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Breaking new ground: floristic diversity and conservation implications in Bordj Bou Arreridj Forests, Algeria

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Abstract. This study assessed the floristic diversity and conservation status of two ecologically significant forests in Bordj Ghedir region, southeastern Bordj Bou Arreridj, Algeria: Ouled Hanneche (10,221.69 ha) and Ouled Khelouf (8,580.47 ha), covering a combined area of 18,802.16 hectares. Field inventories conducted in March 2023 across 13 stations, with 13 plots collected using random sampling methods. We identified 71 plant species from 32 families and 64 genera. The *Asteraceae* and *Lamiaceae* families were dominant. Hemicryptophytes and Therophytes were the most abundant life forms, and chorological analysis indicated a predominance of Mediterranean elements. Ecological indices (Shannon H' up to 3.602; Simpson 1-D up to 0.97) confirmed high species richness and diversity, particularly in the Ouled Hanneche forest. Despite this richness, the ecosystems face threats from overgrazing, wildfires, and insect pests. The findings provide a critical baseline for conservation and underscore the need for sustainable management strategies, including protected area enforcement and community engagement, to preserve this unique Mediterranean biodiversity hotspot.

Key words: Bordj Bou Arreridj, forest of bordj ghedir, biodiversity indices, floristic diversity.

INTRODUCTION

Aquatic and terrestrial ecosystems support a diverse array of organisms, including animals, plants, and microorganisms. Over the past decades, biodiversity within these ecosystems has faced significant pressures, such as climate change and human activities (Brondízio et al., 2019; Muposhi, 2024). Additionally, biological diversity is increasingly threatened by overexploitation, leading to the decline and disappearance of species. Protecting these living species is essential not only for preserving biodiversity but also for maintaining the ecosystems that provide vital natural resources (Díaz et al., 2019; Bilassé et al., 2023; Isbell et al., 2023).

The Convention on Biological Diversity (CBD), established in 1992, represents a landmark global effort to address these challenges through conservation, sustainable use of resources and equitable sharing of benefits (Convention on Biological Diversity,

1992). Despite international commitments, biodiversity loss continues, particularly in key habitats such as forests, which have lost around 6.5 million hectares per year since 2010. Forest degradation not only reduces carbon storage and biodiversity, but also disrupts ecosystem services essential to human livelihoods (Hansen et al., 2013). This decline can be attributed to various environmental changes (like climate change) and human activities (such as logging, agriculture, and urbanization) (Gibbs et al., 2010; Hosonuma et al., 2012 and Gustave, 2022).

Among the world's biodiversity hotspots, the Mediterranean basin stands out for its exceptional plant diversity and high endemism. This region faces severe anthropogenic and environmental stressors, including an increased frequency and intensity of wildfires driven by climate change (hotter, drier summers) and human negligence (Batllori et al., 2019; Fayad, 2023 and Moreno et al., 2023). These fires lead to direct species loss, soil erosion, and long-term alteration of ecosystem structure and function (Bowd et al., 2019; Nolan et al., 2021; Thom, 2023 and Navarro-Cano et al., 2024). However, comprehensive data on Mediterranean endemic species is still scarce, which hampers the effectiveness of conservation strategies (Fenu et al., 2020; Fady, 2022; Mendoza-Fernandez et al., 2022; Pipinis et al., 2022; Heba et al., 2023 and Lanzas et al., 2024). In Algeria, forests cover less than 2% of the country's surface area, with continuing losses due to fires, overgrazing and unsustainable land use (DGF, 2022). The Ouled Hanneche and Ouled Khelouf forests (Bordj Bou Arriridj, Algeria) illustrate these pressures, representing ecologically important but vulnerable areas within the Tellian and Saharan Atlas ranges (Forest conservation of Bordj Bou Arreridj, 2023).

Floristic studies are essential for understanding species diversity, guiding conservation and informing sustainable management (Dajoz, 2000; Ludovicy et al., 2022; Elgadi et al., 2024 and Ribeiro et al., 2024). However, gaps persist in regional assessments, particularly in Bordj Bou Arreridj, where climatic and anthropogenic impacts are increasingly threatening endemic flora.

