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DIAGNOSIS OF THE PLANT BIODIVERSITY OF AN ANTHROPOGENIC ZONE IN ALGIERS: CASE OF THE BOUZARÉAH FOREST MASSIF

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Abstract.

The flora of peri-urban forests is usually understudied compared to other forest types. This flora harbors a plant biodiversity that deserves better understanding. The Bouzaréah forest massif is a geographical area that boasts high biological diversity. It possesses a rich and diverse flora, the characteristics of which need to be determined for sustainable management. Over the decades, this area has experienced continual regression, mainly due to a combined action of climatic, ecological, and anthropogenic factors. 65 phytosociological surveys were conducted in the study area. Plant groups were determined using a modified TWINSPAN classification. For each vegetation group, diagnostic species were selected based on their fidelity index (phi coefficient). We identified 7 plant groups and selected 69 diagnostic species. Results obtained and verified through field investigations show that group 5, a shrubland located on the north-facing slope where conditions are favorable, is the richest and most diversified in plant species compared to other groups. Given the alarming degradation of ecosystems by humans and the current context of climate change, understanding the floristic diversity, structure, and characteristics of different floristic groups is crucial for effective management of urban forest spaces.

KEY WORDS: -Structure, Forest formations, Bouzaréah forest massif, Algeria.

1. INTRODUCTION

At present, the acquisition, description, classification, and preservation of various taxa are of scientific priority for the assessment and management of plant biodiversity. The unique habitats of each plant species are subject to in-depth studies aimed at better understanding the establishment and distribution of these species (Lavergne 2003). Geologically, biologically, and culturally, the Mediterranean basin is considered one of the richest and most complex regions (Blondel and al. 2010).

The ecosystems of the Mediterranean basin are threatened by numerous anthropogenic impacts, seriously endangering this biological heritage (Blondel and Médail, 2007). Inventorying and evaluating biodiversity constitute the first step in assessing the richness of a country's flora and fauna (Treurnicht and al. 2017).

Urban spaces are essential for improving quality of life and the attractiveness of cities. They play a crucial role not only socially and ecologically but also economically (Hou and Yuan 2010). The conservation of their biodiversity is perceived as a highly important environmental challenge. Its significance has become an increasingly important environmental requirement at both local and international levels (Clergeau, 2007; Aronson and al. 2014). The flora of urban environments is found in highly fragmented landscapes and strongly modified by human activity.

Algiers, the continuously developing capital of Algeria, is trending towards a major metropolis, and natural spaces are shrinking (Abla and al. 2022). It is a Mediterranean metropolis built on the foothills of the Algerian Sahel hills. It has diverse biogeographic zones and possesses biological resources of great interest. Among these biogeographic zones is the Algiers coastal sub-sector, which includes the Bouzaréah forest massif. It remains the most important green space and harbors highly diverse biodiversity, including threatened species such as *Onopordum algeriense* (Munby) Pomel (Djelid and al. 2020). This forest massif is subject to strong pressures from human activities, including illegal wood harvesting, bushfires, and unplanned plant removal. Several plants are directly threatened by urban expansion, such as *Onopordon algeriense*, a very common plant on the lower northern slopes of the Bouzaréah massif (Faurel 1959).

Given the degradation of ecosystems due to human activities and climate change, which exert additional pressure, it is crucial to understand floristic diversity, structure, and characteristics of different floristic groups for effective management. In Algeria, there is limited knowledge about the structure of forest and pre-forest vegetation (Meddour 2012).

In this context, this study aims not only to highlight the originality and diversity of the flora of the Bouzaréah massif, enrich our knowledge about the structure of forest groups, and obtain a precise inventory and detailed diagnosis of existing plant groups, but also to identify threats to this flora. These are all essential parameters for reflection and the implementation of any action aimed at their protection, conservation, and valorization in the context of sustainable development.

