicum* Link, and the third with *Macrochloa tenacissima (L.) Kunth* Despite almost constant animal pressure, the cedar sometimes manages to form a characteristic vegetation community.

Tetraclinis articulata (Vahl) Mast. typically grows as a coppice in areas where *Pinus halepensis* is present, which is a type of pine tree found in the Mediterranean region. Under these conditions, the thuya (*Tetraclinis articulata*) thrives and is able to reject the stumps. This growth behavior contributes to the high density of *Tetraclinis articulata* in these areas, as noted Kadik (1987). This information offers valuable insight into the environmental preferences and growth strategies of *Tetraclinis articulata*, shedding light on how the species manages to dominate specific understory environments and sustain high population densities within forest ecosystems.

Three different ecological "facies" or growth forms of *Tetraclinis articulata (Vahl) Mast.* **based on the soil type**

F1: At Ampilodesmos: This facies occurs in areas with deep, slightly silty soils, situated on northern exposures, and in depressions. These conditions may provide more moisture retention and shelter from harsh sun, which is favorable for *Tetraclinis articulata (Vahl) Mast.* growth in this type of environment.

F2: In Rosmarinus: it is found in rendzine-type soils, which are typically shallow, calcareous (limestone-rich), and well-drained. These conditions are found on southern exposures, where the area likely receives more sunlight and heat, which is typical for plants that thrive in drier, more arid conditions.

F3: In Stipa: This facies represents the extreme conditions, likely referring to harsher, drier environments where the soil and conditions are more severe. *Stipa* (a genus of grasses) suggests a more open, grassy environment, possibly with less fertility or moisture availability, which is challenging for most plants.

These facies demonstrate how *Tetraclinis articulata (Vahl) Mast.* is able to adapt to and thrive in a range of different environmental conditions. By forming different growth patterns or "facies" based on soil type, exposure, and associated vegetation, the species can optimize its growth in a variety of habitats. This adaptability across diverse environmental conditions is key to its ecological success and high density in certain areas.

Besides, the botanical profile of these three facies makes it possible to provide an overview of the behavior of the flora orchestra of Tetraclinaie through surveys on the four average exposures fairly representative of the floristic composition of this group. The phytoecological description of the Beni Affane massif (in Sdamas forest) performed by various authors: Boudy (1955) and Kadik (1987), confirm the phytoecological aspects synthesized in the table above. These surveys show the floristic diversity of the undergrowth of a Tetraclinae in a semi-arid zone and stresse the importance of the presence and covering of the main species of the shrub and bushy stratum.

Alcaraz (1982) and Fennane (1988 a and b) described two groups in Thuya on the vegetation of the Algerian West:

_ Grouping on calcareous soils *Satureja fontanesii, Arisarum vulgare, Aspargus stipularis and Withtania frutescens.*

_ Grouping with abundance of *Quercus coccifera L., Calicotome intermedia* C.Presl, *Ampilodesmos mauritanica, Chamaerops humilis L.*

Alcaraz (1982) and Fennene (1988) identified two distinct groups of vegetation associated with Thuya in the Algerian West:

- Grouping on calcareous soils in the upper warm semi-arid, distinguished by their richness in *Satureja fontanesii*, *Arisarum vulgare*, *Asparagus stipularis* and *Withania frutescens*.
- Grouping with an abundance of *Quercus coccifera L.*, *Calicotome intermedia* C.Presl, *Ampelodesmos mauritanicus* Link. and *Chamaerops humilis L.*.

This association is closely related to that of the Aleppo pine but lacks characteristic indicator plants such as rosemary and globularia (Boudy, 1952). In Algeria, among the described Thuya stands, the *Lonicero-Quercetum cocciferae callitretosum* (Baumgartner 1966 in Barbero et *al.*, 1981) appears to be the most refined grouping within the *Calycotomo-Tetraclinetum*.

5. Conclusion:

The ecological characterization of the Beni Affane massif reveals a complex vegetation mosaic centered around *Tetraclinis articulata*, a species of high ecological plasticity. This conifer forms distinct facies in response to varying environmental factors such as soil depth, exposure, and hydric availability. The floristic surveys conducted across different slope orientations and ecological contexts underline the diversity of understory species and the adaptive strategies employed by the dominant formations.

The semi-arid bioclimate of the study area, with extended drought periods and thermal extremes, exerts significant selective pressure on plant communities, favoring xerophytic and sclerophyllous taxa. The study also emphasizes the role of edaphic heterogeneity in shaping species composition, notably through the development of specialized associations on rendzine and calcareous soils.

These findings enhance our understanding of Mediterranean forest dynamics under stress conditions and underscore the importance of integrative ecological assessments for managing and conserving relict forest ecosystems. Promoting sustainable management of *Tetraclinis articulata* stands will be crucial in mitigating the effects of land degradation and preserving biodiversity in the semi-arid zones of North Africa.

The Beni Affene Mountains, part of the Algerian West, have been chosen as a model for a phytoecological study of *Tetraclinis articulata (Vahl) Mast.* groups, because this species dominates the region and is characterized by its resistance to degradation conditions.

The bioclimatic study of the region reveals a Mediterranean diet characterized by two distinct seasons: a rainy period of five months and a longer dry period of seven months. The gradual evolution

of the drought period imposes a strong evapotranspiration on the vegetation, which allows it to develop adaptation systems modifying the landscape by imposing xerophilic vegetation. From a vegetation perspective, a total of 21 plant species were identified as either characteristic of *Tetraclinis articulata (Vahl) Mast.* or commonly associated with its groupings. Among these, five species were found to be particularly frequent: *Tetraclinis articulata (Vahl) Mast.* (33%), *Pistacia lentiscus L.* (11%), *Globularia alypum L.* (8%), *Phillyrea angustifolia* (9%), and *Rosmarinus officinalis L.* (15%).

The remaining species were observed at lower frequencies, not exceeding 6%, including: *Quercus coccifera L.* (2%), *Cistus salviifolius L.* (6%), *Ferula communis L.* (1%), *Macrochloa tenacissima (L.) Kunth* and *Olea europaea* (5% each), and *Calycotome intermedia* (2%). Other taxa were represented by minimal percentages, such as: *Chamaerops humilis L.*, *Thymus algeriensis Boiss. & Reut.*, *Thymelaea hirsuta (L.) Endl.*, *Teucrium aureiforme Pomel*, and *Drimia numidica (Jord. & Fourr.)*. The Beni Affene Mountains, located in western Algeria, were selected as the reference site for a phytoecological study of *Tetraclinis articulata (Vahl) Mast.* formations. This selection was justified by the strong dominance of the species in the region and its notable resilience to degradation.

A bioclimatic analysis of the study area highlighted a Mediterranean-type climate, with two clearly defined seasons: a rainy period lasting approximately five months, and a dry period of about seven months. The intensification of drought conditions in recent years imposes significant evapotranspirative stress on the vegetation, leading to the development of xerophytic adaptations that shape the landscape and support the persistence of drought-tolerant plant communities.

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