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Thriving green havens in baking deserts: Plant diversity and species composition of urban plantations in the Sahara Desert

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Abstract: Hot arid zones represent vital reservoirs of unique species and ecosystems, holding significant importance for biodiversity. This study aimed to explore the plant diversity associated with tree plantations in urban ecosystems under hyper-arid climatic conditions in the Sahara Desert of Algeria. In May 2022, 30 quadrats measuring 1 m^2 each were established at the base of *Phoenix dactylifera*, *Leucaena leucocephala*, and *Tamarix aphylla*, corresponding to the dominant tree species in each of three plantations. In each quadrat, the plant quantitative inventory was conducted to measure plant diversity and similarity among the studied plantations. Based on this, we assessed the plant functional traits and rarity/abundance status of the flora. The findings revealed a diverse flora associated with the studied plantations, comprising 29 plant species grouped into 27 genera and 12 families. Notably, Poaceae (accounting for 30.8% of the flora), Asteraceae (25.0%), and Zygophyllaceae (21.6%) were well-represented. With an overall density of approximately 555 individuals/m^2, *Zygophyllum album* (120 individuals/m^2) and *Polypogon monspeliensis* (87 individuals/m^2) emerged as the most abundant species. Functional trait analysis underscored the pivotal role of therophytes (constituting over 50.0% of the flora) and anemochorous species (33.0%–62.5%). Phytogeographic analysis emphasized the prevalence of the Saharo-Arabic element (constituting over 31.0% of the flora) and the Mediterranean Saharo-Arabic element (9.5%–21.5%). The Cosmopolitan element thrived under disturbance factors, recording percentages from 13.0% to 20.0% of the plant community. The rarity/abundance status of the flora emphasized the significance of rare, common, and very common species in the studied plantations. These findings could provide fundamental data for the effective control and management of biodiversity in hot hyper-arid urban ecosystems.

Keywords: urban plantations; plant diversity; plant functional traits; rarity/abundance status; Sahara Desert; Algeria

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1 Introduction

Arid and semi-arid areas encompass approximately one-third of the Earth's landmass and sustain a population of nearly one billion, frequently comprising some of the most economically

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disadvantaged individuals globally (FAO, 2019). Arid deserts collectively cover an expansive area of 75.0×10^6 km^2, constituting roughly 30.0% of the Earth's total land surface (Abd El-Ghani et al., 2017; Chenchouni and Neffar, 2025). The Sahara Desert, recognized as the largest hot arid desert globally, spans approximately 8.0×10^6 km^2, characterized by an annual precipitation of below 100 mm (Chenchouni et al., 2025). This extensive region exhibits a maximum north–south distance of 2000 km from Biskra in Algeria to Agadez in Niger and an east–west expanse of approximately 5500 km from Port Sudan in Sudan to Nouahhibou in Mauritania along the 20°N latitude (Le Houérou, 1990). Establishing a conducive local environment for human habitation in arid areas has evolved into a pivotal concern (Nilson et al., 2000). Additionally, plantations emerge as indispensable components of ecosystems in arid areas, playing a vital role in sustaining conditions conducive to human settlement, recreational activities, and nature exploration (Breuste et al., 2008).

Cities host a myriad of both intentionally planted and naturally occurring plant formations. These formations manifest in diverse entities such as parks, public gardens, private gardens, and street trees (Selmi, 2011; Mehdi et al., 2012; Itani et al., 2020) collectively identified as urban green spaces (Jo, 2002) or urban forests (Nowak et al., 2006). Urban forests play a pivotal role in delivering ecosystem services to human populations (MEA, 2005). These services encompass mitigating heat islands and atmospheric pollutants (Nowak et al., 2006) and reducing carbon dioxide levels through carbon sequestration (Green and Keenan, 2022). In the urban milieu, forests hold a central position in societal life, serving diverse functions in the realms of food, socio-cultural practices, agro-forestry, economics, and socio-ecology (Lessard and Boulfroy, 2008; Osseni et al., 2020). Moreover, forests offer essential habitats for associated biodiversity (Fuwape and Onyekwelu, 2011; Mouane et al., 2024). The multifaceted ecosystem benefits derived from urban forests significantly enhance the environmental quality of cities, thereby influencing the health and well-being of urban inhabitants (Jim and Chen, 2008; Escobedo et al., 2010; Young, 2010). However, urban forests face myriad pressures stemming from climatic conditions, soil composition, atmospheric factors, and disruptions caused by diverse human activities (Rejeb et al., 2003).

In recent decades, substantial endeavors have been undertaken to position urban forestry as a pivotal instrument for the conservation of plant resources and the sustainable development of urban ecosystems. However, in arid areas, particularly in Algeria, these initiatives have primarily centered around traditional reforestation practices and awareness-raising campaigns, often neglecting the complex factors influencing the survival prospects of planted trees (Osseni et al., 2014). Limited attention has been dedicated to the examination of urban green spaces in Algeria, as evidenced by scant scholarly contributions (Sakhraoui, 2021; Souddi and Bouallala, 2021, 2022; Bendiouis et al., 2022). Within the hot arid zones of Algeria, plantations serve diverse objectives, primarily aimed at enhancing the physical, physiological, and psychological well-being of the local population (Toth, 1965; Osseni et al., 2020; Souddi and Bouallala, 2022). These plantations encompass both indigenous species (*Balanites aegyptiaca*, *Nerium oleander*, *Olea europaea*, *Phoenix dactylifera*, *Leucaena leucocephala*, *Tamarix aphylla*, *Tamarix gallica*, etc.) and non-native species (*Acacia cyanophylla*, *Acacia famesiana*, *Parkinsonia aculeata*, *Elaeagnus angustifolia*, *Casuarina equisetifolia*, *Leucaena leucocephala*, *Moringa oleifera*, and *Dodonaea viscosa*), which are adept at thriving in the Saharan environment (Toth, 1965; Le Houérou, 1995; Souddi and Bouallala, 2021).

Presently, in the emerging field of plant ecology research within the hot arid zones of Algeria, the focus has predominantly been on exploring the plant diversity of urban green spaces (Souddi and Bouallala, 2021, 2022). Against this backdrop, our study endeavored to ascertain the plant diversity associated with a specific green space landscape in the hot arid zones of Algeria, specifically the linear plantations along road networks. Our primary objectives were to comprehensively explore the plant diversity of urban plantations in hot arid zones and to analyze the associated ecological dynamics. Specifically, we aimed to identify the dominant plant families and species within these plantations, examine the biological, morphological, and dispersal spectra, unravel the phytogeographic elements influencing the flora, and assess the rarity/abundance status of the flora. The findings can contribute to the understanding of urban green spaces in challenging climatic contexts, and offer insights into the complex relationships among flora, environmental factors, and human activities. Additionally, they will help unveil the patterns of adaptability and resilience exhibited by plant species in response to the unique challenges posed by hot arid environments. Our assumptions are rooted in the premise that plant communities in these zones are shaped not only by natural ecological processes but also by anthropogenic interventions, which can influence the sustainability and vitality of urban green spaces. By elucidating these aspects, we aimed to provide valuable knowledge for informed decision-making in the realms of urban planning, conservation, and ecological management.