2. STUDY METHODOLOGY

- ***Study Area***

This research was carried out in the Bouzaréah forest massif, which has public domain status and is subject to forest regulations managed by the General Directorate of Forests, under the supervision of the Ministry of Agriculture and Rural Development. It covers an area of 840 ha (Fig.1). Located in the northwest part of Algiers, in a coastal position less than 1 kilometer from the Mediterranean Sea, it represents the largest natural green space in the city of Algiers and plays a very important protective role for all agglomerations along the coast. The bioclimate is subhumid with warm winters. The highest point of the massif reaches 320 meters with the following geographical coordinates: 2.949199° to 3.003078° East longitude; 36.788202° to 36.811109° North latitude. Geologically, the terrain is diverse with the presence of metamorphic rocks (schists, mica schists, gneiss) (ISL-BRGM 2006).

Figure 1. Location of the study area.

On the ground, sampling was carried out subjectively. This involved selecting samples at each station that appeared most representative and sufficiently homogeneous (Gounot 1969). The area of each phytosociological survey was 100 m². Within this area, all plant species encountered were recorded. Thus, 65 phytosociological surveys were conducted during the spring of the years 2021 and 2022. The composition and richness of the vegetation were recorded through exhaustive floristic surveys with abundance-dominance coefficients for each species, based on the Braun-Blanquet coding (1932). Thus, 126 species were identified using the flora of Quézel and Santa (1962-1963). The nomenclature was updated using the synonym index of the North African flora (Dobignard and Chatelain, 2010 -2013).

- ***Floristic Classification and Statistical Analysis***

The analysis of phytosociological data was performed using the modified TWINSPAN method (Hill, 1979; Roleček, Tichý, Zelený, and Chytrý, 2009), integrated into the JUICE 7.0 program (Tichý 2002). TWINSPAN analysis is one of the most common classification methods in the plant ecological community (Lepš and Šmilauer, 1999). The minimum group size was set to 3, and coverage thresholds were set at 0%, 5%, and 25%. Whittaker's beta diversity index (Whittaker 1972) was used to analyze group heterogeneity, because it provides balanced classifications, respecting group size and heterogeneity, and because of its robustness (Roleček and al. 2009).

We applied the OptimClass procedure (Tichy and al. 2010) to identify an optimal cluster depth in the dendrogram presented by the modified TWINSPAN algorithm, also implemented in JUICE. OptimClass was applied in mode 1. Faithful species were determined based on the p-value of Fisher's exact test, with a threshold set at p value = 10^{-6} (Tichy and al. 2010). Species with a frequency above 50% were classified as constant species, and those with a maximum coverage value exceeding 20% were considered dominant in an individual group.

We adopted the informal approach of Alvarez and al (Djebbouri and Terras, 2022; Ik-Gürsoy, Uğurlu, and Oldeland, 2015; Menz and al .2012) for naming plant groups. This means that the naming of plant groups always includes the name of the most diagnostic species and the species with the highest coverage.

- ***Calculation of Diversity Indices***

We calculated the following diversity indices for each survey:

Shannon-Wiener Index

It takes into account the number of species and the evenness of the species (Hill 1973). The index increases with an increase in unique species or greater uniformity.

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

This index is expressed in bits per individual, with values ranging from 0 bits to 5 bits per individual (Frontier 1983) .

Simpson Index

$$\lambda = \sum_{i=1}^{S} p_i^2$$

This equitability index expresses the dominance of a species when it tends towards 0 or the co-dominance of multiple species when it tends towards 1.

Evenness - Pielou 1975

Shannon's evenness proposed by Pielou (1975) is calculated by dividing H' by H'max. Evenness has a value between 0 and 1, with 1 representing complete equality.

$$E_H = H'/H'_{max} = H'/\ln S.$$

Species richness (S), Shannon-Wiener diversity index (H'), and Simpson diversity index were calculated to describe the species diversity pattern for each plot (alpha diversity, α) and for each vegetation group identified by TWINSPAN (beta diversity, β). Differences between the mean values of diversity indices among vegetation groups were evaluated using non-parametric analysis of variances with the Kruskal-Wallis test and multiple comparisons of mean ranks. Differences were considered significant if $P < 0.05$. This analysis was performed using SPSS 24.0 software.

