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JUNIPER GROVES IN THE REGION OF TLEMCEN, WESTERN ALGERIA: BIOLOGICAL AND ECOLOGICAL ASPECTS

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Abstract

This study investigates the plant communities of *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* in the coastal region of Tlemcen. The low number of individuals reflects strong anthropogenic degradation at both sites. Factorial correspondence analysis identified five phytoecological groups: two at Rechgoune, assigned to the Oleo-Ceratonion alliance and the Pistacio-Rhamnetalia alaterni order, and three at Marsat Ben M'hidi, related to halo-psammophilous associations and sub-associations. The biological spectrum is dominated by therophytes (16-27 species), followed by chamaephytes (0-15), hemicryptophytes (3-9), geophytes (2), and phanerophytes (2-8). These results highlight the ecological diversity, evolutionary trends, and vulnerability of juniper formations in this coastal ecosystem.

Introduction

The family Cupressaceae comprises evergreen trees and shrubs with fibrous or scaly bark, persistent foliage, and unisexual cones. Among its genera, *Juniperus* L. is one of the most diverse, with over 70 taxa across the Northern Hemisphere, particularly in temperate and Mediterranean regions (Adams 2014). *Juniperus* species are ecologically important, providing food and shelter for wildlife, stabilizing soils, and supporting fragile ecosystems (Barbero *et al.* 1990, Quézel 2000). In Algeria, five *Juniperus* taxa are recorded (Maire 1952, Quézel and Santa 1962). *J. thurifera* L. and *J. sabina* L. are very rare, *J. communis* L. is rare, and *J. oxycedrus* L. and *J. phoenicea* L. face severe degradation from habitat loss, overgrazing, and urbanization (Médail and Quézel 1999, Benabid 2000). This study focuses on *J. phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*, key species in Mediterranean coastal dunes that stabilize sand, host diverse floristic communities, and maintain biodiversity (Cabezudo *et al*. 2009, Costa *et al*. 2012). Their populations along the Algerian coast have declined, and ecological data remain limited. While western Mediterranean studies have examined the phytosociology and conservation of *Juniperus* formations (Barbero *et al*. 1990, Quézel 2000, Costa *et al*. 2012), little is known about their biological spectrum and phytoecological groups in Algeria, especially in the Tlemcen coastal region. Recent work on nearby stations such as Rachgoune and Djebel Fellaoucen has provided complementary insights (Ghalem *et al*. 2022, Ghalem *et al*. 2023a). The objective of this study is to survey the plant communities associated with *J. phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*, to identify plant associations, alliances, and sub-associations, and to analyze their biological spectrum for assessing vegetation diversity and conservation status.

Materials and Methods

Study sites were selected based on the presence of *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa*. Two representative stations were chosen on the Tlemcen coast

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within the Traras Mountains: Rechgoune (Sifax) and Marsat Ben M'hidi (Fig. 1), both harboring populations of the target taxa and diverse associated vegetation. Field surveys used a mixed sampling approach (stratified and subjective) to capture plant community variability. Phytosociological relevés were conducted in ecologically homogeneous areas following Gounot (1961), Daget and Poissonet (1971), and Long (1974). Species were identified using *Flore de l'Algérie* (Quézel and Santa 1962) and the *Index synonymique et bibliographique de la flore d'Afrique du Nord.*