2 Materials and methods

2.1 Study area

The investigation was conducted in the Adrar Province, precisely, the Fenoughil, Ouled Hadj Mamoun and Tamentit regions, situated in the southwestern part of Algeria. Geographically, it is bordered to the north by Aougrout District, to the south by Zaouiet Kounta District, and to the east by Aoulef District. The climate in the study area is classified as hyper-arid, characterized by frigid winters with an average minimum temperature not surpassing 5.4°C (most notably observed in January). In stark contrast, summers are intensely hot and arid, with temperatures soaring to a maximum of 46.2°C (predominantly experienced in July). Precipitation levels are exceedingly low, averaging only 9.7 mm annually (Souddi and Bouallala, 2021).

The soils in the study area are predominantly sandy and dry, and characterized by a coarse fraction (>40.0%). The texture is generally sandy or sandy loam. In general, Saharan soils are poorly developed, with undifferentiated horizons and low organic matter content, resulting in low plant diversity (Bouallala et al., 2020). The vegetation landscape in the study area comprises natural formations consisting of halophytic and hygrophilic groupings located in specific habitats such as sabkha and sandy-dry wadis. The spontaneous plant communities are mainly dominated by species including *Tamarix gallica*, *Salsola foetida*, *Imperata cylindrica*, *Phragmites communis*, *Calotropis procera*, and *Zygophyllum album* (Bouallala et al., 2020; Souddi and Bouallala, 2021).

2.2 Sampling method and sampled sites

The focus of this study encompasses alignment plantations situated along diverse road routes, featuring prominent species such as *Phoenix dactylifera*, *Leucaena leucocephala*, and *Tamarix aphylla* (Souddi and Bouallala, 2021). The studied plantations (*Phoenix dactylifera*, *Leucaena leucocephala*, and *Tamarix aphylla* plantations) are located along the National Highway No. 6 and secondary roads, officially designated for reforestation by local authorities each year. Localized irrigation is the method employed for watering the planted trees, with weekly watering being practiced. *Phoenix dactylifera* plantation was sampled in Fenoughil (27°36′28″N, 00°18′26″W), *Leucaena leucocephala* plantation in Ouled Hadj Mamoun (27°44′51″N, 00°13′53″W), and *Tamarix aphylla* plantation in Tamentit (27°45′30″N, 00°16′13″W). For each plantation, ten quadrats were selected along a vegetation belt of 5000 m long and 10 m wide (about 500 hm^2) at equidistant intervals. Each sampled quadrat (1 m×1 m) was positioned around the base of a tree. This standardized sampling area aligns with established practices in floristic studies conducted by El-Ghanim et al. (2010), Fandjinou et al. (2018), and Souddi and Bouallala (2022). A total of 30 quadrats were systematically sampled at the base of the principal alignment trees in the three plantations. Floristic surveys were conducted in May 2022 at the base of these specified trees, which are also called plant nurses for its role in restoring degraded arid lands in North Africa by enhancing plant community diversity and improving soil properties (Neffar et al., 2013). These nurse plants create microenvironments conducive to plant growth, stabilize soil, and improve fertility through organic matter accumulation and nutrient cycling (Neffar et al., 2015, 2018). Harnessing this concept in restoration efforts offers promise for combating desertification and fostering resilient ecosystems in arid regions like North Africa (Neffar et al., 2022).

2.3 Species identification

Species identification adhered to the guidelines delineated by Quézel and Santa (1962, 1963), and in the African Plant Database (version 4.0.0) (https://africanplantdatabase.ch/) and Tela Botanica (https://www.tela-botanica.org/) on the recent flora of Algeria and the southern desert regions. Within each quadrat, we made a meticulous recording of species names to form a comprehensive species list, and systematically determined the quantification of individuals per species.

2.4 Measurements of plant diversity

To ascertain the plant diversity associated with row plantations, we employed a comprehensive set of metrics, including specific richness, frequency of occurrence (Occ), density, similarity analysis, Shannon-Wiener index, equitability index, and other species diversity indices.

2.4.1 Species richness

Species richness (or genus richness) signifies the number of species (or genera) within a given region. This metric serves to analyze the taxonomic structure, allowing the discernment of spatial and temporal variations (Triplet, 2023). Percentages of genera and species per family were computed for each plantation and aggregated for the whole study area (all the three plantations).

2.4.2 Occ

The Occ (%) for a particular species is determined as the ratio of the number of records (k) where the species was present to the total records (K) in the ten quadrats for each plantation (Faurie et al., 2003):

$$\text{Occ} = k / K \times 100\% . \tag{1}$$

Plant species were classified into five occurrence classes (Bensizerara et al., 2013): Class I is very rare species with Occ<20.0%; Class II is rare species with Occ varying from 20.0% to 40.0%; Class III is frequent species with Occ varying from 40.0% to 60.0%; Class IV is abundant species with Occ varying from 60.0%–80.0%; and Class V is very abundant and constant species with Occ>80.0%.

2.4.3 Species density

Species density (individuals/m^2), expressed as the abundance of a plant population per unit area, is crucial for gauging the impact of plant individuals on the environment (Triplet, 2023).

2.4.4 Similarity analysis

Using the EstimateS version 9.1 software (Colwell, 2013), various indices were employed to assess the species similarity between different plantations, including Classic Jaccard index, Classic Sørensen index, Raw Chao-Jaccard index, Estimated Chao-Jaccard index, Raw Chao-Sørensen index, Estimated Chao-Sørensen index, Morisita-Horn index, and Bray-Curtis index.

2.4.5 Shannon-Wiener index

The widely utilized Shannon-Wiener index is computed from quantitative or semi-quantitative vegetation data. A higher index value corresponds to higher diversity (Observatory Network for Long-Term Ecological Monitoring (Roselt/OSS), 2008). The formula is as follows:

$$H' = -\sum_{i=1}^{S}\left(\frac{n_i}{\sum n_i} \times \log_2 \frac{n_i}{\sum n_i}\right), \tag{2}$$

where H' is the Shannon-Wiener index; S is the total number of species; and n_i is the number of individuals of species i.

2.4.6 Equitability index

Equitability index can be calculated using the ratio between the Shannon-Wiener index and the maximum diversity. It is high when all species are well represented (Roselt/OSS, 2008). The formulas are as follows:

$$E = \frac{H'}{H_{max}}, \tag{3}$$

$$H_{max} = \log_2 S, \tag{4}$$

where E is the equitability index; and H_{max} is the maximum diversity.

2.4.7 Other species diversity indices

In addition, species diversity was estimated using a panoply of indices, including Chao-1 index, Simpson's diversity index, Brillouin index, Margalef index, and Berger-Parker index. The formulas are as follows:

$$\text{Chao-1} = S + \frac{F_1^2}{2F_2}, \tag{5}$$

$$1 - D = 1 - \sum_{i=1}^{S} \left(\frac{n_i(n_i - 1)}{N(N-1)} \right), \tag{6}$$

$$H_B = \frac{1}{N} \ln \left(\frac{N!}{\Pi_{i=1}^{S} n_i!} \right), \tag{7}$$

$$D_M = \frac{S-1}{\ln(N)}, \tag{8}$$

$$d = \frac{N_{max}}{N}, \tag{9}$$

where Chao-1 is the Chao-1 index; F_1 is the number of singletons (species represented by only one individual in the samples); F_2 is the number of doubletons (species represented by exactly two individuals in the samples); $1–D$ is the Simpson's diversity index; N is the total number of individuals of all species; H_B is the Brillouin index; D_M is the Margalef index; d is the Berger-Parker index; and N_{max} is the number of individuals for the most abundant species.

