Analysis of species floristics within the oak forests of Guerrouche (Jijel, Algeria)

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ABSTRACT

The Guerrouche forest is home to a fairly important flora heritage which offers this massif a forest cover by the presence of quite remarkable forest stands, from a floristic point of view by the presence of natural vegetation characterized by a diverse flora. This study aims to quantify the floristic diversity of the vegetation associated with the three main tree species (zeen oak, cork oak and afares oak) that inhabit the Guerrouche forest on the basis of distributed floristic surveys, according to a sampling strategy, stratified and systematic, which took into account the species present in each type of tree stand. The floristic surveys thus carried out, numbering 55, made it possible to establish a list of a floristic list made up of 172 species, which belonged to 69 genera and 45 botanical families. Of these, 42 were endemic species, including 4 specific to the study area. The number of rare and very rare species was 70 taxa. The study also revealed the clear degradation of the genus Erica of this ecosystem. Analysis of the overall chorological spectrum showed a dominance of Mediterranean species (209 species), with a dominance (82.3%) of species that were therophyte species. The forest stands of the genus Quercus inhabiting the Guerrouche massif must be supported by the authorities to preserve and conserve this forest heritage against fires, illegal logging, etc. The results of this study will be the subject of development actions and rational management of these natural forest ecosystems.

KEYWORDS: plant diversity, botanical groups, rare and endemic species, Guerrouche, Algeria

ARTICLE HISTORY: received 15 March 2021; received in revised form 22 August 2021; accepted 23 August 2021

1. Introduction

Algerian forests form a part of Mediterranean forests and have been severely disturbed over time (QUEZEL & BARBERO, 1990). Different civilizations have strongly contributed to the reduction of forest cover, and disturbances continued throughout the colonial period. In 1830, the forest cover was 5 million ha (BENSAID ET AL., 1998). After independence, the Algerian forest became only 2.4 million ha (LÉTREUCH, 1995). Faced with this situation, the Algerian Government has initiated various programs to protect and extend the forest heritage through reforestation. The degraded forest ecosystem located largely in the mountains is the priority for the reforestation work. These areas are the most affected by fires and soil erosion. Reforestation activities have particularly focused on promoting higher value-added species such as cork oak Quercus suber and Atlas cedar Cedrus atlantica (MERDAS ET AL., 2017).

The forests of the Mediterranean area are typically composed of deciduous and evergreen species, such asseen oak Quercus canariensis Willd., cork oak Quercus suber L. and afares oak Quercus afares Pomel.
A typical feature of Mediterranean forests is that they include both deciduous and evergreen trees. In addition, many forests are mixtures of deciduous and coniferous trees (Mansourian et al., 2013).

From the precipitation map established by the National Water Resources Agency (NAWR, 1996), the study area is located in annual sections ranging from 850 mm to 1750 mm. The average minimum temperature for the coldest month (January) varies between 6.1°C and 8.1°C. The maximum temperatures for the hottest month (July) are between 30.2°C and 34.8°C. The dry period varies from 3 to 5 months. The high relative humidity of the air (80%) favours the existence and the maintenance of fairly important plant diversity.

The pluviothermal quotient of Emberger Q2 (Emberger, 1955) varies between 110 and 124, placing the Guerrouche Forest in the humid to subhumid bioclimatic stages with variations in mild and warm winters (Daget & David, 1982). The study area is considered to be the rainiest in Algeria.

Our study is based on the use of maps such as the plant formations map, the plant groups map and drawn up from satellite images (Bounar, 2003; Bounar et al., 2012; Boulaachab et al., 2006; Khelifi, 1987; Zedam, 2015). We also used the pre-existing documentation of the Taza Massif (with the master plan that was established within the framework of the forest management of cork stands (DGF, 2004). 57 floristic surveys were carried out in the different plant communities to provide a quantitative description of the richness and diversity floristics of cork oak, zeen oak, afares oak and mixed formations (of zeen oak & cork oak) (Fig. 2). Field visits were carried out over a period of 2016, 2017 and 2018 during the months of March, April and May.