3. RESULTS AND DISCUSSION

The floristic analysis of the surveys revealed 126 species distributed among 105 genera and 35 families, predominantly dominated by Asteraceae with 23 species, Fabaceae and Poaceae with 14 species each. Among these species, the presence of 5 endemic species was noted.

- ***Vegetation Groups and Diagnostic Species***

According to the TWINSPAN classification and subsequent Optim Class analysis, seven types of vegetation groups were obtained, each with a particular floristic composition. Considering a threshold value of 0.30 for the fidelity coefficient (f), **69** diagnostic species were selected for the different vegetation groups (Table 1). Diagnostic species are an important concept in vegetation classification (Whittaker 1962; Westhoff and van der Maarel 1973). The vegetation groups are described as follows:

Group 1: *Eucalyptus camaldulensis* Dehnh.- *Pinus halepensis* Mill.

Group 1 was observed in 20 surveys with 02 diagnostic species. The average number of species per survey is 9.80, and the total number of species is **18**.

Diagnostic species: *Eucalyptus camaldulensis* Dehnh, *Phillyrea angustifolia* L.

Constant species: *Pistacia lentiscus* L., *Pinus halepensis* Mill., *Asparagus acutifolius* L., *Quercus coccifera* L., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz

Dominant species: *Pinus halepensis* Mill., *Pistacia lentiscus* L., *Quercus coccifera* L., *Eucalyptus camaldulensis* Dehnh., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, *Acacia saligna* (Labill.) H.L.Wendl. = *Acacia cyano*, *Smilax aspera* L., *Phillyrea angustifolia* L., *Eucalyptus* *cladocalyx* F. Muell , *Quercus suber* L., *Olea europaea* var. sylvestris L., Erica arborea L., *Cistus monspeliensis* L., *Chamaerops humilis* L.

Group 2: *Arrhenatherum album* (Vahl) – Clayton - *Pistacia lentiscus* L.

This group was encountered in 08 plots with 2 diagnostic species, with Arrhenatherum album (Vahl) Clayton being the most diagnostic species. The average number of species per plot is 16.25, and the total number of species is **46**.

Diagnostic species: *Arrhenatherum album* (Vahl) Clayton. = *Avena alba*Vahl, *Borago officinalis* L.

Constant species: *Pistacia lentiscus* L., *Cistus monsp*eliensis L., *Calycotome spinosa* = *Calicotome spinosa* (L.) Link., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, Rubia peregrina L., *Pinus halepensis Mill., Dactylis glomerata* L.

***Dominant species**: Pistacia* lentiscus L., *Pinus halepensis Mill., Ampelodesmos mauritanicus (Poir.) Durand et Schinz, Calycotome* spinosa =*Calicotome spinosa* (L.) Link., *Pinus pinea* L., *Cistus monspeliensis* L., *Chamaerops humilis* L.

Group 3: *Lavandula stoechas* L.- *Quercus coccifera* L.

Group 3 was observed in 04 plots with 18 diagnostic species. The average number of species per plot is 22.25, and the total number of species is **48**.

Diagnostic species: *Lavandula stoechas* L., *Pteridium aquilinum* (L.) Kuhn, *Eryngium tricuspidatum* L., *Galium tunetanum* Lam., *Specularia falcata* A.DC.= *Legousia falcata* (Ten.)J, *Carthamus arborescens* L., *Bellis sylvestris* Cirillo, *Poa bulbosa* L., *Vulpia myuros* (L.)C.C.Gmel., *Hypericum perforatum* L., *Myosotis collina* Hoffm., *Marrubium vulgare* L., *Helminthotheca glomerata* (Pomel) Greuter., *Aira cupaniana* Guss., *Plantago serraria* L., *Galium aparine* L., *Echinops spinosus* L., *Asperula hirsuta* Desf.

Constant species: *Quercus coccifera* L., *Pistacia lentiscus* L., *Cistus monspeliensis* L., *Calycotome spinosa* =*Calicotome spinosa* (L.) Link., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz.