This study aims to assess plant diversity and community structure in the Ouled Hanneche and Ouled Khelouf forests, evaluate environmental and anthropogenic impacts, and provide actionable insights for their conservation aligned with national and global biodiversity targets.

MATERIALS AND METHODS

Study Area

Bordj Ghedir is located on the high plateaus in the southeastern of Bordj Bou Arreridj, with geographical coordinates of 36°04′23″ North latitude and 4°45′39″ East longitude (WGS84) (Fig. 1). The research focused on two state forests: Ouled Hanneche and Ouled Khelouf. The Ouled Hanneche forest, part of the Hodna Mountains, spans an area of 10,221.69 hectares across the wilayas of Bordj Bou Arreridj and Sétif. The Ouled Khelouf forest is situated entirely within Bordj Bou Arreridj, covering 8,580.47 hectares (Bordj Bou Arreridj conservation, 2023). The region is characterized by a semi-arid climate and mountainous terrain.

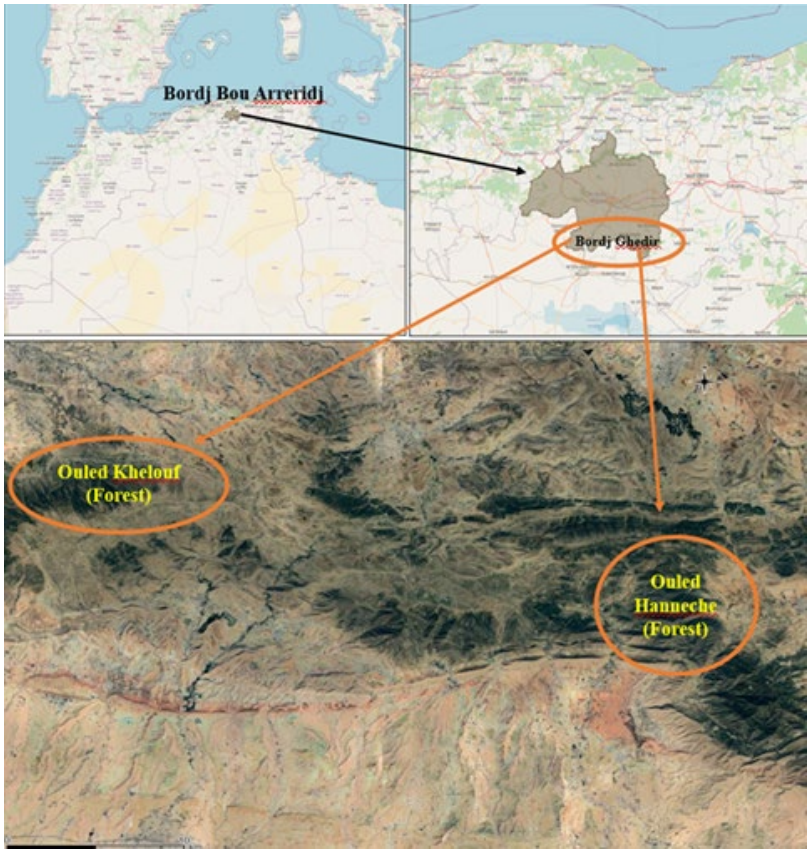

Figure 1. Location of the study area, including the Ouled Hanneche and Ouled Khelouf forests, in the Bordj Bou Arreridj Wilaya, Algeria.

Field methodology, choice of stations and sampling

Two study sites were selected for their ecological significance and representation of the region's forest diversity: the Ouled Khelouf forest and the Ouled Hanneche forest known for its richer floristic diversity in a semi-arid zone. The Ouled Hanneche forest features two exposures (north and south) with an altitudinal range from 1,200 to 1,733 meters, while the Ouled Khelouf forest ranges from 1,341 to 1,700 meters.

During scientific outings in March 2023, a total of 13 stations were established across both forests (4 in Ouled Khelouf forest and 9 in Ouled Hanneche forest). A total of 13 plots were surveyed using the random quadrat method to ensure a representative inventory of the plant community. Station selection was based on environmental factors such as altitude, slope exposure, and vegetation type to capture the ecological heterogeneity in each forest.