The data collection was undertaken by using a systematic sampling method. The choice of stations was based on the following criteria: altitude, slope, exposure and cover of forest stands of Quercus suber L, Quercus canariensis Willd and Quercus afares Pomel, and surveyed using the plot method with a minimum area recommended by the Braun-Blanquet method. The minimum area was calculated.
each time the vegetation formation changed, and was in our case 300 m\(^2\) for forests and 150 m\(^2\) for clear and open stands. 9 surveys were carried out in the *Quercus afares* stands, 11 surveys were undertaken in mixed stands of *Quercus suber* & *Quercus canariensis*, 16 in the formation of *Quercus suber* and 19 in the formation of *Quercus canariensis*.

A factorial analysis of correspondences was used to explain the distribution of the large plant formations of the Guerrouche Forest, and included an ascending hierarchical classification which took into account topographic parameters such as altitude, slope and exposure as well as the overall cover of forest vegetation.

![Geographical location of the study area of the Guerrouche Forest](image)

**Fig. 1.** Geographical location of the study area of the Guerrouche Forest

| Bioclimatic floors | Sub-humid (600 < P < 900 mm/annum) | Humid and Perhumid (P > 900 mm/annum) |
|--------------------|----------------------------------|-------------------------------------|
| Vegetation stage   |                                  |                                     |
| Supra-Mediterranean| -3 < m < 0 300 < Alt < 900 m    | *Quercus canariensis* and *Quercus afares* |
|                    | 1200 < Alt < 1800 m              |                                     |
| Meso-Mediterranean | 0 < m < 3 600 < Alt < 1200 m    | *Quercus suber* and *Quercus canariensis* |
|                    | 0 < m < 5 200 < Alt < 1200 m    | *Quercus suber*                      |

![Simplified diagram of the distribution of forest formations in the Guerrouche Forest Jijel](image)

**Fig. 2.** Simplified diagram of the distribution of forest formations in the Guerrouche Forest Jijel

### 3. Results and discussion

#### 3.1. Plant species richness

Field trips and surveys led to the development of the floristic list, which clearly shows the floristic richness within the protected area with 172 taxa classified by the family. Very rare taxa (RR), rare taxa (R), endemic taxa (E), taxa newly inventoried in the study area (N) and (C) common taxa. This richness has been demonstrated in the form of a floristic catalogue.

The interpretation of the results of the factorial analysis included 55 floristic records and 172 species which allowed the identification of four plant groups. Each grouping was individualized by the analysis and corresponded to the typical formations of cork oak, zeen oak, afares oak and the mixed formation of zeen and cork oak.

The shrub layers of the *Quercus canariensis* and *Quercus suber* formations were dominated by *Cytisus triflorus*. The results obtained in Table 2 clearly show the floristic species richness of the study site with 45 botanical families and the number of species within each of them.
Within this research we counted 172 taxa including 42 endemic species and subspecies for the study region. The highest rate of endemism was recorded at the level of the mixed formation located in the north-east of the study area bordering the Babors Range with 24 taxa, followed by the formations of cork oak with 14 taxa and the formation of afares oak with 3 taxa (Table 4). The families with the most endemic species were: Asteraceae – 7, Caryophylaceae – 6, Brassicaceae – 5, Ranunculaceae – 4, Fabaceae – 4, Geraniaceae – 3, Cistaceae – 3, the other botanical families have 2 or 1 species (Table 3).

There were 70 taxa of rare species distributed across all plant formations of cork oak, zeen oak, afares oak and the mixed formation of zeen and cork oak with 13, 21, 16 and 20 species respectively. The study area was also home to several rare and endangered species to which special attention should be paid (Table 4). Some of these rare species deserve to have their conservation status revised and should therefore be placed on the Red List of the International Union for the Conservation of Nature (IUCN). Fig. 3 shows some photos of the species to be protected and which are endangered. The choice of axes is given by the eigenvalues and the percentage of inertia obtained from the analysis (Table 5).