Dominant species: *Quercus coccifera* L., *Pistacia lentiscus* L., *Pinus halepensis* Mill., *Lavandula stoechas* L., *Cistus monspeliensis* L., *Cistus salvifolius* L., *Arbutus unedo* L.

Group 4: *Jasione montana* L.- *Pistacia lentiscus* L.

This group appeared in 08 plots with 10 diagnostic species. The average number of species per plot is 20.38, and the total number of species is **55**.

Diagnostic species*: Jasione montana* L., *Fumana thymifolia (L.) Verlot, Silene coeli -rosa* (L.)A.Br. *Rhaponticum acaule* (L.)DC., *Daphne gnidium* L., *Anthyllis vulneraria* L.(Arqsafir), *Prasium majus* L., *Capparis spinosa* L., *Genista linifolia* L., *Sanguisorba minor* Scop.

Constant species: *Pistacia lentiscus* L., *Quercus coccifera* L., *Cistus monspeliensis* L., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, *Pinus halepensis* Mill., *Olea europaea* var. sylvestris L., *Dactylis glomerata* L., *Cistus salvifolius* L.

Dominant species: *Pistacia lentiscus* L., *Quercus coccifera* L., *Pinus halepensis* Mill., *Olea europaea* var. sylvestris L., *Erica arborea* L., *Arbutus unedo* L.

Group 5: *Coleostephus myconis* (L.) Rchb.f - *Olea europaea* var. sylvestris L.

This group comprises 04 plots and 21 diagnostic species. The average number of species per plot is 26.25, and the total number of species is 51.

Diagnostic species: *Coleostephus myconis* (L.) Rchb.f ., *Avena sterilis* L., *Oryzopsis miliacea* (L.) Benth. et Hook. f. ex Asch, *Andryala integrifolia* L., *Trifolium stellatum* L., *Clematis flammula* L., *Rubus ulmifolius* Schott., *Muscari comosum* (L.) Mill., *Medicago murex* Willd., *Smilax aspera* L., *Galactites tomentosus* Moench., *Medicago turbinata* (L.) All., *Anthemis pedunculata* Desf., *Plagius grandis* (L.) Alavi et Heywood, *Trifolium angustifolium* L., *Plantago lagopus* L., *Briza maxima* L., *Plantago serraria* L., Anthoxanthum odoratum L., *Daucus carota* L., *Calycotome spinosa =Calicotome spinosa* (L.) Link.

Constant species: *Pistacia lentiscus* L., *Olea europaea* var. sylvestris L.

Dominant species: *Olea europaea* var. sylvestris L., *Pistacia lentiscus* L., *Smilax aspera* L., *Rubus ulmifolius* Schott., *Rhamnus alaternus* L., *Quercus coccifera* L., *Pinus canariensis* C.Sm., *Clematis flammula* L., *Cistus monspeliensis* L., *Calycotome spinosa =Calicotome spinosa* (L.) Link., *Arbutus unedo* L.

Group 6: *Ornithogalum umbellatum* L.- *Pinus halepensis* Mill.

Group 6 was encountered in 09 surveys and comprises 09 diagnostic species. The average number of species per survey is 25.44, and the total number of species is **70**.

Diagnostic species: *Ornithogalum umbellatum* L., *Lagurus ovatus* L., *Olea europaea* var. sylvestris L., *Quercus suber* L., *Rhamnus alaternus* L., *Pulicaria odora* (L.) Rchb.=*Inula odora* L., *Atractylis gummifera= Carlina gummifera* (L.) Less., *Lavatera trimestris* L., *Eucalyptus gomphocephala* DC.

Constant species: *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, *Pistacia lentiscus* L., *Quercus coccifera* L., *Pinus halepensis* Mill., *Cistus monspeliensis* L., *Asparagus acutifolius* L., *Arbutus unedo* L., *Phillyrea angustifoli*a L., *Galium aparin*e L., *Daucus carota* L., *Smilax aspera* L., *Rubia peregrina* L., *Erica arborea* L., *Dactylis glomerata* L., *Anthemis pedunculata* Desf.