Methods for processing results

The results were analyzed using several methods. Ecological composition analysis employed key metrics such as Species Richness (S.R.), Absolute Abundance (Aa), Relative Abundance (RA), and Relative Frequency (RF) to assess species distribution

and ecosystem dynamics (Ramade, 1984; Krebs, 1999; Magurran, 2004). Ecological structure analysis utilized indices like the Shannon-Weaver index (H') (Shannon & Weaver, 1949), Simpson index (D) (Simpson, 1949), Piélou's equitability index (J) (Pielou, 1966), and Berger-Parker index (D/B) (Berger & Parker, 1970) to evaluate species diversity, evenness, and community structure. Additionally, diversity estimators, including Chao 1 and Chao 2 (Chao, 1984), were applied to further analyze biodiversity patterns. Together, these methods provided comprehensive insights into ecosystem composition, structure, and diversity.

Mathematical Formulae for Ecological Indices

- **Shannon-Weaver Index (H′):** $H' = -\sum(pi \cdot \ln(pi))$ (Magurran, 2013).

Where pi is the proportion of individuals belonging to species i, and S is the total number of species. Range: 0 (low diversity) to > 4 (high diversity).

- **Simpson Index (1-D):** $D = \sum(pi^2)$ (Magurran, 2013).

Range: 0 (low diversity) to 1 (high diversity).

- **Piélou's Equitability (J):** $J = J = \frac{H'}{\ln(S)}$

Range: 0 (dominance) to 1 (perfect evenness).

- **Berger-Parker Index (D):** $d = \frac{Nmax}{N}$

Where NmaxNmax is the number of individuals in the most abundant species, and NN is the total number of individuals. Range: 0 (low dominance) to 1 (high dominance).

- **Chao1 Estimator:** $S_{chao1} = S_{ods} + (F_1^2/2F_2)$

Where S_{obs} is the number of observed species, F1 is the number of singletons, and F2 is the number of doubletons.

RESULTS

Taxonomic hierarchy of species

In this study, a floristic inventory was conducted across various zones of the two forests mentioned earlier. The inventory included 71 species and 64 genera, belonging to 32 families, as illustrated in Fig. 2 and Table 1.

Table 1. Chorological type of species in the study area

Type	Number of species	Percentage %
Mediterranean-Atlantic	5	4%
Mediterranean	35	70%
Western Mediterranean	7	6%
Eastern Mediterranean	2	2%
Cosmopolitan	7	7%
Southern European	6	4%
Eurasian	5	4%
European	2	1%
Southern Eurasian	2	2%

The histogram (Fig. 2) displays the distribution of plant families in the study area. The most dominant families are *Asteraceae* and *Lamiaceae*, each represented by 10 species. Families with a less represented number of species (only 1 specie) include *Amaranthaceae, Amaryllidaceae, Anacardiaceae, Compositae, Cupressaceae, Fabaceae, Fagaceae, Iridaceae, Liliaceae, Malvaceae, Oleaceae, Papaveraceae, Papilionaceae, Resedaceae, Rutaceae*, and *Thymelaeaceae*. Families represented by 2 species are *Apiaceae, Boraginaceae, Caryophyllacées, Crassulaceae, Geraniaceae, Pinaceae, Rubiaceae.* Families with a

medium number of species (3 or 4 species) include *Asparagaceae* and *Brassicaceae* (4 species each), as well as *Cistaceae, Plantaginaceae, Poaceae,* and *Rosaceae* (3 species each).

This taxonomic hierarchy highlights the diversity and distribution of plant families within the study area, with Asteraceae and Lamiaceae being the most prominent.