### Table 2. Distribution of species in the Guerrouche Forest by botanical families

| Botanical families | Number of species | Botanical families | Number of species | Botanical families | Number of species |
|--------------------|------------------|--------------------|------------------|--------------------|------------------|
| Brassicaceae       | 18               | Aceraceae          | 3                | Papaveraceae       | 1                |
| Caryophylaceae     | 14               | Thymelaeaceae      | 3                | Anacardiaceae      | 1                |
| Lamiaceae          | 13               | Cistaceae          | 3                | Plumbaginaceae     | 1                |
| Asteraceae         | 12               | Violaceae          | 3                | Oleaceae           | 1                |
| Fabaceae           | 10               | Caprifoliaceae     | 3                | Apocynaceae        | 1                |
| Poaceae            | 9                | Crassulaceae       | 2                | Orobancheaceae     | 1                |
| Apiaceae           | 7                | Berberidaceae      | 2                | Ericaceae          | 1                |
| Rubiaceae          | 7                | Salicaceae         | 2                | Anacardiaceae      | 1                |
| Polypodiaceae      | 6                | Euphorbiaceae      | 2                | Aquifoliaceae      | 1                |
| Geraniaceae        | 6                | Rhamnaceae         | 2                | Pteridaceae        | 1                |
| Scrophulariaceae   | 5                | Convolvulaceae     | 2                | Dryopteridaceae    | 1                |
| Orchidaceae        | 5                | Plantaginaceae     | 2                | Smilacaceae        | 1                |
| Fagaceae           | 4                | Gentianaceae       | 2                | Araliaceae         | 1                |
| Linaceae           | 4                | Cupressaceae       | 1                | Iridaceae          | 1                |
| Boraginaceae       | 4                | Liliaceae          | 1                | Anacardiaceae      | 1                |

### Table 3. Number of endemic and rare species per family within the Guerrouche forest

| Botanical families | Number of endemic species | Botanical families | Number of rare species | Botanical families | Number of rare species |
|--------------------|---------------------------|--------------------|------------------------|--------------------|------------------------|
| Asteraceae         | 7                         | Asteraceae         | 7                      | Fagaceae           | 1                      |
| Poaceae            | 2                         | Poaceae            | 6                      | Ranunculaceae      | 1                      |
| Caryophylaceae     | 6                         | Lamiaceae          | 6                      | Berberidaceae      | 1                      |
| Ranunculaceae      | 4                         | Brassicaceae       | 5                      | Cistaceae          | 1                      |
| Brassicaceae       | 5                         | Orchidaceae        | 4                      | Plumbaginaceae     | 1                      |
| Crassulaceae       | 1                         | Caryophylaceae     | 4                      | Gentianaceae       | 1                      |
| Fabaceae           | 4                         | Rosaceae           | 4                      | Ericaceae          | 1                      |
| Geraniaceae        | 3                         | Aceraceae          | 3                      | Pteridaceae        | 1                      |
| Linaceae           | 2                         | Apiaceae           | 3                      | Smilacaceae        | 1                      |
| Apiaceae           | 1                         | Boraginaceae       | 3                      | Araliaceae         | 1                      |
| Cistaceae          | 3                         | Salicaceae         | 2                      | Orobanchaceae      | 1                      |
| Scrophulariaceae   | 1                         | Crassulaceae       | 2                      | Plantaginaceae     | 1                      |
| Rubiaceae          | 1                         | Fabaceae           | 2                      | Fagaceae           | 1                      |
| Campanulaceae      | 1                         | Rhamnaceae         | 2                      | Ranunculaceae      | 1                      |
| Violaceae          | 1                         | Thymelaeaceae      | 2                      | Berberidaceae      | 1                      |
Table 4. Rare and threatened species of the Guerrouche Forest

| Species not included in the IUCN Red List | Species on the IUCN Red List |
|------------------------------------------|-------------------------------|
| *Asperula odorata* L.                    | *Arabis doumetii* Coss.       |
| *Satureja juliana* L.                    | *Saxifraga numidica* Maire    |
| *Hieracium ernesti* Maire                | *Teucrium kabylicum* Batt.   |
| *Viburnum lantana* L.                    | *Fedia sulcata* Pomel.        |
| *Convulvulus dryadum* Maire              | *Carum montanum* (Coss & Dur.) Benth. et Hook. |
| *Stellaria holostea* L.                  | *Lonicera kabylica* Rehder.   |
| *Chrysanthemum fontanesii* (B. & R.) Q. & S. | *Teucrium atratum* Pomel.     |
| *Bupleurum montanum* Coss.               | *Epidemium perralderianum* Coss. |
| *Quercus afrares* Pomel                  | *Phlomis bovei* de Noé.       |
| *Sedum pubescens* Vahl.                  | *Sedum multiceps* Coss & Dur. |
|                                          | *Pimpinella battandieri* Chabert |
|                                          | *Moehringia stellarioides* Coss. |

Table 5. Eigenvalues from factorial correspondence analysis

|               | Factorial axis F1 | Factorial axis F2 |
|---------------|-------------------|-------------------|
| Own value     | 26,817            | 14,669            |
| Variability (%) | 42,566            | 23,284            |