2.5 Plant functional traits

2.5.1 Raunkiaer life forms

The concept of biological spectra, pioneered by Raunkiaer in 1907 (Raunkiaer, 1934), was employed to encapsulate the proportions of each biological type within the flora of each plantation. The determination of biological types was grounded in the meticulous work of Quézel (1965) and Tela Botanica. The raw and real biological spectra were established for each plantation and the whole study area (all three plantations). Note that the raw spectra were determined based on the percentages of species, while the real spectra used the percentages of individuals for all plant functional traits.

2.5.2 Morphological types

Morphological types that can be used to distinguish annual and perennial classifications were identified following the frameworks outlined by Quézel and Santa (1962, 1963), Ozenda (2004), and Tela Botanica. The raw and real morphological spectra were compiled for each plantation type and the whole study area.

2.5.3 Dispersal types

Utilizing the classification proposed by van der Pijl (1982), plants were categorized into five primary dispersal categories: anemochory, autochory, barochory, hydrochory, and zoochory. The identification of dispersal types drew upon following Vela (2002), Jauffret (2001), Quézel and Santa (1962, 1963), Bouallala et al. (2020), Azizi et al. (2021), and Tela Botanica. The raw and real dispersal spectra were delineated for each plantation and the whole study area.

2.5.4 Phytogeographic (chorological) types

The determination of chorological types for recorded species was adhered to the methodologies outlined by Quézel and Santa (1962, 1963), Quézel (1965), Bouallala et al. (2020), and Tela Botanica. Both raw and real phytogeographic spectra were constructed for each plantation and the whole study area.

2.6 Rarity/abundance status of the flora

The assessment of abundance was conducted in accordance with the criteria for the new flora of Algeria and the southern desert regions established by Quézel and Santa (1962, 1963). Abundance categories included fairly common, common, very common, particularly widespread, quite rare, rare, very rare, and extremely rare. Both raw and real rarity/abundance spectra were developed for each plantation and the whole study area.

3 Results

3.1 Plant community composition and structure of the three urban plantations

Table 1 shows that the study area harbored 29 species across 27 genera, distributed among 12 botanical families. Examining different plantations revealed varying percentages of genera and species within families (Table 2). The *Phoenix dactylifera* plantation emerged as the most species-rich, featuring 24 species, 22 genera, and 8 families. Following closely, the *Leucaena leucocephala* plantation exhibited 19 species, 18 genera, and 10 families, while the *Tamarix aphylla* plantation lagged behind with 15 species, 14 genera, and 9 families. The most frequently occurring species were *Zygophyllum album*, *Bassia muricata*, and *Launaea nudicaulis*, boasting Occ of 66.7% (Class IV), 56.7% (Class III), and 53.3% (Class III), respectively. The total number of individuals approximated 555, with Poaceae, Asteraceae, and Zygophyllaceae contributing significantly, accounting for 171 individuals (30.8%), 139 individuals (25.0%), and 120 individuals (21.6%), respectively (Table 1).

Species densities across different plantations were comparable, with the maximum observed in the *Tamarix aphylla* plantation, totaling 189 individuals/m^2. *Zygophyllum album* exhibited the highest density (120 individuals/m^2), reaching its peak in the *Leucaena leucocephala* plantation (62 individuals/m^2) and a minimum in other plantations (40 individuals/m^2 for each). In the second position, *Polypogon monspeliensis* recorded 87 individuals/m^2, peaking in the *Tamarix aphylla* plantation (40 individuals/m^2) and reaching its minimum in the *Leucaena leucocephala* plantation (17 individuals/m^2). Species with the lowest density included *Anagallis arvensis*, *Colocynthis vulgaris*, *Cynanchum acutum*, *Euphorbia granulata*, and *Phalaris minor*, each with a single individual (Table 1). Additionally, *Aster squamatus*, *Launaea resedifolia*, and *Merremia dissecta* each had a density of 2 individuals/m^2.

3.2 Species richness partitioning in the three urban plantations

Figure 1 shows the partitioning of plant species richness in the *Phoenix dactylifera*, *Leucaena leucocephala*, and *Tamarix aphylla* plantations. Within these plantations, specific species were observed in communal arrangements, signifying their omnipresence (*Bassia muricata*, *Polypogon monspeliensis*, *Lolium multiflorum*, *Heliotropium bacciferum*, *Launaea nudicaulis*, *Chenopodium mural*, *Calotropis procera*, *Zygophyllum album*, *Sonchus oleraceus*, and *Launaea glomerata*). However, certain species were exclusive, meaning they were found solely in one type of plantation. In the *Tamarix aphylla* plantation, the exclusive species was *Anagallis arvensis*. The *Leucaena leucocephala* plantation featured two exclusive species: *Phalaris minor* and *Colocynthis vulgaris*. The *Phoenix dactylifera* plantation boasted seven exclusive species: *Cynanchum acutum*, *Senecio massaicus*, *Salsola foetida*, *Cynodon dactylon*, *Imperata cylindrica*, *Launaea resedifolia*, and *Euphorbia granulata.* Five species were shared between the *Leucaena leucocephala* and *Phoenix dactylifera* plantations (*Aster squamatus*, *Cutandia dichotoma*, *Phragmites australis*, *Merremia dissecta*, and *Pergularia tomentosa*). Two species were identified

Table 1 Plant density, plant functional traits, and rarity/abundance status of plant species associated to the three urban plantations in the Sahara Desert of Algeria

Family	Species	*n*	LF	MT	DT	CT	AA	Occ (%)	Class Occ	Plantations
Amaranthaceae	*Bassia muricata*	56	Ther	Annual	Zoo	M-SA	C	56.7	III	*Lle+Pda+Tap*
	Chenopodium murale	17	Ther	Annual	Baro	Cosm	R	16.7	I	*Lle+Pda+Tap*
	Salsola foetida	2	Cham	Perennial	Anemo	SA	R	3.3	I	*Pda*
Apocynaceae	*Calotropis procera*	18	Phan	Perennial	Anemo	Tr-SA	R	36.7	II	*Lle+Pda+Tap*
	Cynanchum acutum	1	Hemi	Perennial	Anemo	M-As	RR	3.3	I	*Pda*
	Pergularia tomentosa	5	Cham	Perennial	Anemo	SA	CC	13.3	I	*Lle+Pda*
Asteraceae	*Aster squamatus*	2	Ther	Annual	Anemo	S-Am	C	6.7	I	*Lle+Pda*
	Lactuca serriola	14	Ther	Annual	Anemo	PTm	AC	20.0	I	*Pda+Tap*
	Launaea glomerata	16	Ther	Annual	Anemo	M-SA	RR	30.0	II	*Lle+Pda+Tap*
	Launaea nudicaulis	51	Ther	Annual	Anemo	SA	CC	53.3	III	*Lle+Pda+Tap*
	Launaea resedifolia	2	Ther	Annual	Anemo	M-SA	CC	3.3	I	*Pda*
	Pulicaria arabica	15	Hemi	Perennial	Anemo	SA	AC	10.0	I	*Pda+Tap*
	Senecio massaicus	7	Ther	Annual	Anemo	SA	R	3.3	I	*Pda*
	Sonchus oleraceus	32	Ther	Annual	Anemo	Cosm	CCC	36.7	II	*Lle+Pda+Tap*
Convovulaceae	*Merremia dissecta*	2	Ther	Annual	Anthropo	Tr-Am	-	6.7	I	*Lle+Pda*
Cucurbitaceae	*Colocynthis vulgaris*	1	Ther	Annual	Anemo	M-SA	CC	3.3	I	*Lle*
Euphorbiaceae	*Euphorbia granulate*	1	Ther	Annual	Baro	SA	C	3.3	I	*Pda*
Heliotropiaceae	*Heliotropium bacciferum*	7	Cham	Perennial	Baro	SA	CC	16.7	I	*Lle+Pda+Tap*
Orobanchaceae	*Cistanche phelypaea*	6	Ther	Annual	Anemo	M-SA	C	6.7	I	*Lle+Tap*
Poaceae	*Cutandia dichotoma*	9	Ther	Annual	Anemo	M	C	16.7	I	*Lle+Pda*
	Cynodon dactylon	5	Hemi	Perennial	Baro	Cosm	CCC	3.3	I	*Pda*
	Imperata cylindrica	20	Hemi	Perennial	Anemo	Tr-M-SA	AC	3.3	I	*Pda*
	Lolium multiflorum	29	Ther	Annual	Baro	M	CC	33.3	II	*Lle+Pda+Tap*
	Phalaris minor	1	Ther	Annual	Zoo	PSTr	AR	3.3	I	*Lle*
	Phragmites australis	20	Hemi	Perennial	Anemo	Cosm	C	16.7	I	*Lle+Pda*
	Polypogon monspeliensis	87	Ther	Annual	Zoo	PSTr	CC	36.7	II	*Lle+Pda+Tap*
Primulaceae	*Anagallis arvensis*	1	Ther	Annual	Anemo	Cosm	R	3.3	I	*Tap*
Resedaceae	*Randonia africana*	8	Cham	Perennial	Baro	SA	R	16.7	I	*Lle+Tap*
Zygophyllaceae	*Zygophyllum album*	120	Cham	Perennial	Baro	SA	C	66.7	IV	*Lle+Pda+Tap*