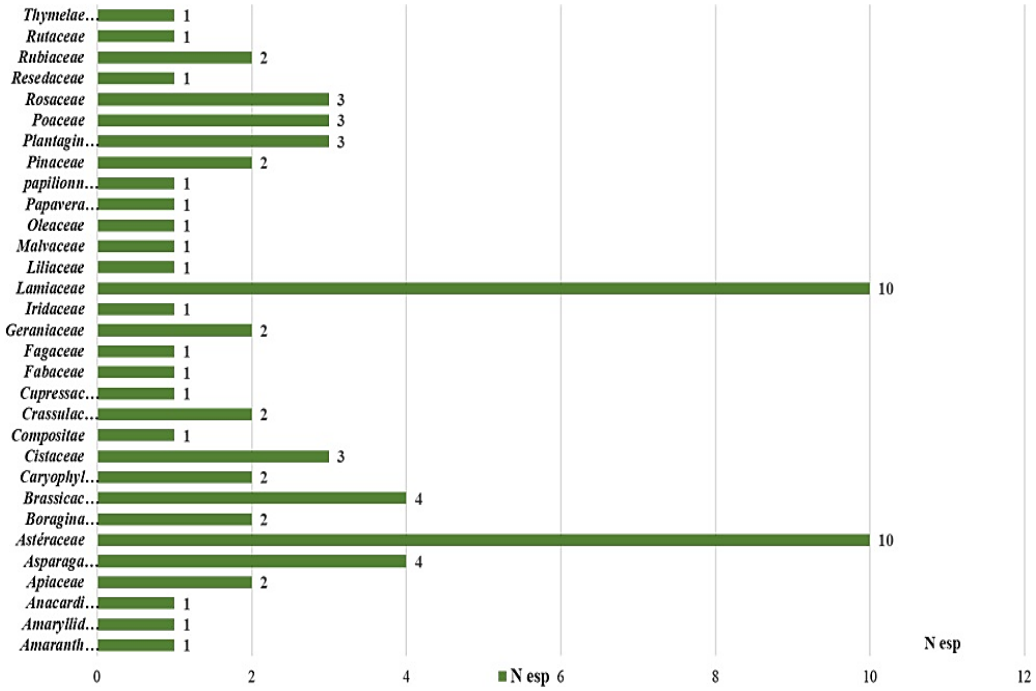

Figure 2. Histogram of plant family distribution in the study area.

The circular diagram (Fig. 3) illustrates the overall biological spectrum of all species in the study area. The most dominant life form is hemicryptophytes, representing 30% of the species. This is followed by therophytes at 25%, chamaephytes at 15%, and geophytes at 14%. Nanophanerophytes account for 10%, while the least represented life forms are microphanerophytes (4%) and mesophanerophytes (2%).

This distribution highlights the prevalence of hemicryptophytes and therophytes in the study area, reflecting the adaptation of plant species to the local environmental conditions.

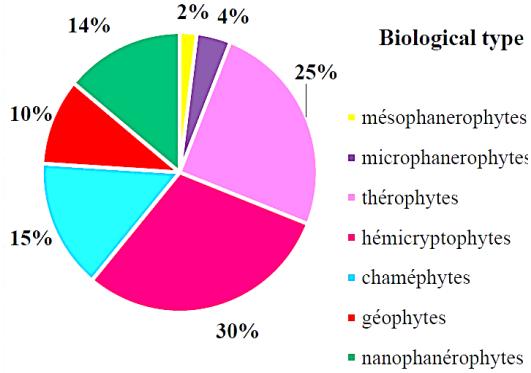

Figure 3. Overall biological spectrum of the study area.

Morphological plant analysis

Analysis of the vegetation in the Bordj Ghedir region, focusing on the two forests, indicates a significant overall presence of herbaceous species. There are 45 herbaceous species, which cover 60% of the green space. The tree and shrub component covers 15% of the space, with 5 tree species and 6 shrub species. Shrubs and sub-shrubs cover a combined 10% of the green space, with shrubs representing 6.8% (9 species) and sub-shrubs representing 3.2% (6 species).

Chorological type

The phytogeographical element according to Braun Blanquet (1919) *sensu* Rivas-Martinez (2017), corresponds to the floristic and phytosociological expression of a well-defined extended territory; it encompasses the species and phytogeographical collectives characteristic of a given region or domain. Chorology is the discipline that studies the delimitation and distribution of species, including those of genera, families, orders, and beyond (Lomolino et al., 2017).

Table 1 shows the chorological type of species in the study area. The most prevalent type is Mediterranean, comprising a high percentage of 70% and a greater number of species (35). The other chorological types have lower percentage (1–7%).