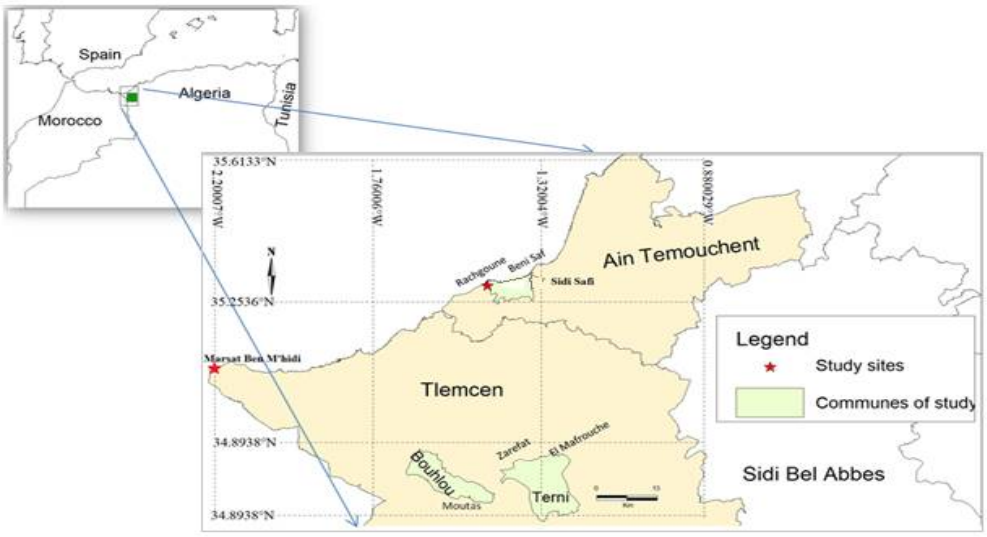

Fig. 1. Geographical location of study stations.

Relevé areas were set at a minimum of 100 m², in line with previous phytosociological studies on the western Algerian coast (Djebaili 1978, Bouazza and Benabadji 2002). Sampling plots were established where both target juniper subspecies were present.

Station descriptions

- Rechgoune (Sifax): Located in the Takembrit region, daïra of Oulhaça El Gheraba, wilaya of Aïn Témouchent, ~12 km southwest of Béni Saf.
- Marsat Ben M'hidi: Located in the commune of Marsat Ben M'hidi, wilaya of Tlemcen, NW Algeria (35°04′30″ N, 2°05′51″ W).

Results and Discussion

The analysis of species accompanying the genus *Juniperus* in the two studied stations revealed clear floristic and ecological structuring. At Rechgoune, two main groupings were identified. The first is dominated by *J. phoenicea* subsp. *turbinata*, *Cistus monspeliensis*, *Phagnalon saxatile*, *Scabiosa stellata*, and *J. oxycedrus* subsp. *macrocarpa*, corresponding to the alliance Juniperion phoeniceae (Rivas-Martínez 1975, 1987). The presence of *Myrtus communis* and *J. oxycedrus* subsp. *macrocarpa* suggests affinities with the association Myrto communis-*Juniperetum oxycedri* (Franquesa 1995), typical of thermo-Mediterranean and sub-maritime heliophilous matorral. The second grouping includes *J. phoenicea* subsp. *turbinata*, *J. oxycedrus* subsp. *macrocarpa*, *Thymus ciliatus*, *Teucrium polium*, *Phragmites communis*, *Retama*

monosperma, *Rhamnus alaternus*, *Euphorbia paralias* and *Chrysanthemum grandiflorum*. This floristic assemblage is related to *Juniperetum oxycedri* subsp. *macrocarpae* (Zohary and Orshan 1966) and Spartio juncei-*Juniperetum oxycedri* subsp. *macrocarpae* (Vagge and Biondi 1999). Biological spectra indicate the dominance of therophytes (20 species), followed by chamaephytes (14 species), hemicryptophytes and phanerophytes (8 each), and geophytes (2 species), showing the scheme TH >CH >HE = PH >GE for A1 and TH >CH >HE >PH >GE for B1. The presence of 14 chamaephytes, alongside 8 phanerophytes and 8 hemicryptophytes, suggests a relatively balanced ecological state favorable to the persistence and regeneration of *J. oxycedrus* subsp. *Macrocarpa (Fig. 2).*