Dominant species: *Pinus halepensis* Mill., *Pistacia lentiscus* L., *Quercus coccifera* L., *Quercus suber* L., *Pinus pinea* L., *Olea europaea* var. sylvestris L., *Erica arborea* L., *Cistus monspeliensis* L., *Arbutus unedo* L., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz.

Group 7: *Teucrium polium* L.- *Pinus halepensis* Mill.

This group includes 12 surveys and 07 diagnostic species. The average number of species per survey is 22, and the total number of species is **64**.

Diagnostic species: *Teucrium polium* L., *Hypericum humifusum* L., *Myrtus communis* L., *Pinus pinaster* Soland., *Galium rotundifolium* L., *Arbutus unedo* L., *Cistus salvifolius* L.

Constant species: *Quercus coccifera* L., *Pistacia lentiscus* L., *Cistus monspeliensis* L., *Calycotome spinosa* =*Calicotome spinosa* (L.) Link., *Pinus halepensis* Mill., *Ampelodesmos mauritanicus* (Poir.) Durand et Schinz, *Rubia peregrina* L., *Briza maxima* L., *Asparagus acutifolius* L.

Dominant species: *Pinus halepensis* Mill., *Quercus coccifera* L., *Pistacia lentiscus* L., *Arbutus unedo* L., *Pinus pinea* L., *Phillyrea angustifolia* L., *Erica arborea* L., *Quercus suber* L., *Pinus pinaster* Soland., *Cistus monspeliensis* L.

Table 1. Synoptic table of vegetation sampling and species fidelity values in the seven groups.

Group N	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Number of floristic surveys	**20**	**8**	**4**	**8**	**4**	**9**	**12**
Group 1: *Eucalyptus camaldulensis* Dehnh. -*Pinus halepensis* Mill.							
Eucalyptus camaldulensis Dehnh.	**47.1**	---	---	---	---	---	---
Phillyrea angustifolia L.	**38.3**	---	---	---	---	26.9	12.6
Group 2: *Arrhenatherum album* (Vahl)Clayton-*Pistacia lentiscus* L.							
Arrhenatherum album (Vahl) Clayton.= *Avena alba* Vahl	---	**49.7**	---	---	---	---	---
Borago officinalis L.	---	**33**	---	---	---	---	---
Group 3: *Lavandula stoechas* L. - *Quercus coccifera* L.							
Lavandula stoechas L.	---	---	**76.7**	---	---	---	---

Pteridium aquilinum (L.) Kuhn	---	---	**67.9**	---	---	---	---
Eryngium tricuspidatum L.	---	3.2	**54**	---	---	---	---
Galium tunetanum Lam.	---	---	**53.3**	---	---	16	---
Specularia falcata A.DC.= *Legousia falcata* (Ten.)Janch.	---	---	**51.9**	18.9	---	---	---
Bellis sylvestris Cirillo	---	0.2	**46.9**	0.2	---	---	---
Carthamus arborescens L.	---	0.2	**46.9**	0.2	---	---	---
Poa bulbosa L.	---	---	**42**	8.1	---	4.3	---
Vulpia myuros (L.)C.C.Gmel.	---	---	**39.8**	---	11.3	8.1	---
Hypericum perforatum L.	---	---	**37.1**	---	9.5	6.4	---
Marrubium vulgare L.	---	13	**35.6**	---	---	---	---
Helminthotheca glomerata (Pomel) Greuter.	---	---	**35.6**	13	---	---	---
Aira cupaniana Guss.	---	---	**35.6**	13	---	---	---
Myosotis collina Hoffm.	---	---	**35.6**	13	---	---	---
Galium aparine L.	---	---	**32.2**	---	11.1	25.2	4
Echinops spinosus L.	---	---	**31.2**	---	---	8	3.3
Asperula hirsuta Desf.	---	---	**30.5**	9.8	---	---	2.9
Group 4: *Jasione montana* L.- *Pistacia lentiscus* L.							
Jasione montana L.	---	0.8	---	**63.8**	---	---	---
Fumana thymifolia (L.) Verlot	---	11.7	---	**54.8**	---	---	---
Silene coeli -rosa (L.) A.Br.	---	8.9	---	**49.8**	---	5.8	---
Rhaponticum acaule (L.) DC.	---	---	---	**47.1**	---	---	---
Daphne gnidium L.	---	---	---	**47.1**	---	---	---
Anthyllis vulneraria L. (Arqsafir)	---	10.2	---	**38.1**	---	---	10.2