Note: *n*, the number of individuals of a species; LF, life form; Ther, therophyte; Cham, chamaephyte; Phan, phanerophyte; Hemi, hemicryptophytes; MT, morphological type; DT, dispersal type; Zoo, zoochore; Baro, barochore; Anemo, anemochore; Anthropo, anthropochore; CT, chorological type; M-SA, Mediterranean Saharo-Arabian; Cosm, Cosmopolitan; SA, Saharo-Arabian; Tr-SA, Tropico-Saharo-Arabian; M-As, Mediterrano-Asian; S-Am, South American; PTm, Paleo-temperate; Tr-Am, Tropico-American; M, Mediterranean; Tr-M-SA, Tropico-Mediterranean Saharo-Arabian; PSTr, Paleo-subtropical; AA, abundance appraisal; C, common; R, rare; RR, very rare; CC, very common; AC, fairly common; CCC, particularly widespread; AR, quite rare; Occ, frequency of occurrence; Class Occ, the class for the frequency of occurrence. Class I is very rare species with Occ<20.0%; Class II is rare species with Occ varying from 20.0% to 40.0%; Class III is frequent species with Occ varying from 40.0% to 60.0%; Class IV is abundant species with Occ varying from 60.0%–80.0%. *Pda*, *Phoenix dactylifera*; *Lle*, *Leucaena leucocephala*; *Tap*, *Tamarix aphylla*. "-" means no category.

between the *Phoenix dactylifera* and *Tamarix aphylla* plantations (*Lactuca serriola* and *Pulicaria arabica*). Lastly, two species were found between the *Leucaena leucocephala* and *Tamarix aphylla* plantations (*Cistanche phelypaea* and *Randonia africana*).

Table 2 Genus richness and species richness for different plant families identified in the three urban plantations in the Sahara Desert of Algeria

Family	*Pda* plantation		*Lle* plantation		*Tap* plantation		Overall	
	Genus richness	Species richness	Genus richness	Species richness	Genus richness	Species richness	Genus richness	Species richness
Amaranthaceae	3 (13.6%)	3 (12.5%)	2 (11.1%)	2 (10.5%)	2 (14.3%)	2 (13.3%)	3 (11.1%)	3 (10.3%)
Apocynaceae	3 (13.6%)	3 (12.5%)	2 (11.1%)	2 (10.5%)	1 (7.1%)	1 (6.7%)	3 (11.1%)	3 (10.3%)
Asteraceae	6 (27.3%)	8 (33.3%)	3 (16.7%)	4 (21.1%)	4 (28.6%)	5 (33.3%)	6 (22.2%)	8 (27.6%)
Convovulaceae	1 (4.5%)	1 (4.2%)	1 (5.6%)	1 (5.3%)	-	-	1 (3.7%)	1 (3.4%)
Cucurbitaceae	-	-	1 (5.6%)	1 (5.3%)	-	-	1 (3.7%)	1 (3.4%)
Euphorbiaceae	1 (4.5%)	1 (4.2%)	-	-	-	-	1 (3.7%)	1 (3.4%)
Heliotropiaceae	1 (4.5%)	1 (4.2%)	1 (5.6%)	1 (5.3%)	1 (7.1%)	1 (6.7%)	1 (3.7%)	1 (3.4%)
Orobanchaceae	-	-	1 (5.6%)	1 (5.3%)	1 (7.1%)	1 (6.7%)	1 (3.7%)	1 (3.4%)
Poaceae	6 (27.3%)	6 (25.0%)	5 (27.8%)	5 (26.3%)	2 (14.3%)	2 (13.3%)	7 (25.9%)	7 (24.1%)
Primulaceae	-	-	-	-	1 (7.1%)	1 (6.7%)	1 (3.7%)	1 (3.4%)
Resedaceae	-	-	1 (5.6%)	1 (5.3%)	1 (7.1%)	1 (6.7%)	1 (3.7%)	1 (3.4%)
Zygophyllaceae	1 (4.5%)	1 (4.2%)	1 (5.6%)	1 (5.3%)	1 (7.1%)	1 (6.7%)	1 (3.7%)	1 (3.4%)
Total	22 (100.0%)	24 (100.0%)	18 (100.0%)	19 (100.0%)	14 (100.0%)	15 (100.0%)	27 (100.0%)	29 (100.0%)

Note: "-" means no value. The values in parentheses are the corresponding percentages.

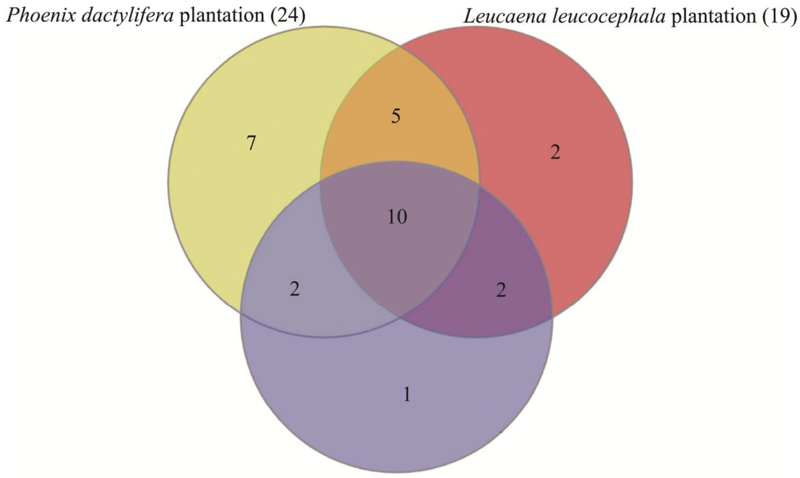

Fig. 1 Venn diagram illustrating the partitioning of plant species richness in the three urban plantations in the Sahara Desert of Algeria

3.3 Similarity analysis of plant community composition among the three urban plantations

The similarity analysis based on various indices revealed that the optimal values of similarity between *Leucaena leucocephala* and *Phoenix dactylifera* plantations were computed using the following indices: Estimated Chao-Sørensen index (84.4%) and Raw Chao-Sørensen index (82.7%) (Table 3). Similarly, the highest values of similarity between *Leucaena leucocephala* and *Tamarix aphylla* plantations were determined by the following indices: Estimated Chao-Sørensen index (90.9%) and Raw Chao-Sørensen index (90.2%). Likewise, the most favorable values of similarity between *Phoenix dactylifera* and *Tamarix aphylla* plantations were calculated using the following indices: Estimated Chao-Sørensen index (79.5%) and Raw Chao-Sørensen index (79.2%).