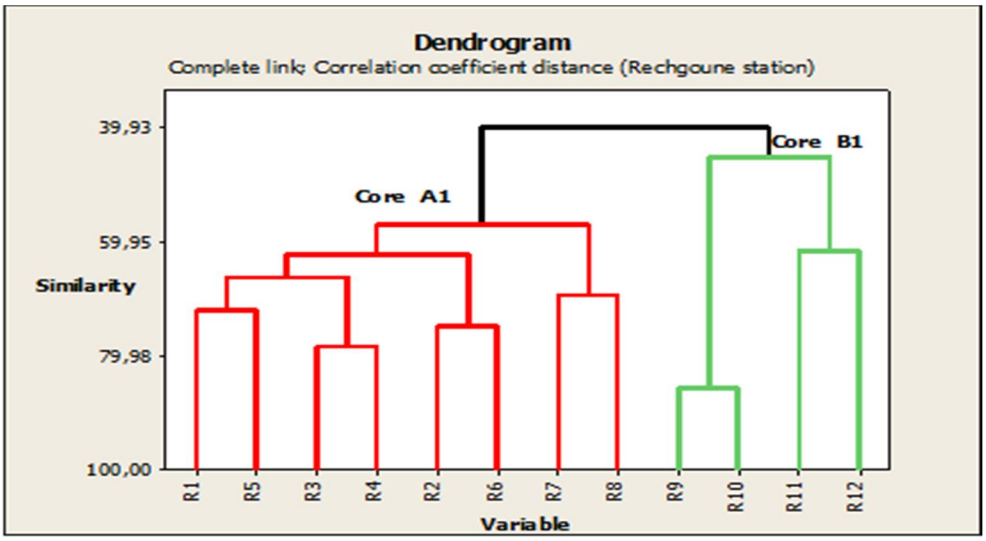

Fig. 2. Dendrogram of the Rechgoune station.

The dendrogram does not represent a direct finding of the study, but rather an analytical tool that integrates field survey data (species presence/absence and abundance) into a hierarchical classification. Using Minitab software, we combined field data with species occurrence to identify floristic groupings associated with *Juniperus phoenicea* and *J. oxycedrus*. The dendrogram allows the recognition of species clusters that co-occur with the target taxa, from which we calculated frequency and contribution values. These quantitative results form the basis for defining alliances, associations, and sub-associations, which were subsequently validated by field observations and phytosociological criteria.

At Marsat Ben M'hidi, the dendrogram distinguished three groupings. The first (A2) is characterized by species with 100% frequency and high contributions, including *Daucus carota* subsp. *gummifer*, *J. phoenicea* subsp. *turbinata*, *Lobularia maritima*, *Matthiola sinuata*, *Ononis variegata*, *Sedum acre* and *Stipa tortilis*. These species may belong to associations such as Sedo acris-Juniperetum phoeniceae, with sub-associations defined by *Lobularia maritima*, *Matthiola sinuata*, and *Ononis variegata*. The second grouping (B2) includes *Asteriscus maritimus*, *Atriplex halimus*, *Centaurea pullata*, *J. phoenicea* subsp. *turbinata*, *Lavatera maritima*, and *Thymus ciliatus*, which relate to Junipero phoeniceae-Asteriscetum maritimi and Atriplici halimi-Juniperetum phoeniceae. The third grouping (C2) comprises *J. phoenicea* subsp. *turbinata* together with *Dactylis glomerata*, *Fagonia cretica*, *Lagurus ovatus*, *Paronychia argentea*, *Pinus maritima*, and *Trifolium stellatum*, showing affinities with Dactylido glomeratae-Juniperetum

phoeniceae and Junipero phoeniceae-Paronychietum argenteae, and subdividing into several sub-associations such as *Fagonietosum creticae*, *Laguro ovati-Trifolietosum arvensis*, and *Fago creticae-Paronychietosum argenteae*.

At Rechgoune, two main groupings were identified.

- Core A1 is dominated by *Juniperus phoenicea* subsp. *turbinata*, *Cistus monspeliensis*, *Phagnalon saxatile*, *Scabiosa stellata*, and *Juniperus oxycedrus* subsp. *macrocarpa*. This assemblage corresponds to a thermo-Mediterranean, sub-maritime, heliophilous matorral. The biological spectrum shows the dominance of therophytes (20 species), followed by chamaephytes (14 species). Hemicryptophytes and phanerophytes are equally represented (8 each), while geophytes are scarce (2 species). The scheme for A1 is TH > CH > HE = PH > GE (Fig. 3).
- Core B1 includes *J. phoenicea* subsp. *turbinata*, *J. oxycedrus* subsp. *macrocarpa*, *Thymus ciliatus*, *Teucrium polium*, *Phragmites communis*, *Retama monosperma*, *Rhamnus alaternus*, *Euphorbia paralias*, and *Chrysanthemum grandiflorum*. The corresponding biological scheme is TH > CH > HE > PH > GE.

The high number of chamaephytes (14 species), combined with balanced proportions of phanerophytes and hemicryptophytes, suggests a relatively stable ecosystem that provides favorable conditions for the growth and regeneration of *J. oxycedrus* subsp. *macrocarpa*.