Prasium majus L.	---	---	---	**36.6**	---	11	---
Capparis spinosa L.	---	13	---	**35.6**	---	---	---
Genista linifolia L.	---	---	---	**33**	---	---	---
Sanguisorba minor Scop.	---	---	---	**32.9**	---	---	18.5
Group 5: *Coleostephus myconis* (L.) Rchb.f .- *Olea europaea* var. sylvestris L.							
Coleostephus myconis (L.) Rchb.f.	---	---	---	---	**77.7**	0.6	---
Avena sterilis L.	---	---	---	---	**75.2**	---	---
Oryzopsis miliacea (L.) Benth. et Hook. f. ex Asch. Et Schweinf.	---	---	---	---	**67.6**	16.4	---
Andryala integrifolia L.	---	---	9.1	---	**63.9**	---	---
Trifolium stellatum L.	---	2.6	---	---	**52.5**	0.8	---
Clematis flammula L.	---	---	---	---	**50.9**	10.3	10.3
Rubus ulmifolius Schott.	---	---	---	---	**50.2**	20.6	1.8
Muscari comosum (L.) Mill.	---	---	---	---	**49.2**	13.7	---
Medicago murex Willd.	---	14.4	---	---	**44.7**	---	4.3
Smilax aspera L.	11	---	---	---	**42.8**	25.1	---
Galactites tomentosus Moench.	---	---	18.3	---	**40.6**	13.3	---
Medicago turbinata (L.) All.	---	---	10.5	---	**38.5**	7.4	---
Anthemis pedunculata Desf.	---	---	15.2	---	**37**	20	---
Plagius grandis (L.) Alavi et Heywood	---	---	---	---	**35.7**	---	17.7
Briza maxima L.	---	---	---	---	**35.6**	9.3	28.4
Plantago lagopus L.	---	13	---	---	**35.6**	---	---
Trifolium angustifolium L.	---	---	---	13	**35.6**	---	---
Anthoxanthum odoratum L.	---	---	7.4	---	**33.9**	4.4	---

Daucus carota L.	---	---	---	---	**33.2**	26.1	---
Calycotome spinosa =*Calicotome spinosa* (L.) Link.	---	19.9	9.2	---	**30.5**	---	16.3
Group 6: *Ornithogalum umbellatum* L.-*Pinus halepensis* Mill.							
*Ornithogalum u*mbellatum L.	---	---	4.8	---	---	**47.2**	4.8
Lagurus ovatus L.	---	---	---	---	---	**44.4**	---
Olea europaea var. sylvestris L.	---	---	---	19.3	29.8	**41.4**	---
Quercus suber L.	---	---	---	---	14.5	**38.1**	4.4
Rhamnus alaternus L.	5.5	---	---	---	11.2	**33.3**	1.7
Atractylis gummifera= *Carlina gummifera* (L.) Less.	---	---	---	14.2	---	**32.5**	---
Pulicaria odora (L.) Rchb. = *Inula odora* L.	---	14.2	---	---	---	**32.5**	---
Eucalyptus gomphocephala DC.	---	---	---	---	---	**31.1**	---
Lavatera trimestris L.	---	---	---	---	---	**31.1**	---
Group 7: *Teucrium polium* L.-*Pinus halepensis* Mill.							
Teucrium polium L.	---	---	---	---	---	---	**54.8**
Hypericum humifusum L.	---	---	---	---	---	---	**47.1**
Myrtus communis L.	20	---	---	---	---	4.9	**42.8**
Pinus pinaster Soland.	1.4	---	---	---	---	---	**41.8**
Galium rotundifolium L.	---	---	---	---	---	---	**38.3**
Arbutus unedo L.	---	---	1.5	---	1.5	24.2	**35.6**
Cistus salvifolius L.	---	---	---	15.6	5.3	0.7	**32.7**
Plantago serraria L.	---	---	**34.3**	7.6	**34.3**	---	---