Table 3 Qualitative and quantitative similarity estimates of plant community composition between each two urban plantations in the Sahara Desert of Algeria

Estimate index	*Lle–Pda* plantations	*Lle–Tap* plantations	*Pda–Tap* plantations
Number of shared species observed in the two plantations	15	12	12
Estimated number of Chao-shared species	18.5	12.3	12.1
Classic Jaccard index (%)	53.6	54.5	44.4
Classic Sørensen index (%)	69.8	70.6	61.5
Raw Chao-Jaccard index (%)	70.5	82.2	65.6
Estimated Chao-Jaccard index (%)	73.0	83.2	66.0
Raw Chao-Sørensen index (%)	82.7	90.2	79.2
Estimated Chao-Sørensen index (%)	84.4	90.9	79.5
Morisita-Horn index (%)	73.1	78.1	79.0
Bray-Curtis index (%)	59.0	63.8	61.5

3.4 Plant diversity analysis of the three urban plantations

The assessment of plant diversity in each plantation (Table 4) revealed that various plantations exhibited similar Shannon-Wiener index values (ranging from 2.26 to 2.73) and equitability index values (ranging from 0.77 to 0.87). The *Phoenix dactylifera* plantation recorded the highest value of Shannon-Wiener index (2.73). In contrast, the *Leucaena leucocephala* plantation registered the lowest value of Shannon-Wiener index (2.26) and equitability index (0.77).

Table 4 Plant diversity indices of plant communities associated with the three urban plantations in the Sahara Desert of Algeria

Diversity index	*Pda* plantation	*Lle* plantation	*Tap* plantation
Species richness	24	19	15
Shannon-Wiener index	2.73	2.26	2.35
Equitability index	0.86	0.77	0.87
Chao-1 index	29	24	15
Simpson's diversity index	0.91	0.84	0.88
Brillouin index	2.52	2.10	2.21
Margalef index	4.41	3.46	2.67
Berger-Parker index	0.16	0.34	0.21

3.5 Plant functional traits of the three urban plantations

Across all plantations and at the whole study area level, therophytes emerged as the most prominently represented biological type, surpassing 53.0% in both raw and real spectra (Fig. 2a). Notably, the *Phoenix dactylifera* plantation exhibited the highest percentages of hemicryptophytes in both raw and real spectra, exceeding 20.8% compared to other types. Chamaephytes secured the second position in the *Leucaena leucocephala* and *Tamarix aphylla* plantations and at the whole study area level, with values exceeding 17.2% in raw spectra and exceeding 20.0% in real spectra. Phanerophytes, on the other hand, displayed percentages not exceeding 6.7% in both raw and real spectra across all plantations and at the whole study area level.

Both raw and real morphological spectra across all plantations and at the whole study area level underscored the prevalence of annuals over perennials, with values surpassing 53.0% (Fig. 2b). The highest percentages of annuals were observed in the *Tamarix aphylla* plantation with 73.5% and 66.7% for the real and raw spectra, respectively. The perennials scored the highest percentages in the real spectra of the *Phoenix dactylifera* plantation with 41.7%, and had the highest percentages in the real spectra of the *Leucaena leucocephala* plantation with 47.0%.

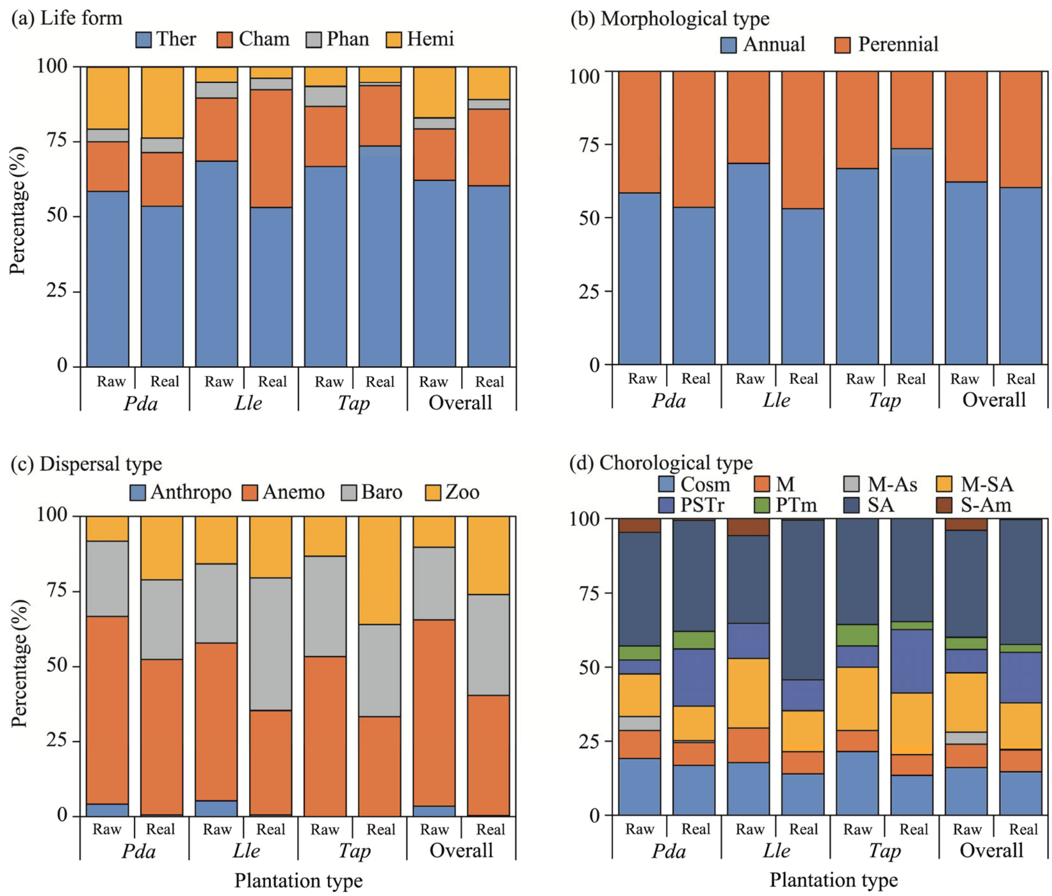

Fig. 2 Distribution of different life forms (a), morphological types (b), dispersal types (c), and chorological types (d) identified in the three urban plantations in the Sahara Desert of Algeria in both raw and real spectra. *Pda*, *Phoenix dactylifera*; *Lle*, *Leucaena leucocephala*; *Tap*, *Tamarix aphylla*. Ther, therophyte; Cham, chamaephyte; Phan, phanerophyte; Hemi, hemicryptophytes; Anthropo, anthropochore; Anemo, anemochore; Baro, barochore; Zoo, zoochore; Cosm, Cosmopolitan; Med, Mediterranean; M-As, Mediterrano-Asian; M-SA, Mediterranean Saharo-Arabian; PSTr, Paleo-subtropical; PTm, Paleo-temperate; SA, Saharo-Arabian; S-Am, South American.