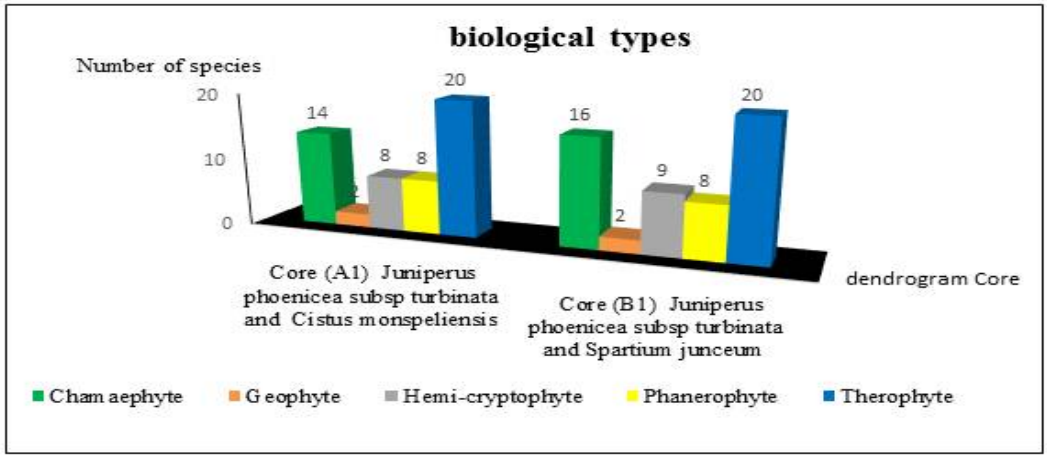

Fig. 3. Biological spectrum of plant communities associated with *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* in the coastal region of Tlemcen. (A) Rechgoune station: Core A1 (*J. phoenicea* subsp. *turbinata* - *Cistus monspeliensis*) and Core B1 (*J. phoenicea* subsp. *turbinata* – *Spartium junceum*). (B) Marsat Ben M'hidi station: biological spectra of the three cores (A2, B2, C2) showing differences in the relative abundance of therophytes, chamaephytes, hemicryptophytes, phanerophytes, and geophytes.

Table 1. Relative contribution of species and surveys in cores A1 and B1 (Rechgoune).

Core	Genus	Species	Axis 1	Frequency	Factor	Surveys
A1	*Juniperus*	*oxycedrus* subsp. *macrocarpa*	0.484	III	0.6514	R1
A1	*Juniperus*	*phoenicea* subsp. *turbinata*	2.701	V	0.7683	R2
A1	*Cistus*	*monspeliensis*	2.788	V	0.7664	R3
A1	*Cladanthus*	*arabicus*	2.181	V	0.6471	R4
A1	*Phagnalon*	*saxatile*	2.281	V	0.6288	R5

A1	*Scabiosa*	*stellata*	2.356	V	0.6903	R6
A1	*Pinus*	*pinaster* (= *maritima*)	1.844	IV	0.5762	R7
A1	-	-	-	-	0.4314	R8
B1	*Juniperus*	*oxycedrus* subsp. *macrocarpa*	0.484	III	0.1386	R9
B1	*Juniperus*	*phoenicea* subsp. *turbinata*	2.701	V	0.0139	R10
B1	*Thymus*	*ciliatus*	-0.749	V	-0.1373	R11
B1	*Teucrium*	*polium*	-0.899	V	0.2281	R12
B1	*Rhamnus*	*alaternus*	-0.207	V	-	-
B1	*Phragmites*	*australis* (= *communis*)	-0.757	V	-	-
B1	*Spartium*	*junceum*	-0.662	IV	-	-
B1	*Euphorbia*	*paralias*	-0.899	IV	-	-
B1	*Chrysanthemum*	*grandiflorum*	-0.899	IV	-	-

The table summarizes the taxa associated with *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* in cores A1 and B1. Contributions were obtained from field surveys and Minitab clustering, integrating frequency, axis contribution, and survey data.

Table 2 A2. Relative contribution of species and surveys in Group A2 (Marsat Ben M'hidi).