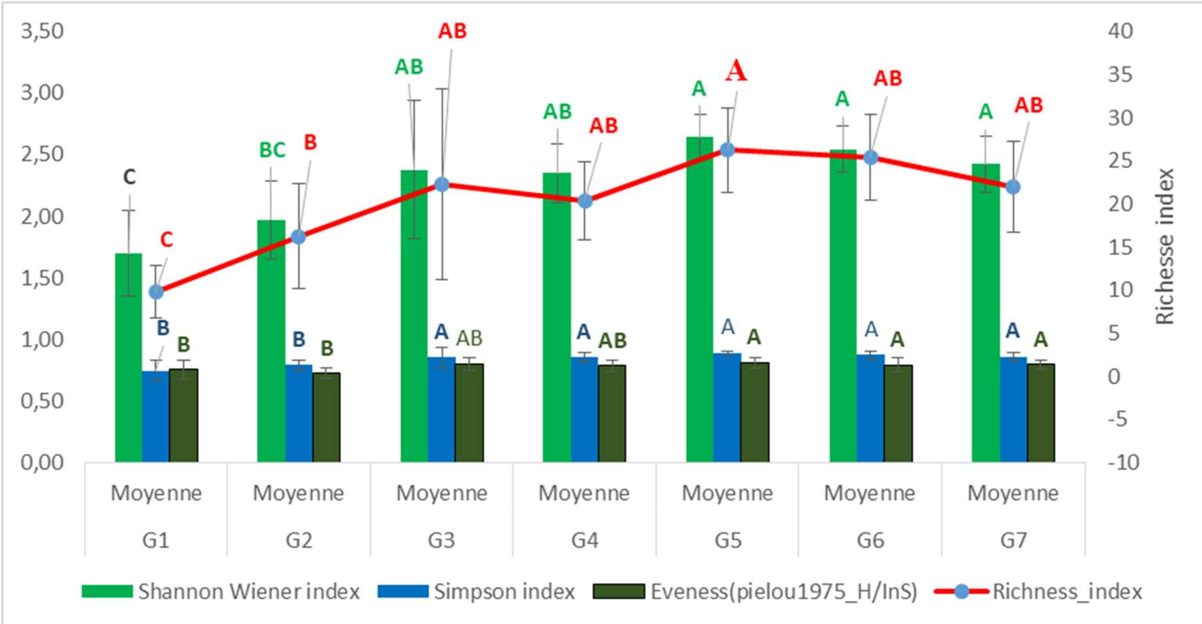

Figure 2. Mean values of diversity indices (Means ± Standard error) in the identified groups of plant species. Different letters in each column indicate a significant difference at the 0.05 level according to the Kruskal Wallis testx.

The analysis of biodiversity index results shows that Group (G1) (*Eucalyptus camaldulensis* Dehnh. - *Pinus halepensis* Mill.) is the least diversified. This is attributed to the planting of Eucalyptus outside its original geographic zone, resulting in limited undergrowth vegetation (Fig. 3), development, particularly herbaceous vegetation, once the plantation reaches a certain age. Allelopathy, a negative effect, significantly hinders biodiversity under Eucalyptus plantations (Tassin and al. 2011). The leaves and litter on the forest floor contain phytotoxic phenolic acids, tannins, and flavonoids (Bernhard-Reversat 1998).

Figure 3. *Eucalyptus camaldulensis* (red gum) plantation (photos: S. ABLA 2022).

Because of their slender form, eucalyptus plantations are usually not very closed. Lack of light therefore does not seem to be a direct obstacle to the development of an undergrowth. However, excess light filtering through the canopy may encourage the growth of a carpet of grasses, which could hinder the development of forest species whose seeds are dispersed from nearby natural forests (Kanowski and al. 2005).