Results of analysis using ecological composition indices

The species richness (Table 2) in the two forests is almost identical in terms of the values recorded across all stations, with a differentiation of families and species from one station to another. This also demonstrates the influence of stationary factors (exposure, altitude, and direction) on forest richness.

Table 2. Stationary variations in species richness in two forests

Forest	Ouled Khelouf				Ouled Hanneche								
Station	1	2	3	4	1	2	3	4	5	6	7	8	9
RS	23	18	23	19	34	35	32	32	32	30	38	32	22

Upon the completion of our field surveys in the forest, we found around 272 individuals recorded in the 3 stations of the Ouled Khelouf forest, with the highest number of individuals being 82 at station 3 (El-Ghebaire). In the Ouled Hanneche forest, we found approximately 1,102 individuals recorded across the 7 stations, with the highest number of individuals being 157 at station 7 (Zbire) (Table 3).

Table 3. Absolute abundance of the two forests

Forest	Ouled Khelouf				Ouled Hanneche								
Station	1	2	3	4	1	2	3	4	5	6	7	8	9
Aa	78	52	82	60	107	133	111	127	118	113	157	122	114

Table 4 presents the relative abundance of individuals in the Ouled Khelouf and Ouled Hanneche forests. In Ouled Khelouf, a total of 272 individuals were recorded, with the highest number (82) recorded at the El-Ghebaire station, reflecting the greatest relative abundance, where the sum of station values equals 1. In Ouled Hanneche, a total of

1,102 individuals were recorded, with the highest number (157) observed at the Zbire station, also indicating the greatest relative abundance, with all station values summing to 1.

Table 4. Relative abundance of the two forests

Forest	Station	N	Aa	AR
Ouled	1	272	78	0.286765
Khelouf	2		52	0.191176
	3		82	0.301471
	4		60	0.220588
Ouled	1	1102	107	0.097096
Hanneche	2		133	0.12069
	3		111	0.100726
	4		127	0.115245
	5		118	0.107078
	6		113	0.102541
	7		157	0.142468
	8		122	0.110707804
	9		114	0.103448

Table 5. Relative frequency of two forests

Forest	Splots	AR	FR (%)
Ouled	1	0.286765	28.67647
Khelouf	2	0.191176	19.11765
	3	0.301471	30.14706
	4	0.220588	22.05882
Ouled	1	0.097096	9.709619
Hanneche	2	0.12069	12.06897
	3	0.100726	10.0726
	4	0.115245	11.5245
	5	0.107078	10.7078
	6	0.102541	10.25408
	7	0.142468	14.24682
	8	0.110707804	11.0707804
	9	0.103448	10.34483

Table 5 shows the relative frequency for the Ouled Khelouf and Ouled Hanneche forests. In Ouled Khelouf, the highest relative frequency is 30.147% at station 3 (El-Ghebaire), while in Ouled Hanneche, the highest relative frequency is 14.246% at station 7 (Zbire), with the total relative frequency for both forests summing to 100%.

Results of analysis using ecological structure indices

From Table 6, the Shannon diversity index (H) was calculated for both Ouled Khelouf and Ouled Hanneche forests, where a higher value of H indicates greater community diversity. In Ouled Khelouf, the index values are nearly identical across all stations (1, 2, 3, and 4), with the highest value of 2.874 recorded at station 3 (El-Ghebaire). Similarly, in Ouled Hanneche, the index values are almost the same across all stations (1, 2, 3, 4, 5, 6, 7, 8, and 9), with the highest value of 3.602 recorded at station 7 (Zbire).

Table 6. Ecological structure indices for the Ouled Khelouf and Ouled Hanneche forests

Forest	Station	Shannon (H')	Simpson (1-D)	Piélou (J)	Berger-Parker (D)
Ouled	1	2.871	0.921	0.915	0.192
Khelouf	2	2.772	0.917	0.959	0.192
	3	2.874	0.907	0.916	0.268
	4	2.47	0.852	0.838	0.333
Ouled	1	3.446	0.960	0.977	0.140
Hanneche	2	3.466	0.963	0.974	0.112
	3	3.360	0.960	0.969	0.090
	4	3.342	0.960	0.964	0.078
	5	3.359	0.960	0.969	0.084
	6	3.349	0.961	0.984	0.088
	7	3.602	0.970	0.990	0.089
	8	3.416	0.964	0.985	0.081
	9	3.041	0.950	0.983	0.087