Genus species	Axis1	Frequency	Factor	Surveys
Juniperus phoenicea subsp *turbinate*	2.16379588534809	V	0.727447479491484	R1
Daucus carota subsp *gummifer*	1.79249332532757	V	0.756665210278268	R3
Lobularia maritima	2.59103736381054	V	0.622966696298929	R4
Matthiola sinuate	2.32835099373383	V		
Ononis variegate	2.32835099373383	V		
Sedum acre	3.09547743998009	V		
Stipa tortilis	2.1111922831516	V		

Table 2 B2. Relative contribution of species and surveys in Group B2 (Marsat Ben M'hidi).

Genus species	Axis1	Frequency	Factor	Surveys
Juniperus phoenicea subsp *turbinata*	2.16379588534809	V	0.555549713971213	R2
Juniperus oxycerdrus subsp *macrocarpa*	-0.466808683838038	II	-0.0386346069623614	R8
Asteriscu smaritimus	-2.31205235386893	V	0.442731911246375	R9
Atriplex halimus	-1.89744253851566	V	0.425437712178325	R10
Centaurea pullata	-2.01884648032412	V		
Lavatera maritima	-1.81957755600365	V		
Thymus ciliates	-1.94082139655432	V		

Table 2 C2. Relative contribution of species and surveys in Group C2 (Marsat Ben M'hidi).

Genus species	Axis1	Frequency	Factor	Surveys
Juniperus phoenicea subsp *turbinate*	2.16379588534809	V	-0.520752523782784	R5
Dactylis glomerate	-2.0887945976764	V	-0.29165703340144	R6
Fagonia cretica	-1.3356550539965	V	-0.186129895623112	R7
Lagurus ovatus	-1.3670726462333	V		
Paronychia argentea	-1.3356550539965	V		
Pinus maritima	-1.3670726462333	V		
Trifolium stellatum	-1.3670726462333	V		

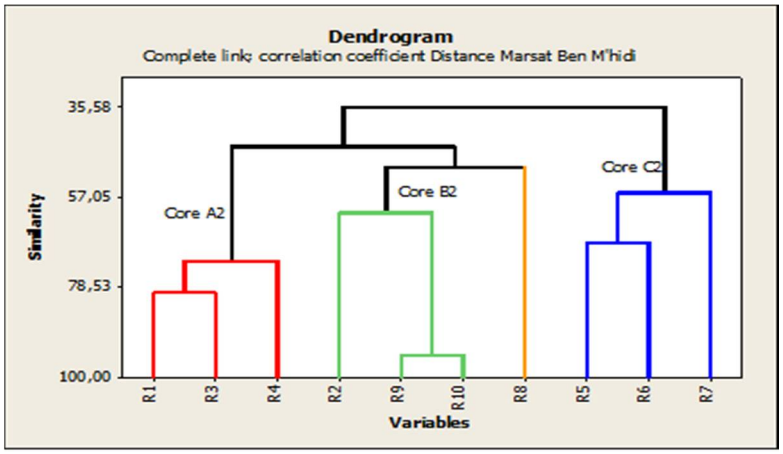

Fig. 4. Dendrogram of species co-occurrence at Marsat Ben M'hidi station, highlighting groups associated with *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus*. Clusters were derived from field survey data (presence/absence and abundance) using Minitab software and helped define floristic associations.

The biological spectra of Marsat Ben M'hidi reveal the dominance of therophytes across the three groupings, with notable differences: A2 is marked by the absence of chamaephytes and equal representation of geophytes and phanerophytes, B2 presents a balanced distribution of chamaephytes, hemicryptophytes and geophytes, while C2 shows a gradient TH >CH >HE >PH >GE. The absence of chamaephytes in A2 can be attributed to intense anthropogenic degradation, including sand extraction for construction and overgrazing, which have altered soil structure and reduced the capacity of *J. phoenicea* populations to regenerate. Previous studies (Quézel 1956, Daget and Poissonet 1964, Kadi-Hanifi 2003) indicate that therophytization represents a resistance strategy to harsh climatic conditions, while Barbero *et al.* (1990) noted that grazing and disturbance increase nitrate availability and favor ruderal species. Comparable patterns were also reported by Ghalem *et al.* (2022, 2023a) in the case of *Malva subovata* communities of northwestern Algeria.