Dispersal spectra results indicated a predominance of anemochorous species in the raw spectra across all plantations and at the whole study area level (Fig. 2c). In the real spectra of the *Phoenix dactylifera* plantation and at the whole study area level, anemochorous species exhibited percentages between 33.3% and 52.6%. Notably, the *Leucaena leucocephala* plantation showcased more than 44.2% of barochorous species, while the *Tamarix aphylla* plantation recorded over 36.0% of zoochorous species. Anthropochorous species had minimal representation, confined to the *Leucaena leucocephala* and *Phoenix dactylifera* plantations.

The studied flora underscored a substantial presence of the Saharo-Arabic element (Fig. 2d) across all plantations with percentages ranging from 26.3% to 51.4%. The Mediterranean Saharo-Arabic element secured the second position in both raw (17.2%) and real (14.6%) spectra at the whole study area level. This element maintained the same position in the raw and real spectra of the *Leucaena leucocephala* and *Tamarix aphylla* plantations. In the third position, the Cosmopolitan element exhibited percentages of 13.8% and 13.5% in the raw and real spectra, respectively, at the whole study area level. Across different plantations, this element exceeded 15.5% in the real spectra and surpassed 13.2% in the raw spectra. However, aside from the Paleo-subtropical element, which recorded percentages between 9.9% and 21.5% in all real spectra, other phytogeographic elements exhibited minimal representation. Notably, the Mediterranean-Asian and Tropico-Mediterranean Saharo-Arabian elements were absent in the

Leucaena leucocephala and *Tamarix aphylla* plantations. Similarly, the Tropical-America and South-America elements were absent in the *Tamarix aphylla* plantation, and the Paleo-temperate element was absent in the *Leucaena leucocephala* plantation.

3.6 Rarity/abundance status of the flora

The obtained results revealed the presence of seven abundance categories (fairly common, common, very common, particularly widespread, fairly rare, rare, and very rare) (Table 1; Fig. 3). All raw spectra exhibited elevated values for the categories: rare (16.7%–26.7%), common (20.0%–33.3%), and very common (25.0%–33.3%). The real spectra also demonstrated robust representation in the categories: common (31.0%–52.8%) and very common (29.4%–38.6%). Rare species included *Chenopodium mural*, *Salsola foetida*, *Calotropis procera*, *Senecio massaicus*, *Anagallis arvensis*, and *Randonia africana*. Common species encompassed *Bassia muricata*, *Aster squamatus*, *Euphorbia granulata*, *Cistanche phelypaea*, *Cutandia dichotoma*, *Phragmites australis*, and *Zygophyllum album*. Very common species consisted of *Pergularia tomentosa*, *Launaea nudicaulis*, *Launaea resedifolia*, *Colocynthis vulgaris*, *Heliotropium bacciferum*, *Lolium multiflorum*, and *Polypogon monspeliensis*. The remaining categories had limited representation. Notably, fairly common species were absent in the *Leucaena leucocephala* plantation, and quite rare species were absent in both the *Phoenix dactylifera* and *Tamarix aphylla* plantations.

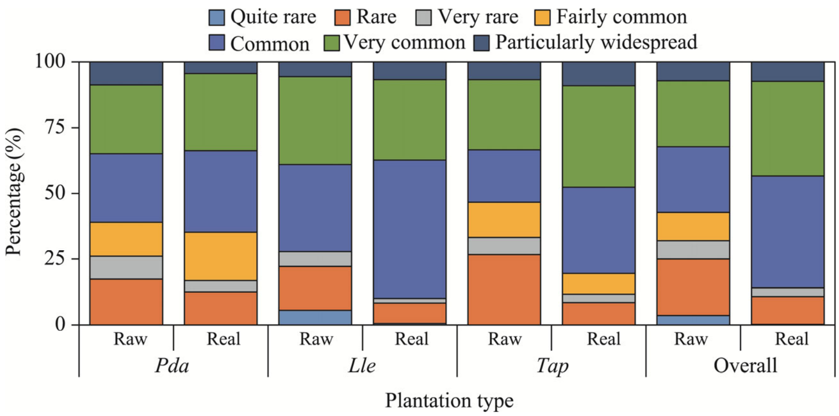

Fig. 3 Rarity/abundance status of the flora in the three urban plantations in the Sahara Desert of Algeria in both raw and real spectra

3.7 Interrelationships between plant functional traits, rarity/abundance status, and occurrence classes of the three urban plantations

The dominance of therophytes (60.2%) followed by chameaphytes (25.6%) was evident across all plantations. While therophytes were predominantly annuals, chameaphytes, hemicryptophytes, and phanerophytes were identified as perennials, which exhibited percentages of 73.2%, 17.2%, and 9.6%, respectively. In terms of dispersal types, perennials were categorized as either barochores (71.9%) or anemochores (28.1%), whereas annuals were predominantly zoochores (45.8%), followed by anemochores (39.1%) and barochores (14.7%). The predominant chorological types included the Saharo-Arabian element, comprising 66.3% of barochores and 33.7% of anemochores; the Paleo-subtropical was characterized as zoochoric; the Mediterranean Saharo-Arabian encompassed 73.1% of zoochores and 26.9% of anemochores; the Cosmopolitan species were represented by 71.0% of anemochores and 29.0% of barochores. Regarding rarity/abundance status, 39.9% of the inventoried plants with Saharo-Arabian chorology were identified as either common (60.2%) or very common (30.7%) in the Algerian flora. Particularly widespread species were entirely Cosmopolitan species. Very rare species originated largely from a Mediterranean Saharo-Arabian background (98.0%), while rare species had Tropico-Saharo-Arabian (41.2%), Cosmopolitan (39.7%), and Saharo-Arabian (19.1%) phytogeographical origins.

Concerning the Occ, very rare and rare species within the Algerian flora displayed low prevalence in the community (Fig. 4).