Fig. 3. Other botanical groups with a few numbers of species within the protected area of Guerrouche (Jijel)
1 – *Sedum multiceps* Coss. et Dur., 2 – *Sedum pubescens* Vahl., 3 – *Phlomis bovei* de Noé, 4 – *Carum montanum* (Coss. & Dur.) Benth. et Hook., 5 – *Pimpinella battandieri* Chabert, 6 – *Lonicera kabylica* Rehder
3.2. Individualization of forest stands

The analysis of the factorial map relating to the factorial plane 1-2 (Fig. 4), allows to note, the detachment of the floristic records according to their type of formation, one notes 8 (eight) records are attached to the high altitude groupings (*Quercus afares*), opposed to the group of records of (*Quercus suber*) which occupy the low altitudes, 16 (sixteen) records are in the center of the plan focus the records of the mixed formation of (*Quercus suber, Quercus afares, Quercus canariensis*) with 10 records floristic, the pure formation of Quercus canariensis is well marked in the positive part of the F1 and F2 axis (Fig. 4). We therefore ended up defining four forest stands according to the variables altitude, exposure, slope, soil depth, and annual precipitation and the minimum temperatures of the coldest month.

In this type of investigation, (AHC) made it possible to define clear classes of grouping records: A (*Quercus suber*), B (*Quercus faginea*), C (*Quercus afares*) and D (mixed formation *Quercus suber, Quercus canariensis, Quercus afares*) which was not possible by a simple AFC (Fig. 5). In general, the factors responsible for the diversification of forest stands in the Guerrouche forest are factors which correspond to the climatic gradient, the thermal altitudinal gradient and the rise in vegetation or biological elevation.

This analysis also makes it possible to differentiate the high-altitude groups, represented by *Quercus afares*. These groups are made up of species adapted to a humid bioclimate with cold to very cold winters and medium altitude groups. On the other hand, the mid-altitude groups are better preserved than these high altitude ones. In the same altitudinal range and under the same bioclimate, the thermal altitudinal factor is an important element in the evolution of the Guerrouche Range.
4. Conclusions

The species richness and the floristic diversity analysis of the Guerrouche Forest have found 172 taxa including 42 endemic species. The highest rate of endemism was recorded at the level of mixed stands located to the north-east of the study area bordering the Chain of Babors. Existing data on endemism in Algeria are scarce and fragmentary. The study region by nature of its geographical position and wide pedological variation as well as its great climatic variations has allowed the development of a rich and varied endemic flora, through its ecological and phytogetic originality. These data justify its classification, with the whole of Little Kabylia, as the nerve center “hot spot” of northern Algerian (VELA & BENHOUHOU, 2007; VALDÉS ET AL., 2002).

However, the Guerrouche Forest, despite the legislative protection that it enjoys, is subject, like most Mediterranean natural ecosystems, to worrying degradation, because of anthropogenic activities (uncontrolled harvesting of wood, exploitation of cork, uprooting of plants of interest, etc.) and uncontrolled grazing it is seriously deteriorating its specific wealth. To address this problem and to maintain the ecological integrity of this ecosystem, an integrated strategy for the conservation of this floristic diversity must be put in place soon. This strategy must first focus on the forest species, which, through their uniqueness, constitute the essential framework of this natural ecosystem, in particular zeen oak Quercus canariensis Willd, cork oak Quercus suber L. and afares oak Quercus afares Pomel which each have a very remarkable economic value (cork, wood, etc.). Indeed, these oak groves constitute the main forest formations of the Guerrouche Forest and include in their floral constitutents several endemic or/and rare species of the genera Cyclamen, Corydalis, etc. The study area is also home to several rare and sometimes endangered species to which special attention should also be paid (Table 4). Some of these rare species deserve to have their conservation status revised and should therefore be placed on the Red List of the International Union for the Conservation of Nature (IUCN). This particularly concerns these species: Moehringia stellaroides Coss, Asperula odorata L., Satureja juliana L., Viburnum lantana L., Hieracium ernesti Maire, Convolvulus dryadum Maire, Stellaria holostea L., Chrysanthemum fontanesii (B & R) Q. & S., Bupleurum montanum Coss and Sedum pubescens Vah. It is therefore time to think seriously about the protection of these species and to urgently establish a management strategy to conserve these habitats and their plant heritage.

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