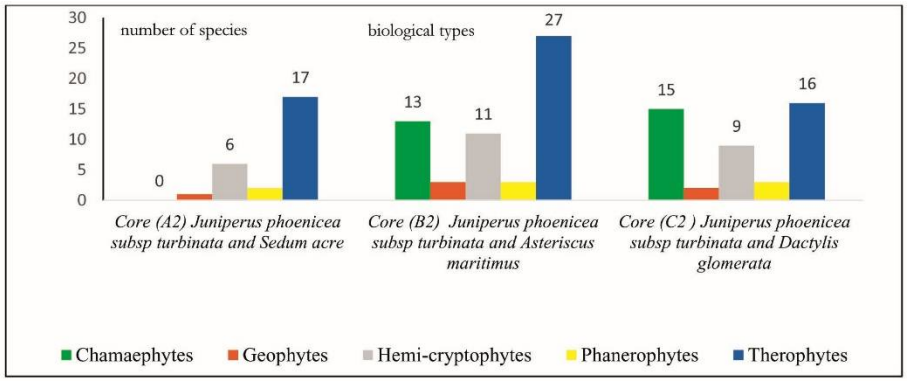

Fig. 5. Floristic clusters at Marsat Ben M'hidi station showing groups of species associated with *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus*, based on field survey data.

At Marsat Ben M'hidi, the dendrogram distinguished three main groupings.

- Core A2 includes *Daucus carota* subsp. *gummifer*, *Juniperus phoenicea* subsp. *turbinata*, *Lobularia maritima*, *Matthiola sinuata*, *Ononis variegata*, *Sedum acre*, and *Stipa tortilis*. This assemblage corresponds to several sub-associations, reflecting the influence of coastal and ruderal species. The biological spectrum shows TH > HE > PH > GE > CH = 0, with the absence of chamaephytes due to strong anthropogenic disturbance (sand extraction, overgrazing).
- Core B2 is characterized by *Asteriscus maritimus*, *Atriplex halimus*, *Centaurea pullata*, *J. phoenicea* subsp. *turbinata*, *Lavatera maritima*, and *Thymus ciliatus*. This group shows affinities with juniper–asteriscus and juniper–atriplex associations. The biological scheme is TH > CH > HE > GE = PH.
- Core C2 includes *J. phoenicea* subsp. *turbinata* with *Dactylis glomerata*, *Fagonia cretica*, *Lagurus ovatus*, *Paronychia argentea*, *Pinus maritima*, and *Trifolium stellatum*. The corresponding biological spectrum is TH > CH > HE > PH > GE.

Factorial correspondence analysis further illustrates the ecological differentiation of the two stations. *J. oxycedrus* subsp. *macrocarpa* thrives on relatively stable sandy soils with minimal marine intrusion, while seed dispersal by birds or gravity supports natural regeneration. At Rechgoune, juniper formations are linked to Asparago albi-Rhamnion oleoidis and Oleo-Ceratonion, whereas Marsat Ben M'hidi is characterized by halo-psammophilous assemblages with moderately halophilous species. Coastal limestone and cliff communities dominated by junipers occur in semi-arid to dry bioclimatic stages, within the order Pistacio lentisci-Rhamnetalia alaterni. Additional associations at Marsat Ben M'hidi include Chamaeropodo humilis-Juniperetum phoeniceae (Biondi *et al*. 2001) and Teucrio fruticantis-Juniperetum phoeniceae (Arrigoni *et al*. 1985).

Human pressures (logging, clearing, grazing, quarrying, and recurrent fires), together with climatic deterioration, threaten the stability of these juniper formations. The progressive replacement of pre-forest and forest communities by stress-tolerant taxa increases the risk of extinction of rare and endemic species.

The present study highlights the floristic richness and ecological specificity of *Juniperus phoenicea* subsp. *turbinata* and *J. oxycedrus* subsp. *macrocarpa* communities along the coastal region of Tlemcen. Both stations exhibit distinct patterns of association and biological spectra, with therophytes dominating as an adaptive response to environmental stress. However, strong anthropogenic pressures and climatic deterioration are accelerating the degradation of these fragile habitats. Effective conservation measures, including habitat protection, in situ regeneration, and restoration strategies, are urgently required to preserve these unique Mediterranean juniper ecosystems and ensure their long-term stability. This study is in line with recent efforts devoted to the systematics and conservation of Malva subovata in northwestern Algeria (Ghalem *et al*. 2023b), highlighting the urgent need for integrative strategies to preserve Mediterranean coastal biodiversity. The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

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