Table 6 represents the Simpson 1-D index for both Ouled Khelouf and Ouled Hanneche forests, where the index ranges from 0 (minimum diversity) to 1 (maximum diversity). In Ouled Khelouf, the results show that the maximum diversity is found in the Chouchet Naima and

El-Ghebaire stations, while the minimum diversity is observed in the Laayoun station. Similarly, in Ouled Hanneche, the Simpson 1-D index indicates maximum diversity across all stations (1, 2, 3, 4, 5, 6, 7, 8, and 9).

Table 6 shows the species equirepartition index (Piélou's equitability index) for both Ouled Khelouf and Ouled Hanneche forests, with values ranging from 0 (dominance of one species) to 1 (equirepartition of species). In Ouled Khelouf, the results are nearly identical across stations 1, 2, 3, and 4, with the highest value of 0.959 recorded at the Chouchet Naima station. Similarly, in Ouled Hanneche, the index values are very close across all stations (1, 2, 3, 4, 5, 6, 7, 8, and 9), with the highest value of 0.990 observed at the Zbire station.

Berger-Parker index (Table 6) which measures the proportion of the community represented by the most abundant species, for both Ouled Khelouf and Ouled Hanneche forests. In Ouled Khelouf, the highest value of 0.333 is recorded at the Laayoun station, while in Ouled Hanneche, the highest value of 0.140 is observed at the Agar station compared to the other stations.

Analysis of biodiversity indices for Ouled Khelouf and Ouled Hanneche forests

The analysis of forest diversity utilized several ecological indices, with results summarized in Table 6. The findings for each index are as follows:

Shannon Diversity Index (H'), this index increases with higher species richness and evenness. In Ouled Khelouf, the index values were very consistent across all four stations, with the highest value (H' = 2.874) recorded at station 3 (El-Ghebaire). A similar pattern of high uniformity was observed in Ouled Hanneche across its nine stations, where the maximum diversity (H' = 3.602) was found at station 7 (Zbire).

Simpson's Diversity Index (1-D), Ranging from 0 (minimal diversity) to 1 (maximal diversity), this index measures dominance. In Ouled Khelouf, the highest diversity was found at the Chouchet Naima and El-Ghebaire stations, while the Laayoun station showed the lowest diversity. In contrast, the Simpson index indicated consistently high diversity across all stations in Ouled Hanneche.

Pielou's Evenness Index (J'), this index ranging from 0 (dominance by one species) to 1 (perfect species evenness), showed little variation across stations in both forests. In Ouled Khelouf, the values were nearly identical, peaking at 0.959 in Chouchet Naima. Similarly, Ouled Hanneche exhibited very uniform and high evenness, with a maximum of 0.990 at the Zbire station.

Berger-Parker Index, this index measures the proportional dominance of the most abundant species. A higher value indicates greater dominance. In Ouled Khelouf, the Laayoun station had the highest dominance value (0.333). In Ouled Hanneche, the Agar station showed the highest level of dominance (0.140) compared to the other stations.

Analysis results using diversity estimators

Table 7 presents the diversity estimators, including Chao1 and Chao2, which estimate the number of unobserved species based on those observed once or twice, for both Ouled Khelouf and Ouled Hanneche forests. In Ouled Khelouf, the Laayoun station has the highest values for Chao1 (32.52) and Chao2 (41.1) compared to the other stations, while the values for stations 1, 2, 3, and 4 are nearly identical and closely aligned, suggesting similar levels of unobserved species. In Ouled Hanneche, the Zbire

station records the highest values for Chao1 (38) and Chao2 (38.06), whereas the values across stations 1, 2, 3, 4, 5, 6, 8, and 9 are very similar and closely grouped, indicating consistent levels of unobserved species across these areas.