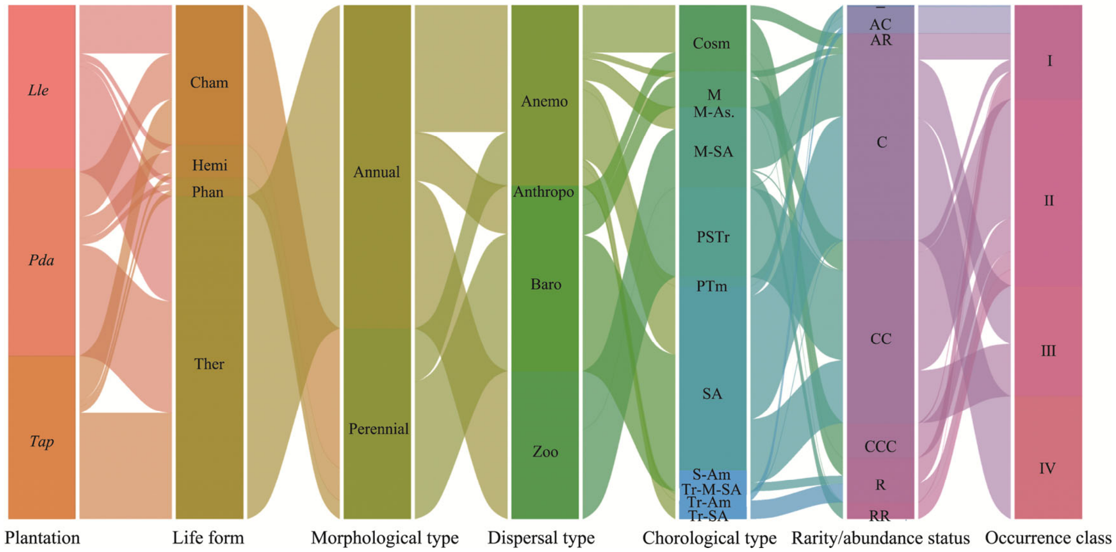

Fig. 4 Alluvial diagram displaying the distribution of life forms, morphological types, dispersal types, chorological types, rarity/abundance status, and occurrence classes of the three urban plantations in the Sahara Desert of Algeria. Tr-M-SA, Tropico-Mediterranean Saharo-Arabian; Tr-Am, Tropico-American; Tr-SA, Tropico-Saharo-Arabian; AR, quite rare; R, rare; RR, very rare; AC, fairly common; C, common; CC, very common; CCC, particularly widespread. Class I is very rare species with frequency of occurrence<20.0%; Class II is rare species with frequency of occurrence varying from 20.0% to 40.0%; Class III is frequent species with frequency of occurrence varying from 40.0% to 60.0%; Class IV is abundant species with frequency of occurrence varying from 60.0%–80.0%.

4 Discussion

In the exploration of plant diversity within urban plantations of hot arid zones, our study underscored the substantial contributions of Poaceae, Asteraceae, and Zygophyllaceae. The prevalence of Poaceae and Asteraceae aligns with prior research on the floristic biodiversity of the Algerian Sahara (Bradai et al., 2015; Bouallala et al., 2020, 2022; Azizi et al., 2021). The prevalence of these families in the current study can be attributed to their inherent characteristics, notably their prolific seed production, facilitating effective dispersal and their adaptive capacity to colonize diverse environments (Al-Robai et al., 2017; Souddi and Bouallala, 2022). The high representation of Poaceae and Asteraceae in our findings suggests their adaptability to the challenging conditions of hot arid zones, where resource availability and environmental stressors present significant challenges for plant life (Neffar and Chenchouni, 2025). The prolific seed production of these families enhances their ability to establish and proliferate, contributing to their dominance in the studied urban environments. Poaceae and Asteraceae, with their widespread distribution, owe their success in hot arid zones to specific adaptive features: deep root systems, reduced water loss mechanisms, and efficient dispersal strategies well-suited to dryland landscapes. These traits enable their thriving in urban ecosystems within hot arid zones, establishing them as pivotal contributors to vegetation dynamics. These findings align with the broader ecological context of arid areas, emphasizing the adaptability and resilience of certain plant families in the face of environmental constraints (Bouallala et al., 2020, 2023; Neffar and Chenchouni, 2025). The unique composition and distribution of plant species observed in our study provide valuable insights into the dynamics of urban green spaces in hot arid zones. The understanding of the specific families dominating these plantations not only contributes to our knowledge of local biodiversity but also holds implications for sustainable urban planning, landscaping, and conservation efforts in regions characterized by challenging environmental conditions.

4.1 Life forms

This investigation reaffirms the prevalence of therophytes (60.2%) and chamaephytes (25.6%) within the challenging environments of hot arid zones, aligning with prior research findings (Osman et al., 2014). Therophytes, constituting the most represented biological type with 18 species across all plantations and the study area, play a crucial role in adapting to the arid conditions of the Sahara Desert. Specialists in Sahara flora have highlighted the direct dependency of therophytes on precipitation, emphasizing their adaptation strategy of escaping extreme conditions through seed dormancy (Quézel, 1965; Carrière, 1989; Monod, 1992). The pronounced dominance of therophytes in our study area is linked to the irrigation practices employed in the plantations, drawing water from boreholes. This underscores the influence of artificial water supply in shaping the biological composition of urban plantations in hot arid zones. The controlled irrigation facilitates the germination and establishment of therophytes, showcasing the dynamic interaction between anthropogenic interventions and plant community structures. Chamaephytes, occupying the second position with five species, exhibit the highest values in the *Leucaena leucocephala* and *Tamarix aphylla* plantations and across the whole study area. This resilience aligns with their adaptation to the unique environmental conditions of hot arid zones (Jauffret and Visser, 2003; Chenchouni, 2012; Bradai et al., 2015; Gamoun et al., 2018). Their ability to thrive in these conditions positions them as key contributors to the plant diversity in such challenging ecosystems. Hemicryptophytes, represented by five species, exhibited minimal presence in all plantations except in the *Phoenix dactylifera* plantation where they may find optimal conditions for development. The significance of hemicryptophytes in the Maghreb region is intricately tied to localized soil conditions, particularly soil moisture and organic matter levels (Floret et al., 1990; Barbero et al., 2001). This variability underscores the nuanced relationship between plant adaptation strategies and the intricacies of local environmental factors. Phanerophytes were represented solely by *Calotropis procera* in the study area, which aligns with the general rarity of this biological type in hot arid zones (Bouallala, 2013; Gamoun et al., 2018). The solitary presence of phanerophytes emphasizes their limited occurrence in environments characterized by aridity and serves as an essential contribution to the understanding of plant functional strategies in hot arid urban ecosystems.

4.2 Morphological types

The morphological spectra underscored a prevailing dominance of annuals over perennial counterparts. This prevalence aligns with the adaptive strategy of annuals, characterized by a shorter life cycle that enhances resilience to maintenance activities in urban green spaces (Gomaa, 2012). The efficient adaptation of annuals to short-term environmental conditions highlights their resilience in managed landscapes, contributing to the overall dynamics of plant communities in these settings.

4.3 Dispersal types

The comprehensive examination of dispersal spectra across plantations revealed a nuanced ecological interplay. Anemochorous species emerged as dominant species across all plantations, a phenomenon attributed to the unique characteristics of their diaspores, which facilitate easy wind-mediated transportation (Bouallala et al., 2020). Barochoric species, recording substantial percentages in both raw and real spectra, showcases the significance of physiological mechanisms influencing their dispersal strategies (Bouallala et al., 2020). Notably, zoochorous species exhibited notable representation, particularly in the real spectra, emphasizing the vital role of animals in ecosystem functioning within hot arid zones (Bradai et al., 2015). The limited presence of anthropochorous species, primarily in the *Leucaena leucocephala* and *Phoenix dactylifera* plantations, underscores the influence of human activity on the dispersal patterns of certain species.

4.4 Phytogeographic (chorological) types

The dominance of the Saharo-Arabic element in the studied plantations, regardless of the represented biological spectra, reflects a strategic adaptation to the harsh conditions of hot arid zones (Salama et al., 2014; Bouallala et al., 2020; Azizi et al., 2021). This adaptation underscores the ecological significance of native species adept at thriving in arid environments. The Mediterranean Saharo-Arabic element occupied a significant niche in the *Leucaena leucocephala* and *Tamarix aphylla* plantations, suggesting that environmental factors favor its development in the Sahara Desert. Likely influenced by compensatory factors, such as soil water availability, the Saharo-Arabic and Mediterranean Saharo-Arabic elements exhibit an adaptive capacity to unique conditions (Azizi et al., 2021). In third place, the Cosmopolitan element, surpassing 13.5% in both raw and real spectra, emerges as an indicator of human activities and influences (El-Saied et al., 2015; Kouba et al., 2021). The presence of Cosmopolitan species reflects the complex relationship between human interventions and the establishment of certain plant species, signifying the impact of anthropogenic factors on plant biogeography in urban ecosystems.