Group (G5) (*Coleostephus myconis* (L.) Rchb.f - *Olea europaea* var. sylvestris L.) recorded the highest Shannon diversity index of 2.642 bits (Fig. 2) and a Pielou equitability of 0.812. x, is more diverse in species than other groups due to its less exposed location to heat during long summer days, retaining more moisture in the soil necessary for plant growth.

In addition to group (G5), groups (G6, G7) also recorded relatively high mean richness indices and Shannon diversity indices, exceeding 2.6 bits (Fig. 2), and Pielou equitability over 0.8. According to Orth and Colette (1996), the Shannon index is high for species with equal importance and low when a few species have high coverage, while equitability tends towards 0 when one species has very high coverage and towards 1 when all species are equally important. This is due to the importance of rare and infrequent taxa. (Table 1). The constancy of certain species is also partly to blame.

These groups are represented by open matorrals and these results are comparable to those given by Medjahdi (2010), who indicates for the Traras Mountains that the floristic richness of habitats is highest for more or less open wooded matorrals, and decreases in the case of degradation and closure of the environment, while (Djebbouri and al. 2022) for the Saida region shows that SHANNON index values are lower overall (< 2.8 bits) and equitability varies between 0.4 and 0.9, but they are higher in treed matorrals than in closed formations.

As for the Evenness-Pielou 1975 index, it shows good equity between these groups studied, as the values obtained are all high and close to 1. The differences between the mean values are not statistically significant ($p \geq 0.05$). These indices, close to 1 indicate that plant individuals have an almost homogeneous distribution in the groupings (Sebata 2017).

The rest of the groups on the southern slopes of the Bouzaréah massif, where conditions are less favorable, experience little regeneration of the forest stratum, in the form of scrubland accompanied by shrub vegetation including *Calycotum spinosa* L. and *Phillyrea angustifolia* L., which subsequently provides an environment conducive to fires, many of which are deliberate (Benabadji and al. 2007).

No phytosociological study has been conducted in the Bouzaréah forest massif, making it difficult to compare vegetation composition and diversity. However, based on this study's results and continuous vegetation observation, it's evident that most identified groups have been severely disrupted by anthropogenic activities, such as the reported wild fires in 2001(Fig. 4), by the Directorate of Forests and the Green Belt of the Wilaya of Algiers, when a fire broke out in the massif and lasted 3 days. 130 ha were burnt, in addition to offences and illegal felling.

This situation necessitates reflection from forest services to consider plans for assisting in the reconstruction of forest cover in this urban forest massif.

Figure 4. Some human activities in the Bouzaréah forest (photos: Bainem Forestry Department, 2001). 1 and 2: a burnt stand of Aleppo pines; 3: offences and illegal felling.

4. Conclusion

This study, conducted in previously unexplored vegetation, revealed relatively high diversity, which had been subject to very few studies, often in the form of simple surveys by the forest services of the Wilaya of Algiers. It includes 126 plant species belonging to 105 genera and 35 families.

The examination of the current state of flora in the vegetation formations of the Bouzaréah forest massif reveals varying levels of floristic degradation. It has become essential to establish a classification and detailed description of the vegetation. This research deepened our understanding of floristic composition and structural characteristics through the identification of 07 vegetation groups.

Evaluation of different diversity indices shows that among the analyzed groups, Group (G5) exhibits the greatest floristic diversity due to its location on the North Slope of the massif, where conditions are most favorable for its development compared to Group (G1), which consists of Eucalyptus plantations and is the least diversified group. Moreover, Eucalyptus plantations and expansion should not come at the expense of massif ecosystems. Eucalyptus plantations should be planned to mitigate their negative impacts on biodiversity and soil quality.

This study demonstrates a diversity of vegetation formations with various potentials. They will likely be subject to increasing human disturbances in the future, as the Bouzaréah forest massif is located in the heart of the capital city of Algiers. This issue therefore requires in-depth research to identify management methods ensuring the conservation of natural resources in peri-urban spaces.

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