Table 7. Diversity estimators for two forests

Forest	Ouled Khelouf				Ouled Hanneche								
Station	1	2	3	4	1	2	3	4	5	6	7	8	9
Chao1	26.46	18.27	24.27	32.52	35.73	37.13	35.47	33.35	33.86	30.09	38	32.3	22
Chao2	28.27	18.44	25.46	41.1	36.73	38.02	36.53	33.79	34.55	30.2	38.06	32.5	22
RS	23	18	23	19	34	35	32	32	32	30	38	32	22

Notable Plant Species and Photographic Documentation

The study identified several ecologically and medicinally significant plant species. Among the most widespread and notable species are (Fig. 5):

Figure 4. Photographs of key plant species in the study area: A) *Quercus ilex*, B) *Cedrus atlantica*, C) *Stipa tenacissima*, D) *Olea europaea*, E) *Thymus vulgaris* L., F) *Juniperus phoenica* L.

DISCUSSION

This study represents one of the first comprehensive assessments of floristic diversity in the Bordj Ghedir forests, a region that has been underrepresented in biodiversity research despite its ecological significance. Focusing on the Ouled Khelouf and Ouled Hanneche forests, this research inventoried vegetation and analyzed floristic diversity across 10,221.69 hectares. By documenting 71 plant species from 32 families and 64 genera.

This work fills a critical gap in the understanding of Algeria's plant biodiversity. The findings reveal notable floristic richness, with *Asteraceae* and *Lamiaceae* being the most dominant families, each represented by ten species. Other significant families include *Amaranthaceae*, *Fabaceae*, *Rosaceae*, and *Oleaceae*, among others. Notable species recorded include ecologically and culturally significant taxa such as the Holm oak (*Quercus ilex*), Atlas cedar (*Cedrus atlantica*), and medicinal plants like Olive (*Olea europaea* L.), Mastic tree (*Pistacia lentiscus* L.), and Rosemary (*Rosmarinus officinalis* L.). A significant finding was the first recorded presence of *Ruscus aculeatus* in the Bordj Bou Arreridj region. While no strongly invasive alien species were dominant in the surveyed plots, the presence of disturbance-indicator species, such as *Stipa tenacissima* L., signals ecosystem degradation and potential vulnerability to plant invasions, a factor that requires monitoring. This study not only enhances the scientific documentation of the region's flora but also provides a baseline for future biodiversity monitoring and conservation efforts in this ecologically important area.

The study reveals no significant difference in species richness (S.R.) between the Ouled Hanneche and Ouled Khelouf forests, suggesting minimal unobserved species. However, Ouled Hanneche exhibits greater biodiversity compared to Ouled Khelouf. Comparisons with other regions, such as Boussaada & Bensid'houm (2020), show that the diversity in these forests surpasses that of the Bordj Bou Arreridj region, which has a Shannon index (H) of 3.359, Simpson's index (1-D) of 0.9456, and Piélou's equitability index (J) of 0.8586, indicating high plant coverage and equitable species distribution. Similarly, Taibaoui et al. (2020) reported lower diversity levels in other vegetation units, with Shannon-Weaver index values ranging from 3.34 to 2.40 and Pielou index values of 0.55 and 0.39, while this study shows higher equitability.

The Biological spectrum, Hemicryptophytes dominate the forest ecosystem at 30%, followed by therophytes (25%), offers key insights into the prevailing environmental conditions. The proportion of Chamaephytes (15%) is a classic indicator of a Mediterranean climate with a pronounved dry season, but it can also signal ecosystem disturbance and overgrazing, as thes species complete their life cycle quickly to avoid summer drought and herbivory (Allen, 2014; Valerio et al., 2022). The proportion of Geophytes is (14%). Nanophanerophytes account for 10%, while microphanerophytes and mesophanerophytes are less represented, at 4% and 2%, respectively. The vegetation is predominantly herbaceous, with 45 species covering 60% of the area. Trees and shrubs collectively account for 15%, including five tree species and six shrub species. Chorological analysis highlights the Mediterranean element as the dominant biogeographical influence. Hermaphroditism is the most prevalent plant sexuality, observed in 52 species, followed by autogamous pollination in 49 species. Barochory (seed dispersal by gravity) is the dominant dissemination mechanism, accounting for 60% of the species.