4.5 Rarity/abundance status of the flora

The examination of abundance, particularly in the raw spectra, revealed a nuanced distribution across the rarity spectra, encompassing the rare, common, and very common categories. However, in the refined lens of the real spectra, a notable consolidation was observed, with a predominant representation of the common and very common categories. This nuanced abundance pattern underscores the intricate interaction of factors shaping the plant communities in the challenging environment of hot arid zones. The presence and abundance of plant species in these zones are intricately woven into a complex tapestry of abiotic and biotic factors. Edaphoclimatic and geomorphological variables, known to significantly influence vegetation patterns (Ozenda, 2004), interact dynamically with the activities of living organisms (Bouallala et al., 2020). The convergence of these factors creates a mosaic of ecological niches, fostering a diverse assembly of plant species, each negotiating its rarity/abundance status based on a delicate balance of environmental conditions.

Notably, plantations in hot arid zones emerge as not just mere patches of greenery but rather dynamic ecosystems accommodating multi-interest plants with varied rarity/abundance status. This multifaceted nature of the vegetation in urban environments underscores the resilience and adaptability of certain species to the challenging conditions prevalent in these zones. As such, the rarity/abundance patterns observed in the studied plantations reflect a complex interplay of ecological factors, shedding light on the adaptive strategies of plant species in response to the unique challenges posed by the hot arid environments.

4.6 Insights on urban green space dynamics in hot arid zones

Our investigation into the plant diversity of urban plantations in hot arid zones provides not only a comprehensive understanding of the prevailing families and biological spectra but also valuable insights into the broader dynamics of urban green spaces. The dominance of Poaceae and Asteraceae, attributed to their prolific seed production and adaptability to challenging arid conditions, accentuates their pivotal role in shaping urban ecosystems. This insight is crucial for sustainable urban planning, landscaping, and conservation efforts in regions characterized by environmental stressors. The adaptability of these dominant families suggests their potential contribution to green infrastructure resilience in urban areas facing water scarcity and temperature extremes. Urban planners and conservationists can leverage this knowledge to strategically design and manage green spaces, fostering biodiversity while considering the unique ecological characteristics of hot arid zones.

While our study primarily focuses on ecological factors influencing flora in urban environments, it is imperative to acknowledge the substantial impact of anthropogenic interventions on plant community structures. The prevalence of Cosmopolitan species, indicative of human activities, prompts consideration of the complex relationship between urbanization and plant biogeography. The intentional or unintentional introduction of species by human activities significantly influences the composition and distribution of plant species in urban landscapes. Recognizing these anthropogenic influences is essential for predicting and managing urban biodiversity effectively. Future research endeavors could delve deeper into the specific mechanisms through which human activities shape plant communities, facilitating a more nuanced understanding of the urbanization-flora interaction.

The rarity/abundance status analysis illuminated the complex interplay of abiotic and biotic factors in shaping plant communities in hot arid zones. Understanding the delicate balance of environmental conditions that govern rarity and abundance provides practical implications for green space management. Urban planners and land managers can use this knowledge to optimize the selection and arrangement of plant species, tailoring green spaces to local ecological nuances. By recognizing the ecological intricacies of rarity and abundance, management practices can promote biodiversity, resilience, and adaptability within urban plantations. Additionally, the consideration of rarity/abundance dynamics offers a nuanced perspective for prioritizing conservation efforts and identifying species of ecological importance within hot arid urban ecosystems.

4.7 Conservation strategies and urban ecosystem management

The study's findings on urban green spaces in hot arid zones yield valuable practical implications for ecology conservation, land planning, and habitat management. Conservation efforts can leverage insights into plant community dynamics, focusing on preserving key families like Poaceae, Asteraceae, and Zygophyllaceae and species with essential traits such as therophytes. Incorporating ecological knowledge into urban planning enhances the resilience of green spaces, and emphasizes the significance of Poaceae and Asteraceae in sustainable landscaping. Habitat management practices can prioritize anemochorous plants, adapt to the dominance of therophytes and chamaephytes, and foster adaptation of plant species to arid environments. Phytogeographic considerations, particularly the Saharo-Arabic and Mediterranean Saharo-Arabic elements, guide conservation planning to preserve native elements and promote conditions conducive to their development. The study underscores the role of urban plantations as habitats for multi-interest plants, prompting initiatives to preserve and promote diversity. Adaptive management strategies responsive to climate change impacts are crucial in hot arid zones. Overall, the study provides a comprehensive roadmap for ecologically sound conservation practices, informed urban planning, and effective habitat management in hot arid zones, contributing to the resilience and sustainability of ecosystems in challenging landscapes (Chenchouni and Neffar, 2025; Neffar and Chenchouni, 2025).

5 Conclusions

Our comprehensive exploration of urban green spaces in hot arid zones has unraveled complex dynamics across multiple dimensions, from plant diversity to life forms, morphological types, dispersal types, phytogeographic (chorological) types and rarity/abundance status. The amalgamation of ecological insights with anthropogenic influences not only enriches our understanding of these complex systems but also lays a robust foundation for advancing sustainable urban planning and conservation endeavors. The acknowledgment of nuanced relationships among the flora, environmental variables, and human activities underscores the significance of a holistic approach in deciphering the interaction shaping plant communities in challenging climatic contexts. This holistic perspective not only aligns with the ideas articulated in the introduction but also reaffirms the critical need for informed decision-making to ensure the continued resilience and vitality of urban green spaces in the ever-evolving landscape of environmental changes. Our study emphasized the pivotal role of plant diversity within plantations in hot arid zones, and showcased its variations in different plantation types. Notably, Poaceae, Asteraceae, and Zygophyllaceae emerged as key contributors, underscoring their substantial presence compared to other botanical families. The examination of plant functional traits highlights the dominance of therophytes, particularly annuals, adept at resisting both biotic and abiotic stressors. Anemochorous plants, through their strategic dispersal mechanisms, emerged as crucial players in the ecosystems of these plantations, accentuating their ecological significance. Phytogeographically, our findings illuminated the prevalence of the Saharo-Arabic element, showcasing its adaptability across all plantation types. The Mediterranean Saharo-Arabic element significantly present in irrigated conditions, and the Cosmopolitan element, thriving amidst anthropogenic disturbances characterizing urban plantations, further contribute to the complex ecological tapestry. Overall, our study established that urban plantations in hot arid zones serve as diverse habitats accommodating multi-interest plants, each navigating its rarity/abundance status. The assessment of abundance that reflects the distribution of rare, common, and very common categories, can be used as indispensable data for effective urban plantation ecosystem management in the Sahara Desert of Algeria. Our study not only advances scientific knowledge but also serves as a call to action for policymakers, urban planners, and conservationists to prioritize and adapt their strategies in alignment with the ecological intricacies revealed by our investigation.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

Conceptualization: Mohammed SOUDDI; Methodology: Mohammed SOUDDI, M'hammed BOUALLALA; Resources: Mohammed SOUDDI, M'hammed BOUALLALA; Investigation: Mohammed SOUDDI, M'hammed BOUALLALA; Formal analysis: Mohammed SOUDDI, Haroun CHENCHOUNI; Writing - original draft: Mohammed SOUDDI, Haroun CHENCHOUNI, M'hammed BOUALLALA; Writing - review and editing: Mohammed SOUDDI, Haroun CHENCHOUNI, M'hammed BOUALLALA; Visualization: Haroun CHENCHOUNI; Supervision: M'hammed BOUALLALA. All authors approved the manuscript.

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