The Bordj Ghedir study area exhibits significant plant cover in both forests, with high biodiversity indicated by ecological indices. In the Ouled Khelouf forest, the Shannon index (H) is 2.874, the Simpson index (1-D) is 0.92, and the Piélou equitability index (J) is 0.95, reflecting significant diversity. The Berger-Parker dominance index is 0.333, and diversity estimators Chao 1 and Chao 2 are 32.52 and 41.1, respectively. Similarly, the Ouled Hanneche forest shows even greater diversity, with a Shannon index (H) of 3.602, a Simpson index (1-D) of 0.97, and a Piélou equitability index (J) of 0.99.

The Berger-Parker dominance index is 0.14, and diversity estimators Chao 1 and Chao 2 are 38 and 38.06, respectively.

Despite this richness, the forests face significant threats from overgrazing, wildfires, and the cedar processionary caterpillar (*Thaumetopoea bonjeani*), which are reducing vegetation cover and accelerating degradation. The presence of *Stipa tenacissima* L. signals ecosystem degradation and advanced successional regression, particularly in the Ouled Khelouf forest, where it is more abundant.

Conservation efforts, such as those documented by Salemkour et al. (2017), demonstrate the potential for restoring floristic richness through resting practices. The study area hosts numerous medicinal species, including *Olea europaea* L., *Pistacia lentiscus* L., and *Rosmarinus officinalis* L., many of which are used in traditional medicine. Notably, *Ruscus aculeatus* was recorded for the first time in the Bordj Bou Arreridj region The first recorded presence of Ruscus aculeatus (Butcher's broom) in the Bordj Bou Arreridj region is a significant finding. This shade-tolerant, evergreen subshrub typically indicates well-preserved forest understories with stable microclimates (Bricca et al., 2021). Its discovery suggests the existence of small, ecologically mature refugia within these forests. Field observations also identified critical ecological factors, such as the presence of the Holm oak (*Quercus ilex*), including a notable specimen in Ouled Hanneche, and the Atlas cedar (*Cedrus atlantica*) at Zbire station.

To address these challenges, a comprehensive approach is needed, integrating on-the-ground conservation strategies with advanced decision-support tools. This includes preserving forest heritage by protecting ecological and cultural values, adopting sustainable silvicultural practices (e.g., selective harvesting and replanting) to enhance regeneration and resilience, and conducting targeted research to optimise medicinal plant use. Spatial decision-support systems, such as AHP models, are particularly effective for assessing forest resource sustainability (Pedro & Quinta-Nova, 2024), while remote sensing can directly inform these efforts by identifying priority protection zones, modelling regeneration scenarios, and quantifying extraction-conservation trade-offs (Belloula & Beghami, 2018; Moreira et al., 2025). Community education programmes can use GIS-based tools to visualise ecosystem vulnerabilities, and stricter enforcement of biodiversity regulations ensures a science-based, long-term balance in forest management.

CONCLUSION

This study provides a foundational assessment of the floristic diversity in the Bordj Ghedir forests, documenting 71 plant species from 32 families and 64 genera. The most significant results confirm the area's high ecological value, characterized by a strong Mediterranean influence with dominant families including *Asteraceae* and *Lamiaceae*. Key findings include a high diversity (Shannon index up to 3.602 in Ouled Hanneche) and equitable species distribution (Piélou index up to 0.99). The prevalence of hemicryptophytes (30%) and therophytes (25%) reflects adaptation to the local semi-arid climate. The first recorded presence of *Ruscus aculeatus* in the region and the identification of key tree species like *Quercus ilex* and *Cedrus atlantica* are also notable. However, this biodiversity is under threat from anthropogenic pressures such as overgrazing, wildfires, and forest pests.

By implementing these strategies such as sustainable forest management, fire prevention, invasive species control, and community engagement threats to biodiversity can be mitigated, ensuring the sustainable management of these forests.

To build on these findings, further research is recommended, including increasing the number of sampling stations and extending inventory periods. These efforts will deepen our knowledge of forest ecosystems and contribute to the development of more effective conservation strategies for this critical area, ensuring the preservation of this unique and biodiverse region for future generations. The findings emphasize the urgent need for integrated conservation strategies. Future efforts should focus on sustainable forest management, fire prevention, invasive species monitoring, and active community engagement.

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